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Oral Presentations

Adolescent Scoliosis I

A001: Radiographic Results of Selecting the Touched Vertebra as the Lowest Instrumented Vertebra in Lenke Type 1 (Main Thoracic) & Type 2 (Double Thoracic) Curves at a Minimum 5-year Follow-up

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Introduction: A prior study showed the touched vertebra (TV), defined as the most cephalad thoracolumbar/lumbar vertebra "touched" by the center sacral vertical line (CSVL), as a potential landmark vertebra & recommended lowest instrumented vertebra (LIV) as well. We evaluated a large cohort of Lenke type 1 & 2 cases to determine if selecting the TV as the LIV will produce optimal positioning at a min. 5 yrs postoperative. Our hypothesis was that it would and that fusing short of the TV would lead to a suboptimal result. **Material and Methods:** 299 pts with Lenke 1 (n = 207) or Lenke 2 (n = 92) AIS curves at a min. 5 yr f/u were evaluated. The TV was selected on the preoperative x-ray by 2 independent examiners & confirmed for agreement. The LIV selected was compared to the preoperative TV as well as the LIV-CSVL distance at min. 5 yr f/u. Comparison was made on the LIV-CSVL distance in pts fused short of the TV, to the TV or distal to the TV using standard statistical software. **Results:** When comparing the entire cohort, differences in 5 yr LIV-CSVL absolute values between the 3 groups approached, but did not reach, significance ($P = .055$). In a subanalysis of the lumbar A modifiers (n = 161), main effect ANOVA indicated a significant difference among the 3 groups ($P = .002$). Post hoc comparison revealed that pts fused short of the TV (TV-1) had significantly greater LIV-CSVL distance values than those fused to the TV ($P = .006$) & those fused distal to the TV (TV+1, $P = .002$). There was no significant difference among the 3 groups when looking at lumbar B (n = 76, p = 0.424) & lumbar C (n = 62, $P = .326$) modifiers. **Conclusion:** Selecting the touched vertebra (TV) as the LIV for Lenke type 1A & 2A curves produced optimal LIV positioning at a minimum 5 yrs postoperative, while fusing short of the TV showed statistically increased LIV- CSVL translation. Understanding & utilizing the TV rule assists the surgeon in proper LIV selection in Lenke type 1A & 2A curve patterns for AIS.

A002: Shoulder Balance in Lenke Type 1 Scoliosis Treated by Convex Manipulation: The Role of Osteotomies

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Introduction: Shoulder balance is important for adolescent idiopathic scoliosis, which affects the patient's appearance and satisfaction after scoliosis surgery. We report perioperative and 3-year results in terms of deformity correction and shoulder balance in a consecutive series of patients treated by convex manipulation through an all-level pedicle screws convex instrumentation. **Material and Methods:** From January 2013 to January 2016 we surgical treated 42 consecutive patients (37 F, 5 M, mean age 13 years) affected by Lenke type 1 scoliosis. Mean preoperative Cobb angle was 56° ± 6°. Shoulder balance was evaluated by pre-operative measurement of clavicle angle and T1-tilt. We performed a posterior access only in all patients using polyaxial pedicle screws at each level on the convex side of the curve. Among this patients, we distinguished 2 groups: patients in which posterior column osteotomies (PCO) were performed at the apical level of scoliosis

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only on the convexity of the curve (10 patients), and patients in which PCO were not performed (32 patients). All the correction maneuvers were performed on the convex prebent rod. In all cases motor-evoked potentials monitoring was used. Mean follow-up time was 32 months. **Results:** The average percentage of coronal correction was 76 ± 5% (mean postoperative Cobb angle 15° ± 4°), with no neurological complications. Concerning the post-operative kyphosis, we observed a slight decrease of mean values compared to preoperative measurements (mean reduction of thoracic kyphosis 5° ± 2°). At 3-year follow-up no changes in coronal nor in sagittal plane were observed. Concerning post-operative shoulder balance, we reported a statistically significant change in clavicle angle and T1-tilt in patients operated with asymmetrical PCO respect to patients in which PCO were not performed. **Conclusion:** This case-series study shows the effectiveness and the safety of convex manipulation in Lenke type 1 scoliosis. The coronal correction obtained with this technique is comparable to that obtained with the traditional concave derotation. Concerning shoulder balance correction, PCO, providing a shortening and a higher mobilization of the convex side of the curve, allow a better management of the proximal thoracic spine and, consequently, a better restore of shoulder symmetry.

A003: Sagittal Cervical Compensation in Adolescent Idiopathic Scoliosis

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Introduction: The aim of this study is to analyse the sagittal alignment of cervical spine in surgically treated adolescent idiopathic scoliosis(AIS) and its association with alignment of thoracic and lumbar column. **Material and Method:** A retrospective review of clinical and radiological data from databases of two university hospital spine clinics was performed. 47 consecutive AIS patients were included in the study, the remainder were excluded due to poor quality Xrays where the CS was not properly visible, or previous surgery. Sagittal parameters were evaluated on AP an Lateral X-rays using software: C2-C7 lordosis, C2-C7 SVA, T4-T12 kyphosis, upper thoracic cobb angle, lower thoracic cobb angle, L1-S1 lordosis and Lenke type of scoliosis. These measurements were then evaluated for possible associations with patient age and with pre-existing measurements using t test. **Results:** There were 42 females and 5 males among retrospective databases; mean age at surgery was 15.21 ± 2.34 years. No significant differences in T1SS, C2-7 SVA, C2-7 Cobb angle, thoracic kyphosis were seen during the follow up. On the other hand, preoperative and postoperative measurements of L1-S1, upper thoracic and main thoracic angles showed significant differences. **Conclusion:** Patients with AIS appear to compensate for abnormal thoracic alignment with changes in cervical sagittal alignment. Significantly less cervical kyphosis was seen in Lenke 5 and 6, and greater cervical kyphosis in Lenke 1, 2, 3 curves. Overall the study group, cervical alignment showed no significant correlation with the Lenke types.

A004: Intrathecal Morphine Reduce Blood Loss During Idiopathic Scoliosis Surgery

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Objective: This retrospective study was designed to assess the impact of intrathecal morphine compared with no intrathecal morphine on blood loss during posterior spine instrumented fusion to correct pediatric idiopathic scoliosis. **Material-Method:** A retrospective study was done of the data and the anesthetic charts of 95 patients underwent scoliosis surgery between January 2008 and June 2016 by the same orthopedic surgeon. Forty patients were operated without intrathecal morphine (NITM) and 55 with intrathecal morphine (ITM). A statistical comparison has been done between the two groups of the blood loss, the number of patients received blood transfusions and the volume of the blood transfused. **Results:** Blood loss was significantly greater in NITM group with 2016.1 ± 857.3 ml instead of 725 ± 312.2 ml ($P < .0001$). All the patients (40 patients) of the NITM group received blood transfusions while only 13 patients (from 55 patients) of the ITM group needed blood transfusions. The volume of blood transfused per patient was significantly greater in the NITM group (726.3 ± 487.3 ml) than in the ITM group (295.4 ± 170.9 ml), ($P < .0001$). **Conclusions:** Our data are similar with previous published study and demonstrate that intrathecal morphine in pediatric surgical scoliosis correction decreases significantly the inta-operative blood loss and the number of the blood transfusions.

A005: Spinal Growth in Patients with Juvenile Idiopathic Scoliosis Treated with Boston Brace

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Introduction: In children with juvenile idiopathic scoliosis (JIS), the spinal deformity can have serious consequences for

lung development and may reduce life expectancy. The treatment goal of JIS is to maximize growth of the spine and thorax by controlling the spinal deformity, while simultaneously preserving normal lung development. Bracing and growth-friendly spine surgery have been used to control the curve. However, growth-friendly implants usually requires multiple surgeries, is associated with complications and can decrease spinal growth. The effect of bracing on spinal growth is unknown. The aim of the study is to evaluate spinal growth in braced JIS patients. **Material and Methods:** 38 female JIS patients were retrospectively selected from our database. These patients were diagnosed with JIS and were treated with brace during childhood. Three PA spine radiographs were selected: before start of bracing, after brace treatment and at final follow-up. Age, total length and duration of brace treatment were recorded. The following variables were measured on the radiographs using Surgimap: Cobb angle, T1-T12 length and T1-S1 length. **Results:** The average age of diagnosis was 7.1 years (1.5-9.5). Brace treatment was started at an average age of 11.3 years with a Risser of 0.5 and was stopped at an average age of 14.6 years with a Risser of 4.2. The brace was prescribed for a mean of 40 months. The Cobb angle of the main curve before and after bracing were 33° (20°-60°) and 31° (10°-63°) respectively. At skeletal maturity, 8 patients were treated surgically with a mean angle of 55° (44°-62°) before surgery. Patients not requiring surgical treatment had an mean angle of 28° (13°-53°) at final follow-up. Before treatment, mean T1-T12 length was 241 mm (147-297), T1-S1 length 385 mm (225-463) and total length 1528 mm (940-1790). After treatment, mean T1-T12 length was 279 mm (205-317), T1-S1 length 446 mm (334-518) and total length 1692 mm (1420-1935). And at last follow-up, mean T1-T12 length was 286 mm (240-328), T1-S1 length 458 mm (379-535) and total length 1711 mm (1545-1945). The total length gain from start brace to last follow-up was 43 mm (8-118) for T1-T12 length, 68 mm (6-200) for T1-S1 length and 141 mm (20-431) for total length. Spinal growth during brace treatment was 14.3 mm/year (T1-T12) and 23.3 mm/year (T1-S1). **Conclusions:** Brace treatment may be useful for managing JIS in 30 of 38 patients by preventing progression of the curve. The study is descriptive and provide an overview of spinal growth in patients with JIS treated with the Boston brace. Based on Dimeglio's data, normal spinal growth is 1.1 cm/year (T1-T12) and 1.8 cm/year (T1-S1) between 10 years and skeletal maturity. The braced patients grew 1.4 cm/year (T1-T12) and 2.3 cm/year (T1-S1) during the treatment period indicating that bracing had no significant negative effect on longitudinal spinal growth.

A006: Verticality Perception in Adolescents with Idiopathic Scoliosis

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Introduction: Adolescent idiopathic scoliosis (AIS) is a three-dimensional spine deformation, whose aetiopathogenesis remains unclear. Current literature indicates a possible vestibular origin of AIS. A vestibular deficit may cause an asymmetrical contraction of the axial muscles, which, in turn, leads to a vertebrae malformation in a period of rapid spinal growth, where compensatory (proprioceptive) mechanisms are quite limited. One way to explore vestibular function is the subjective estimation of the gravitational vertical. Deviations or tilts of the perceived visual vertical are the most sensitive sign of a vestibular tone imbalance in roll and occur with lesions on peripheral or central vestibular pathways from the labyrinth to the vestibular cortex. In this study, we aimed to investigate and compare the contribution of different sensory modalities to the subjective estimation of the gravitational vertical between AIS patients and healthy individuals. **Material and Methods:** All study subjects (AIS Group, n = 10, age 11-16y, Cobb's angle > 15o) and healthy age matched adolescents (control group, n = 10) performed a series of subjective internal estimation of verticality in two visual conditions (open/closed eyes) and using three different segments (hand, head and trunk). Specifically, they were asked to control the verticality of a visual rod (displayed on a large TV screen in front of them) using a joystick that was either hand-held [Subjective Visual Vertical (SVV) and Subjective Haptic Vertical (SHV) with open and closed eyes respectively] or attached to the trunk or head [Subjective Postural Vertical (SPV) The rod's initial tilt position was set at 18o of tilt either clockwise or counterclockwise. An electromagnetic tracking sensor attached to the joystick or the trunk/head measured the rod's actual deviation from the gravitational vertical in degrees (error). **Results:** A 2 (group) x2 (visual condition) x3 (segment) ANOVA revealed that the error in the subjective estimation of verticality was greater when the estimate was performed with closed eyes [clockwise: ($F(1,18) = 45,67$, $P = .000$); counterclockwise: ($F(1,18) = 114.67$, $P = .000$]. Moreover, a significant three-way interaction (counterclockwise direction: $F(2,36) = 4.64$, $P = .016$, $h2 = .205$) confirmed that differences among groups in verticality estimation were dependent on the visual condition and the segment used to perform the test. Post-hoc analysis revealed that AIS subjects had a greater error (deviation from the earth vertical) than controls when estimating verticality with the head and closed eyes ($t(18) = -3.6$, $P = .002$). **Conclusion:** Since head acceleration in the roll direction with closed eyes is mostly sensed by the semi-circular canals, these results suggest the presence of a vestibular tone imbalance in AIS participants. These findings may prove useful in the early diagnosis and prognosis definition of AIS.

Cervical Laminoplasty

A007: Correlation between Posterior Migration of Spinal Cord and Cervical Spine Curvature after Cervical Laminoplasty

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Introduction: Cervical laminoplasty is an effective procedure for decompressing multilevel spinal cord compression. Posterior compressive bone as well as hypertrophied ligamentum flavum is directly removed and dorsal migration of the spinal cord allows for indirect decompression of the anterior spinal cord. Spinal cord back shift has been considered the desired end point of posterior decompression procedures. However, a wide range of posterior spinal cord drift has been reported in the literature and reported data refer to different averages, such as that of each level for a given patient, or that of each single level, or the mean value of all patients. The aim of our study was to correlate the posterior migration of the spinal cord after extensive laminoplasty to the cervical spine curvature. **Materials and Methods:** Twenty-nine patients (15 men and 14 women) who underwent bilateral open-door laminoplasty between C3 and C7 levels were included in this study. The average age at operation was 64 years (range, 43-87 years). All patients presented with symptoms of neural compression and magnetic resonance imaging (MRI) findings were consistent with CSM. All patients underwent plain radiographs and MRI pre- and post-operatively. The distance from the posterior edge of each vertebral body to the anterior edge of the spinal cord was measured on sagittal MRI, in order not to be influenced by the postoperative cord expansion. Cervical sagittal alignment was assessed from pre-operative lateral cervical radiographs and classified as lordosis, kyphosis, straight or S-shaped. **Results:** The posterior spinal cord shift ranged from a maximum of 6.2 mm to a minimum of -0.1 mm, with an average of 1.8 mm. The peak shift was 2.8 mm at C5. The mean posterior spinal cord shifts in the different neck alignment groups were 1.8 mm for the lordosis group, 1.5 mm in the straight-neck group, 1.5 mm in the kyphosis group and 2.4 mm in the S-shaped group. The peak shift was located at C5 in the lordosis group (2.8 mm) and in the straight-neck group (3.1 mm), C7 in the kyphosis group (2.8 mm) and C6 in the S-shaped group (3.9 mm). The minimal posterior spinal cord shift was located at C7 in the lordosis group (1.4 mm) and at C3 in the S-shaped group (1.7 mm), in the straight-neck group (0.4 mm) and in the kyphosis group (0.4 mm). In the lordosis and the S-shaped groups we observed the greatest backward movement in the middle of the cervical spine, at the point of maximum concavity, like a bowstring. **Conclusions:** The preoperative lordotic alignment of the cervical spine influences the degree of posterior movement of the spinal cord after extended laminoplasty. Cervical lordosis allows a maximal spinal cord back shift. Moreover, the final spinal cord position is different according to the preoperative alignment of the spine, with a bowstring effect in lordosis and S-shaped cervical spines. Finally, the risk of C5 palsy should be anticipated in lordotic and straight spines where the peak shift is located at C5.

A008: C4/5 Foraminal Stenosis Predicts C5 Palsy after Expansive Open-Door Laminoplasty

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Introduction: Laminoplasty is frequently performed in cervical myelopathy patients, but can lead to unexpected postoperative C5 palsy. Although several studies have examined the pathogenesis and prevention of postoperative C5 palsy, many controversies remain and some radiological findings identified as risk factors were not correlated with our outcomes. **Material and Methods:** This study reviewed 116 patients who underwent open-door laminoplasty for cervical spondylotic myelopathy between January 2014 and April 2016. All operations were performed by one surgeon. C5 palsy was defined as weakness [change in manual muscle testing (MMT) score of 1 or 2] of the deltoid muscle. The patients were divided into groups that developed or did not develop C5 palsy. We evaluated the incidence of C5 palsy, the preoperative C2–7 Cobb angle, and Pavlov ratio at the C4/C5 level using simple cervical lateral radiographs. Furthermore, by using computed tomography (CT), we evaluated the existence of an ossified posterior longitudinal ligament (OPLL), the transverse diameter of the C4/5 foramen, and increases in the anteroposterior (AP) diameter of the spinal canal at the C4/5 levels after surgery. To assess the correlation between C4/5 foraminal stenosis and C5 palsy, we subdivided the C4/5 foramina into two groups: 8 with C5 palsy and 192 without C5 palsy. Finally, a high signal intensity on T2-weighted images of the cervical spinal cord preoperatively was noted. **Results:** Of the 116 patients, 16 cases were excluded and 100 cases were analyzed; postoperative C5 palsy occurred in 8 patients (8%). There were no significant differences between the two groups in sex, age, the presence of an OPLL, or preoperative high signal intensity on T2-weighted images of the cervical spinal cord. The preoperative C2–7 Cobb angle, Pavlov ratio at the C4/C5 level, and increase in AP diameter of the spinal canal at the C4/C5 level were not significantly related to postoperative C5 palsy. However, the average diameter of the C4/5 foramen of the affected side was 2.51 mm, while that of the unaffected side was 3.88 mm ($P = .004$); a diameter of the C4/5 foramen of less than 2 mm was significantly related to C5 palsy in the binary logistic regression test ($P = .000$). In this study, a smaller diameter of the C4/5 foramen was the only factor significantly correlated with C5 palsy after laminoplasty. **Conclusion:** C4/5 foraminal stenosis

is one of the best predictors of C5 palsy, which might be related to ischemic/reperfusion injury of the C5 root nerve after laminoplasty. This should be examined further in prospective comparative or basic experimental studies.

A009: A MRI Characterization of the Dorsal Cervical Cord Migration Behaviour in Laminectomy versus Hybrid Open-Door Laminoplasty

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Introduction: Posterior cervical approach has become the treatment of choice for cervical spinal cord compression related pathology in more than three vertebral levels. Previous studies compared clinical outcomes of cervical laminoplasty with laminectomy and have reported inconsistent findings. There has been a recent development of a hybrid laminoplasty approach (C3 dome osteotomy, C4-6 laminoplasty and upper C7 laminectomy) with muscle sparing techniques. To the best of the authors' knowledge, there are no studies comparing the results of hybrid laminoplasty with laminectomy with fusion. The aim of this study is to compare and evaluate the surgical outcomes of hybrid laminoplasty with laminectomy with fusion in terms of radiological findings. **Material and Methods:** A retrospective review of 42 consecutive patients, who had undergone cervical laminectomy with fusion (LF) or hybrid laminoplasty (HLP) by a single surgeon, was performed. Surgical outcomes were assessed and Image J software was used to evaluate pre- and post-operative Magnetic Resonance Imaging (MRI) scans for posterior cord migration and dural sac expansion of the two groups (LF and HLP). Radiological data captured was analysed using SPSS software. **Results:** 36 cases with pre- and post-op MRI were included in the study. Average follow up duration was 1.5 years. 16 patients had laminectomy with fusion (LF) and 20 had hybrid laminoplasty (HLP). There were no statistically significant differences between the LF and HLP group in terms of age, gender, follow-up duration, pre-operative diagnosis and pre-operative JOA score. There were however 2 cases of post-operative C5 palsy in LF compared to none in HLP. A trend is shown with the laminectomy with fusion (LF) group displaying greater dorsal cord migration than the hybrid laminoplasty (HLP) group at all levels from C2-T1. Comparing between cervical spinal levels, the extent of dorsal cord migration is shown to be greatest at the level of C4-5 in LF (1.94 ± 1.60 mm, $P = .01$) and C5-6 in HLP (1.71 ± 1.17 mm, $P = 0.00$). In comparing patients with post-operative C5 palsy with those who did not acquire C5 palsy, dorsal migration was found to be significantly greater in the C5 palsy group at the levels of C4-5 (4.38 ± 0.50 mm vs 1.64 ± 1.04 mm, $P = .02$), C5-6 (4.97 ± 0.99 mm vs 1.57 ± 1.29 mm, $P = .02$), C6-7 (4.20 ± 0.83 mm vs 0.77 ± 1.09 mm, $P = .02$) and C7-T1 (1.74 ± 0.96 mm vs 0.01 ± 1.33 mm, $P = .045$) as compared to the non-C5 palsy group. **Conclusion:** This is the first MRI study to prove that there is a trend towards greater posterior cord migration in laminectomy with fusion compared to hybrid laminoplasty in patients presenting with cervical myelopathy. A statistically significant greater dorsal cord migration was found at C4-5 spinal level in patients with C5 palsy.

A010: A Metanalysis of Cervical Laminoplasty Techniques: Are Mini-Plates Superior?

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Introduction: Laminoplasty first described by Tsuji in 1982 as an alternative to laminectomy as the treatment for cervical spondylotic myelopathy CSM. The technique was developed in an effort to eliminate the development of instability and kyphosis following laminectomy while achieving minimal reduction in cervical range of movement (ROM) compare to fusion. In the late 1990's, spinal surgeons experimented the use of maxillofacial fixation plates as an alternative to sutures, anchors and local spinous process auto-grafts to provide a more rigid and lasting fixation of laminoplasty. This eventually led to the advent of laminoplasty mini-plates, which are currently used. **Objective:** Is to compare laminoplasty with plate and without plate techniques in terms of functional outcome results. **Material and Methods:** A qualitative and quantitative analysis was performed to evaluate the current available literatures in an attempt to justify the use of plate in laminoplasty. Given the relatively high costs associated with the use of these plates and limited available data in the literatures about laminoplasty techniques and outcome. **Results:** The principal finding of this study was that there was no statistically significant difference in clinical outcome between the two different techniques of Laminoplasty. **Conclusion:** There is no enough evidence in the Literatures to support one technique over the other and hence there is no evidence to support change in practice (using or not using the plate in laminoplasty). Randomized control trial will give better comparison between the two groups.

A011: Comparison between Radiological and Clinical Outcomes of Laminoplasty with a Titanium Miniplate for Cervical Myelopathy

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Introduction: Laminoplasty is a surgical procedure frequently performed for cervical myelopathy. We investigated

correlations between changes in the anteroposterior diameter (APD) of the spinal canal, spinal canal area (SCA), and laminar angle (LA) and clinical outcomes of laminoplasty. **Material and Methods:** Of the 204 cervical myelopathy patients who underwent laminoplasty from July 2010 to May 2015, 49 patients who were evaluated with pre- and postoperative computed tomography of the cervical vertebrae were included. The average age of the patients was 60.4 years (range, 31–82 years), and the average duration of follow-up was 31.6 months (range, 9–68 months). Changes in the APD and SCA were measured at the middle of the vertebral body. Changes in LA were measured where both pedicles were clearly visible. Clinical outcomes were assessed using the Japanese Orthopedic Association (JOA) score and visual analog scale score for pain preoperatively (1 day before surgery) and postoperatively (last outpatient visit) and examining postoperative complications. **Results:** The APD showed an average of 54.7% increase from 11.5 to 17.8 mm. The SCA showed an average of 57.7% increase from 225.9 to 356.3 mm2. The LA increased from 34.2° preoperatively to 71.9° postoperatively. The JOA score increased from an average of 9.1 preoperatively to 13.4 postoperatively. Three patients were found to have hinge fractures during surgery. Postoperative complications, including two cases of C5 palsy, were recorded. The correlation coefficient between the LA change and JOA score improvement was −0.449 ($P < .05$). Patients with a <33.8° (25%) increase in the LA showed the most significant clinical improvement. **Conclusion:** Patients with a <33.8° (25%) change in the LA after laminoplasty with a titanium miniplate showed the most significant clinical improvement. Thus, LA changes can be useful in predicting the clinical outcome of laminoplasty.

A012: Open-Door Laminoplasty for Multilevel Cervical Spondylotic Myelopathy and OPLL using Titanium Reconstruction Miniplate and Screws

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Introduction: To review outcome of 25 patients who underwent open-door cervical Laminoplasty for multilevel cervical spondylotic myelopathy and OPLL using titanium reconstruction miniplate and screws. **Material and Methods:** Records of 18 men and 7 women aged 35 to 78 (mean, 62.6) years, who underwent open-door cervical Laminoplasty for myelopathy using titanium reconstruction miniplate alone were reviewed. 4 patients had 5 levels of decompression (C3-C7), 21 patients had 4 levels of decompression (C3-C6). Foraminotomies were performed in 3 cases (12%). A total of 104 laminae were opened, all of them were fixed with a titanium miniplate. In 21 patients, a 20-hole titanium miniplate bent to the contour of a lamina was used and fixed into 4 laminae and 4 patients fixed in 5 laminae levels. In most patients, screw fixation was unicortical, and no spacer or bone graft was used. Demographic data and surgical data including estimated blood loss (EBL), length of surgery, number of laminoplasty levels, complications and length of hospitalization were collected. Clinical outcomes were assessed with neck pain score using visual analog scale, neck disability index. Nurick's grading was used for quantifying the neurological deficits and outcome analysis was done using Odom's criteria. **Results:** The mean follow-up duration was 1.8 (range: 1–5) years. Diagnosis was cervical spondylotic myelopathy (n = 20), ossification of the posterior longitudinal ligament (OPLL, n = 5). Mean estimated blood loss (EBL) was 120 ml (range: 50-200), mean surgery time was 153 min (range: 75-240). Following Nurick`s scale, 23 patients (92%) improved, 2 (08%) had the same Nurick grade. No intraoperative complications were noted and average hospital stay was 6.12 days (range: 5 to 9). Significance improvements in overall NDI scores occurred at 1 year follow up ($P < .002$). Radiographic evaluation showed an increase in the mean sagittal diameter from 12.2 mm at pre-treatment to 18.3 mm post-surgery. 2 patients developed transient C5 palsy, presenting as shoulder abduction weakness. **Conclusion:** Open-door Laminoplasty technique using titanium reconstruction miniplate and screws is safe, easy and achieves a good canal expansion and neurological recovery and can be used as an alternative treatment for cases of multilevel cervical spondylitic myelopathy and OPLL patients without instability.

Lumbar Adjacent Segment Pathology

A013: Comparative Analysis of Risk Factors for Adjacent Segment Disease after Lumbar Spinal Fusion: More Than 10 Year-Follow-up

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Introduction: There are many concerns about ASD after lumbar spinal fusion using pedicle screws. There are many studies

about the causes that is natural degenerative change or risk factors. It was to analyze risk factors for adjacent segment disease(ASD), by comparing patients occurred ASD with patients followed more than 10 years after lumbar spinal fusion with pedicle screw fixation for degenerative lumbar spinal disease. **Materials and Methods:** From August 1988 to December 2005, 581 patients underwent lumbar spinal fusion of 3 and less segment to treat degenerative lumbar disease. Among them, 180 patients underwent revision surgery for ASD or followed more than 10 years were included in this study. Average The mean age at the initial operation was 53.6 years old and the mean follow-up period was 160.6 months. Gender, age, residence, preoperative diagnosis, fusion method, number of fused segments, whether laminectomy of adjacent segments, preoperative degree of disc degeneration of adjacent segments in MRI, wether adjacent segments included L4-5 or L5-S1, and radiological measurements were analyzed. In radiological measurement, pre-& post-operative lumbar lordotic angle (LLA), correction of LLA, post-operative fusion segment lordotic angle(FSLA) per level were estimated. Statistical univariate analysis was performed with the Chi-square test and multivariate logistic regression analysis was done by using SPSS 14.0. ($P < .05$). **Results:** There were 40 patients with revision surgery due to ASD. Seven patients were operated by decompression or discectomy and 33 patients needed additional fusion. In univatiate analysis, the frequency of ASD was significantly high in cases that age was more than 65 years old ($P = .002$), laminectomy of adjacent segment was performed ($P = .002$), preoperative disc degeneration of adjacent segments in MRI was present($p = 0.001$) and post-operative FSLA per level was <16° ($P = .024$). In multivariate logistic regression analysis, the frequency of ASD was significantly high in case that age was more than 65 years old ($P = .015$, odd ratio = 3.106), laminectomy of adjacent segment was performed ($P = .012$, odd ratio = 5.044) and preoperative disc degeneration of adjacent segments in MRI was present ($P = .022$, odd ratio = 3.008). **Conclusions:** We analyzed risk factors for ASD, by comparing patients occurred ASD with patients followed more than 10 years after lumbar spinal fusion for degenerative lumbar spinal disease. Development of ASD was affected that age was more than 65 years old at initial operation, laminectomy of adjacent segment was performed and preoperative disc degeneration of adjacent segments in MRI was present. In case of old age and patients existed preoperative degenerative change of adjacent segment, careful decision should be considered to carry out lumbar spinal fusion.

A014: Incidence of Adjacent Segment Disease following Posterior Lumbar Interbody Fusion Vs Postero-lateral Fusion: A Snapshot with 5 Years Follow up

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Introduction: One of the major concerns after lumbar fusion surgery is the risk of developing adjacent segment disease (ASD). Both Posterior lumbar interbody fusion (PLIF) and posterolateral fusion (PLF) have been widely used by surgeons to address degenerative lumbar disease. However, the risk factors for developing of ASD are not clear. Some studies suggested that there is a higher rate of ASD with interbody fusion due to a more solid fusion, having a more profound effect on the caudal adjacent segment. In this study, we looked at our cohort of patients to investigate this further and establish other risk factors. **Materials and Methods:** We retrospectively reviewed our spinal unit data base to identify all patients who underwent posterior lumbar interbody fusion (PLIF) and Posterolateral lumbar fusion (PLF) over the last 5 years. 50 Patients of each group were randomly and blindly selected. Those with adjacent segment disease were identified. Co-morbidities, demographics, visual analogue scores preoperatively, then yearly, for the duration of five years were analysed. X-rays and CT scans were analysed and reviewed by 2 independent reviewers to assess the pelvic incidence change and sacral slope change. **Results:** All procedures were done by 3 spinal surgeons who use the same techniques and instrumentation. The difference of incidence of adjacent segment disease between the two groups was statistically insignificant. Both groups had comparative pre-operative co- morbidities; including smoking, diabetes, hypertension, obesity and steroid use. Both groups had similar socio-economic back grounds. X-rays and CT scans reviews showed no significant difference when assessing the pelvic incidence and sacral slope change ($P < .001$) with good inter-observer reliability (kappa 0.95). **Conclusion:** We concluded that smoking, diabetes, hypertension, obesity and steroid use are all risk factors for developing ASD. The incidence of ASD seems to be higher in younger patients with high physical activity. The choice of surgery; PLIF or PLF, does not affect the incidence of ASD.

A015: Paraspinal Muscle, Facet Joint, and Disc Problems: Risk Factors for Adjacent Segment Degeneration after Lumbar Fusion

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Introduction: Adjacent segment degeneration (ASD) is one of the major complications after lumbar fusion. Several studies have evaluated the risk factors of ASD. Although the paraspinal muscles play an important role in spine stability, no study has assessed the relationship between paraspinal muscle atrophy and the incidence of ASD after lumbar fusion. In the present study, we aimed to verify the known risk factors of ASD, such as body mass index (BMI), preoperative adjacent facet joint degeneration, and disc degeneration, and to assess the relationship between paraspinal muscle atrophy and ASD. **Material and Methods:** This is a retrospective 1:1 pair analysis matched by age, sex, fusion level, and follow-up period.

Among the 510 patients who underwent posterior lumbar fusion for degenerative lumbar disease between January 2009 and October 2009, a total of 50 patients with ASD after surgery were selected. Another group of 50 matched patients with degenerative lumbar disease without ASD after spinal fusion were selected as the control group. Each patient in the ASD group was matched with a control patient according to age, sex, fusion level, and follow up period.The risk factors considered were higher BMI, preoperative adjacent segment disc and facet degeneration, and preoperative paraspinal muscle atrophy and fatty degeneration. The radiographic data were compared between the ASD and control groups to determine the predictive factors of ASD after posterior lumbar fusion by using logistic regression analysis. The study was not externally funded. **Results:** Multivariate logistic regression analysis indicated that higher BMI (odds ratio [OR]: 1.353, $P = .008$), preoperative facet degeneration on computed tomography examination (OR: 3.075, $P = .011$), disc degeneration on magnetic resonance imaging (MRI) (OR: 2.783, $P = .003$), fatty degeneration (OR: 1.080, $P = .044$), and a smaller relative CSA of the paraspinal muscle preoperatively (OR: 0.083, $P = .003$) were significant factors for predicting the development of ASD. **Conclusion:** The occurrence of radiological ASD is most likely multifactorial, and is associated with a higher BMI, preexisting facet and disc degeneration on preoperative examination, and a smaller preoperative relative CSA of the paraspinal muscle on MRI.

A016: Minimally Invasive PLIF Did Not Have Advantage Over Conventional PLIF in the Incidence of Adjacent Segment Pathology

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Introduction: Nowadays, adjacent segment pathology (ASP) is one of the problematic complications after posterior lumbar interbody fusion (PLIF). We need to seek the effective methods to decrease the incidence of symptomatic ASP and as a result to decrease the revision surgery. Minimum invasive PLIF (MI-PLIF) is one of the good candidates. Purpose of this study is to investigate whether MI-PLIF surgery could decrease the incidence of symptomatic ASP. **Material and Methods:** At our hospital 467 patients had PLIF between 2005 and 2010. Eligible patients were with single PLIF as an initial lumbar operation. Out of 467, 326 patients with revision surgery, systemic disease, additional decompression at the other segment, and isthmic spondylolisthesis were excluded. Thirty one patients did not satisfy 5-year follow up. Finally, 101 patients were (age; median 65, 37 male and 64 female) included in this study. Follow-up rate was 76%. Forty two patients had PLIF with conventional pedicle screw (C-PS), 33 with percutaneous pedicle screw (P-PS), 26 had stand-alone PLIF (SA). The endpoint was history of the symptomatic ASP at 5 years after operation. Symptomatic ASP was defined to be the pathology with the following three conditions. First, symptom before operation had disappeared or almost completely alleviated postoperatively. Secondly, new symptom had emerged at least three months after operation. Thirdly, the newly emerged symptom was considered to be owing to the pathology confirmed on magnetic resonance imaging(MRI). **Results:** Of 101 patients, 2 patients in SA group had reoperation at index level by 2 years. Two patients (2%) had reoperation at the adjacent segment by 2 years, and 9 patients (9%) by 5 years. The incidence of the symptomatic ASP was 24% in the C-PS group, 24% in the P-PS group, and 21% in the SA group. There was no significant difference with a small sized effect between the C-PS group and P-PS group ($P = .9652$, $r = .01$) nor between C-PS group and SA group ($P = .7814$, $r = .07$). **Conclusion:** In our study minimally invasive PLIF did not have advantage over conventional PLIF in the incidence of adjacent segment pathology.

A017: Lumbar Fusion with Topping Off: A Failed Implant

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Introduction: The lumbar spinal fusion is an established procedure for the treatment of many degenerative diseases of the lumbar spine and spondylolisthesis. However the development of adjacent-level degeneration has been described in many studies as late effect after lumbar spine fusion. The hybrid system topping off was invented to prevent the manifestation of the adjacent-level degeneration. This system includes a rigid spondylodesis and a flexible instrumentation of the adjacent-level. Purpose of this study is the assessment of clinical and radiological outcome. **Material and Methods:** In this prognostic prospective study have been patients included with a degenerative disease of the lumbar spine or spondylolisthesis with an indication for a lumbar fusion and additionally radiological signs of degeneration in the adjacent segment without instability (Pfirrmann Grad 2-4). Exclusion criteria were previous surgery of the lumbar spine and no disc degeneration in the MRI in the adjacent segment. All patients were treated with a monosegmental lumbar interbody fusion and dynamic Stabilization (topping off) of the cranial adjacent level (CD HORIZON BalanC™ rod System Fa. Medtronic plc, Dublin, Irland). The patients were subjected to clinical examination and radiographs pre-operatively and one year after the operation. The assessment of the clinical data has been obtained on the basis of the German spine register using the COMI score and VAS score for back- and leg-pain. The statistical program SPSS (Version 22.76 Chicago, IL, USA) was used for the evaluation of the

data. **Results:** In the study have been 21 patients (5 male and 16 female) included. The average age of the patients was 58.9 ± 10.8 (min: 41, max: 78) years old. The average COMI score pre-operatively was 9.0 ± 0.9 (min: 6.7, max: 10.0). In the one-year-follow-up the average COMI score was 4.3 ± 2.4 (min: 0.0, max: 7.5). The results prove a significant reduction of the COMI score in the one-year-follow-up ($P = .000$). The average pre-operatively VAS was for back-pain 7.6 ± 2.4 (min: 0, max: 10) and for leg-pain 6.9 ± 2.9 (min: 0, max: 10). In the one-year-follow-up the VAS for back-pain was 4.3 ± 2.4 (min: 0, max: 8) and for leg-pain 2.3 ± 3.1 (min: 0, max: 8). Both VAS back- and leg-pain showed a significant reduction in the 1-year follow-up ($P = .000$). No radiological signs for adjacent-level degeneration have been observed in the one-year-follow-up. A fatigue fracture of the dynamic topping off material was verified in 4 cases (3 female and 1 male) during the follow-up. **Conclusion:** Biomechanical studies report about reduced stress forces to the adjacent-level after lumbar spinal fusions with the topping off system. However it is being implied that the topping off segment is with a high rigidity combined. Moreover the instrumentation of an additional segment is associated to higher operation morbidity. Our results demonstrate a significant improvement of the clinical outcome and reduction of the pain after lumbar spinal fusion with topping off, one year after the procedure. Our results are similar to standard lumbar fusion according to the literature one year after the operation. Due to the high rate of implant failure this implant is not being used anymore in our clinic.

A018: Spino-Pelvic Malalignment In Adjacent Segment Disease Developing After Lumbar Fusion

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Introduction: Spinal segment arthrodesis has become a widely accepted treatment for degenerative disorders of the lumbar spine. For today rigid internal fixation with 360° fusion has been viewed as the gold standard for spine stabilizing surgery. However spinal fusion alters the normal biomechanics of the spine and eliminates mobile segments causing overload of adjacent segments. At the same time many patients with degenerative disorders have abnormalities of spino-pelvic parameters, which remain postop. Thus, spinal fusion, according to some authors can accelerate the degeneration of adjacent segments, especially under unfavorable biomechanics of the spine. **Material and Methods:** This retrospective study evaluated 76 patients underwent 360° short fusion lumbar surgery (one and two levels) from 2008 to 2013 for the treatment of degenerative conditions of the lumbar spine. The patients were divided into two groups depending on the presence of symptomatic ASD: first group include 36 patients with symptomatic ASD during 3 years postop, second (control) group include 40 patients with no signs of symptomatic adjacent segment disease. There were 66% females. Mean age of 54 years (range 21-76). Mean follow-up of 4 years (3-7 years). Long cassette standing anteroposterior and lateral radiographs were performed on the preoperative, postoperative and follow-up visits. In all cases we studied preop, postop, and f/up sagittal plane alignment according to Schwab sagittal modifiers. **Results:** In the I group symptomatic ASD was found in 14 cases (38.9%) during 1 year follow-up. There were 6 cases (42.9%) with sagittal imbalance and 11 cases (78.6%) with the difference between pelvic incidence and lumbar lordosis (PI-LL) more than 11°. Summary after 3 years f/up in I group sagittal imbalance was diagnosed in 23 cases (63.9%), in 26 patients (72.2%) PI-LL was above or equal to 11°. Average postop SVA in the I group was + 6.2 cm, average PI-LL mismatch was 13.2°. 86% of the I group patients required revision surgery. In the II group at 3 year f/up sagittal imbalance was identified in 11 patients (27.5%) with average SVA + 2,8 cm. PI-LL above or equal to 11° was found in 10 cases (25%), average value for the II group patients was 8.1°. **Conclusion:** Patients with spino-pelvic alignment disturbances such as sagittal imbalance and PI-LL mismatch have statistically significant increasing risks of developing ASD because of overloading the adjacent segments under unfavorable biomechanics of the spine.

Minimally Invasive Spine Surgery Lumbar

A019: Long Term Fusion Rates and Predictors for Reoperation in Patients with and without Preoperative Degenerative Lumbar Spondylolisthesis following Minimally Invasive Decompression for Lumbar Spinal Stenosis

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Introduction: Minimally invasive decompression (MID) is an effective and safe procedure for lumbar spinal stenosis (LSS). In short-to-moderate term follow-up studies, (ie, <4-5 years) fusion rates have been shown to be lower with similar functional improvement compared to conventional open laminectomy. However, long term follow-up data is still missing. The primary objective of this retrospective cohort study was to evaluate predictors and long-term rates for reoperation in patients with LSS who underwent a MID, stratified for degenerative lumbar spondylolisthesis (DLS). **Material and Methods:** All consecutive patients with LSS with and without grade 1 DLS who had undergone MID between 2002 and 2011

were included in this analysis. The same technique was utilized by the senior author for all patients with neurogenic claudication/mechanical radiculopathy (ie, leg-dominant symptoms that were relieved by postural change and/or rest), no (or tolerable) mechanical back pain, and those with up to a 25% (grade I) spondylolisthesis, and no obvious dynamic instability on imaging. Radiographic dynamic instability was defined as an increase in spondylolisthesis by 4–5 mm or more demonstrated on supine to standing or flexion-extension imaging. Demographic, perioperative, and radiographic data were collected. Reoperation rates defined as any operation on the same or adjacent level were assessed. Revision decompression alone was considered if the aforementioned clinical and radiographic criteria were met, otherwise patient underwent a minimally invasive posterior fusion at revision. Clinical outcome was evaluated using the Oswestry Disability Index (ODI) and visual analog scale (VAS) scores. **Results:** Two-hundred forty-seven patients (mean age 66 years [20 − 88] at the time of the initial surgery) were included. The majority of patients (68.7%) underwent one level decompression. The most common decompressed level was L4-5 (47.2%). Preoperative spondylolisthesis at the level of spinal stenosis was present in 56.9%. Mean follow-up period was 8.2 years [5.0 −14.9]. The overall reoperation rate was 15.8% of which a fusion rate of 6.9% (4.1% vs. 2.8% in patients with and without spondylolisthesis, $P = .546$). The mean time to reoperation in patients with and without spondylolisthesis was 3.9 years [95%CI 1.8 − 6.0] and 2.8 years [95%CI 1.3 − 4.2], respectively for decompression only, and 3.1 years [95%CI 1.0 − 5.3] and 3.1 years [95%CI 1.1 − 5.1], respectively for fusion. At the 5-years follow-up point, no significant difference in the mean improvement of the ODI, VAS leg, and VAS back was observed in patients with and without spondylolisthesis. Logistic regression stratified for spondylolisthesis showed none of the investigated variables (age, gender, Body mass index, level or number of decompression, pelvic incidence, lumbar lordosis, facet angle, baseline VAS leg, VAS back and ODI) were predictive for overall reoperation or fusion at revision. **Conclusions:** Minimally invasive decompression is an effective and durable procedure for the treatment of LSS with or without stable DLS with similar reoperation rates compared to historical data. Using the abovementioned criteria, there were no independent predictors of reoperation following MID in stable DLS.

A020: Minimally Invasive Transforaminal Lumbar Interbody Fusion with Intraoperative CT-Based Spinal Navigation: A Prospective Cohort of 40 Cases

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Introduction: Minimally invasive transforaminal interbody fusion is nowadays a very popular technique. Potential advantages include reduced blood loss, shorter length of stay, and less soft-tissue trauma. Potential disadvantages include increased radiation exposure, longer operative times, and higher risk of screw malpositioning related to a inadequate visualization of anatomical landmarks. Spinal navigation could theoretically improve results with this technique, increasing accuracy during percutaneous screw positioning, decreasing operative time and radiation exposure for both surgeons and patients. We report results on a cohort of 40 operated patients, where we performed mini-open transforaminal interbody fusion (TLIF) at lumbar levels using spinal navigation coupled with an intraoperative mobile CT (iCT-AIRO®), without any use of fluoroscopy, except for the final control of cage position at interbody level. **Material and Methods:** Series includes 40 cases submitted to mini-open TLIF with 22 mm tubular retractors. All patients were affected by a degenerative disease of the spine, at one or two levels, with monolateral radicular pain. In every case decompression and cage positioning were performed without complications through tubular retractor. Screws were positioned percutaneously, before decompression and cage positioning, using iCT-based spinal navigation, without any use of fluoroscopy. Screw position was checked immediately after positioning. **Results:** There were 26 men and 14 women, with a mean age of 60 years (36-84). Thirty-six patients were operated by the same surgeon (PS). Six patients underwent a 2-level procedure. Mean follow-up was 10.5 months. We did not observe any neurological complications. Position of screws was optimal in every case, without any screw repositioning during surgery. Mean duration of surgery was 229 minutes. Surgical times reduced significantly in recent operated cases. No patient was reoperated during follow-up. At radiological analysis, 98% of screws were correctly placed in the pedicle (Heary grade 1). No screw was graded 4 or 5. Mean effective dose for patient was under 15 mSV, and not significantly higher than our previous experience with another imaging method (O-arm). This dose compared very favourably with reported dose for fluoroscopic assisted mini-TLIF.[1] Mean number of intraoperative scans was 2. **Conclusion:** In a recent paper, Ruatti et al.[2] showed a rate of malpositioned screws higher than 20% using spinal navigation for percutaneous screws. This rate was significantly lower with open technique. Use of spinal navigation coupled with an intraoperative CT significantly augmented, in our experience, accuracy in percutaneous screw positioning, compared with spinal navigation associated with a cone-beam CT (O-arm) or with traditional technique with fluoroscopic control. Reasons for this improvement are different, mostly related with a more stable positioning of the reference star on the iliac crest, and with a better quality of intraoperative imaging. In our series, there was significantly less radiation exposure for the surgical team.

Surgical times were significantly higher than traditional open technique without navigation.

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A021: Clinical and Radiological Outcomes of InterFuse-S, A New Modular PLIF, in Patients with Lumbar Disc Herniation

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Introduction: One concern about posterolateral interbody fusion (PLIF) implants is the insufficient primary stability that impacts negatively on fusion rate, increases the chance of subsidence with loss of segmental lordosis. To avoid posterior migration, PLIF also needs to be supplemented with pedicle screws increasing the costs and the surgical complications. Recently, a novel modular PLIF assembled intraoperatively by a rail-and-slot design into the disc space, InterFuse STM, has become available. It can be inserted through the small annulus opening of a classical microdiscectomy, without further facet joint resection preventing the potential for postoperative instability. Once implanted, it provides the largest surface area for load-sharing even when compared to anteriorly inserted cages. The aim of this study is to evaluate the feasibility, safety and outcomes using stand-alone Interfuse-S. We hypothesized that the increased surface area can adequately promote fusion, segmental lordosis with good clinical results obviating the need to add transpedicular screws. **Material and Methods**: Ten consecutive patients, 5 males and 5 females, with extruded lumbar disc herniation underwent PLIF with InterFuse STM. No pedicle screw fixation was performed. Median age was 37.6 years (range 22-46). All patients underwent a single–level procedure (8 patients at L5-S1, 2 patient at L4-5). The indications were extruded lumbar disc herniation. **Results**: No surgical complications or neurological deficits were noted, as reflected in a mean hospitalization of 2.3 days. At 12 months FU, mean back VAS decreased from 7 to 2 ($P < .01$) and leg pain resolved in all patients ($P < .01$). A 100% rate of successful fusion was observed. No cases of implant subsidence or breakage were found. Segmental lordosis was observed in all patients. There was one case of posterior migration that conducted to revision surgery in an obese and heavy lifter patient. **Conclusions**: Stand-alone PLIF with InterFuse STM is a feasible and safe technique compared to conventional PLIF or TLIF in young patients with lumbar disc herniation, without compromising clinical and radiological outcomes. With a less invasive approach, adequate end-plate coverage was obtained with slight root traction and minimal facet joint resection, due to the small size of the single modules. A large footprint reduces the possibility of implant subsidence and migration even when used as a stand-alone implant without posterior stabilization.

A022: Minimally Invasive Transforaminal Lumbar Interbody Fusion and Instrumentation (MIS-TLIF) for the Treatment of Lumbar Isthmic Spondylol Isthesis: Minimum 2-Years Follow-up with Clinical and Radiological Outcomes

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Introduction: To explore the clinical and radiological outcomes of MIS-TLIF in the treatment of lumbar isthmic spondylolisthesis. **Material and Methods:** 32 patients with lumbar isthmic spondylolisthesis underwent MIS-TLIF by the same surgeon in single institution. There were 14 males and 18 females with an average age of 47.5 years old. 21 cases were rated as degree I, 11 as degree II. The surgery, including bilateral decompression, discectomy for neurological relief, interbody fusion, cage insertion and fixation with pedicle screw, was conducted through a small paraspinal incision and assisted with the Quadrant system. VAS and ODI were adopted to evaluate the clinical manifestation pre- and postoperative. The pre- and postoperative spinopelvic parameters including PI sacral slope, PT, LL, and sagittal vertical axis from C7 plumb line were evaluated. **Results:** The average follow-up period was 29.6 (24-72) months. The scores of VAS and ODI after sugery and at the final follow-up were lower than those bofere sugeryc ($P < .05$). The height of intervertebral space after surgery and at the final follow-upincreased significantly compared with that before surgery ($P < .05$). All operated vertebral segments achieved solid bony fusion at the follow-up of 6.5 months postoperatively. The slip degree, slip angle, and HOD improved significantly. Pelvic parameters and sagittal balance improved subsequently. SS was increased by 4.5 degrees, and PT was decreased by 4.5 degrees. LL was increased by 5.0 degrees and sagittal balance was displaced 5.4 mm backward. **Conclusion:** MIS-TLIF may be an easy and safe way in the treatment of lumbar isthmic spondylolisthesis. With local deformity corrected after surgery, all spinopelvic parameters changed subsequently.

A023: Pure Lateral and Oblique Lateral Inter-body Fusion for Treatment of Lumbar Degenerative Disk Disease: Comparison of Two Different Techniques

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Introduction: Inter-body fusion techniques for degenerative disk disease (DDD) are still a controversial indication in the current literature. Although good clinical results have been reported in several randomized clinical trials for a variety of fusion procedures, the lack of clear indications in the treatment of lumbar DDD and the opportunity to fuse may be partially attributed to the invasiveness of open surgical approaches, which often seem to be overly aggressive procedures for a disease that has been shown to benefit even from conservative treatment. Nevertheless, the emerging diffusion of minimally invasive spine techniques, such as LIF or OLIF, is progressively changing the indication for treating patients with lumbar DDD because they can achieve mono- or plurisegmental interbody fusion, allowing much faster recovery with a very low rate of complications. **Materials and Methods:** Between January 2010 and September 2015, at our institution, 45 patients (67 levels) underwent lumbar interbody fusion for pure lumbar DDD above the level of L5–S1 through both pure lateral trans-psoas approach (LIF) (n = 31) or oblique lateral retroperitoneal approach (OLIF) (n = 14). Preoperative radiological evaluation included lumbar MRI, CT scan, and dynamic X-rays. Inclusion criteria were chronic axial low back pain exacerbated by prolonged standing and trunk mobility and previous conservative treatment for a period of at least 6 months failed. Patients with radiologically demonstrated frank segmental instability and/or frank radicular conflict and/or those with lumbar stenosis due to spondilosis, were excluded from the study. Only patients with at least 6 months of follow-up were included in the analysis. Clinico-neurological evaluations with VAS, ODI, and SF-36 tests were routinely performed before the intervention and repeated at follow-up to evaluate the clinical course and quality of life. Statistical analyses were performed using SPSS version 15 software (Chicago, IL, USA). $P < .01$ was considered significant. **Results:** The total levels treated are 67: L2-L3 in 7 cases (10.4%, 6 in the LIF group and 1 in the OLIF), L3–L4 in 31 cases (46.3%, 28 LIF and 3 OLIF), L4–L5 in 21 cases (31.3%, 15 LIF and 6 OLIF) finally L5-S1 in 8 cases (12.0%, all in the OLIF group). Only two intraoperative complications happened without further events: one patient of the OLIF group presented the rupture of the left common iliac vein due to the blades of surgical retractor, and one patient of the LIF group presented a peritoneal laceration; both the complications were successfully treated. In the post-operative period, 21 patients (46.6%, 19 in the LIF group and 1 in the OLIF group) presented motor deficit (3/5 motor) in the ankle flexion associated to a dysesthesia at the territory of L3 and L4. These symptoms had a progressive resolution within 4 to 6 weeks. 5 patients of the LIF group presented a psoas hematomas, which needed 4 days of bedrest. Two patients of the LIF group presented an L4 palsy with a partial resolution in 1 year. In the OLIF group, 7 patients of the oLIF group presented a fluid retroperitoneal collection which did not require ani treatment in any case and one patient presented persistent pain at the surgical side. Regarding the clinical evaluation with the VAS scale, ODI and SF-36 all the patients presented good results at the final follow-up. In the VAS scale appear a difference of 1.27 points between the LIF and the OLIF group in the post-operative period. Similar results are presents in the ODI where the mean difference result of 7.3%, and in the SF-36 tests where regarding the physical scale the difference results of 6.22 points and in the mental scale the difference of 1.55 points in favor of LIF group. **Conclusions:** LIF and OLIF represent mini-invasive procedures for treatment of lumbar DDD. Although generally considered more complex compared to traditional posterior procedures, they are safe and effective, allowing the resolution of disk pain with short hospitalization and fast daily activity recovery. The selection of patients and a good preoperative planning, seem to be detrimental factors to obtain good clinical results.

A024: The Benefits of Minimally Invasive Posterior Lumbar Interbody Fusion in Degenerative Lumbar Spondylolisthesis

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Introduction: The use of minimally invasive surgical (MIS) procedures for the treatment of degenerative lumbar spondylolisthesis is increasing although the outcomes of standard open posterior lumbar fusion surgery remain efficient. The question remains what exactly are the benefits of MIS procedures. The aim of the study was to determine the difference between minimally invasive TLIF (MI-TLIF) results and open TLIF procedures regarding the clinical outcomes, perioperative parameters, fusion rate and adverse events. **Materials And Methods:** In the study, 30 patients with the painful, lumbar degenerative spondylolisthesis (Grade I) not responding to conservative treatment were treated with the open TLIF procedure and 30 patients with minimally invasive TLIF procedure. Clinical outcomes were assessed before, 6 months, one year and two years after the procedure using the Oswestry Disability

Index (ODI) and Visual analogue score (VAS) for back and leg pain, with 15% improvement in ODI and 20% in VAS defined as a clinically significant. The perioperative parameters including blood loss, operative times, exposure to fluoroscopy and length of hospital stay were evaluated. The CT scans of the patients were taken accordingly in order to determine the fusion rate. **Results:** There was a significant improvement for back and leg pain according to ODI and VAS score in both groups with no statistically important difference between the two groups. There was less blood loss and faster recovery time in the MI-TLIF group but higher fluoroscopic exposure and slightly higher length of the surgeries. The fusion rate was the same in the open and MI-TLIF group. **Conclusions:** Both procedures resulted in significant pain reduction and good functional outcome for the patients with better results in the MI-TLIF group regarding the hospital stay and blood loss. According to our results and according to the literature reviews there is still not enough evidence to state that one procedure is superior to other. In time, the MIS procedure might slowly replace the open technique.

Adult Deformity 1

A025: External Validation of MiSLAT Algorithm and Role of XLIF in Management of Adult Degenerative Deformity of Spine

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Introduction: Surgical goals in adult degenerative scoliosis patients are to reduce pain, correct and prevent further deterioration of deformity, restore coronal and sagittal plane balance. Open long segment reconstructions are associated with high complication rates. In view to reduce surgical morbidity, minimally invasive surgeries have been recommended. However, not all adult spinal deformities can be treated with minimally invasive techniques. Several classifications and treatment levels have been recommended. One such algorithm is MiSLAT treatment level. Aim of our study was to assess the external validity of MiSLAT algorithm and to assess the role of XLIF in management of adult degenerative deformity of spine. **Material and Methods:** This was a prospective interventional case series from of patients with symptomatic adjacent segment disease, localised and generalised degenerative deformity of spine who underwent XLIF procedure. MiSLAT algorithm was used to decide treatment level for patients. Pre and post-operative patient reported outcome measures like ODI, VAS score, EQ VAS, EQ-5D index were recorded. Radiological parameters like Cobb angle, lumbar lordosis, pelvic tilt, sacral slope and pelvic incidence were analysed pre and post operatively. Complications rate was reviewed. **Results:** 41 patients had XLIF from May 2012 to January 2016. There were 17 males and 24 females. Mean age at surgery was 61.8 years (range 50 – 94) with a mean follow up of 20.46 months (range 7 – 51). Twelve patients were operated for adjacent segment disease, 13 for localised deformity and remaining 16 for generalised deformity. Among 13 localised deformities, there were 3, 9 and 1 patients with MisLAT type II, III and IV classification respectively. Sixteen of generalised deformity group included 10, 1, 5 patients with MisLAT type IV, V and VI respectively. There was statistical significant difference between pre and post-operative ODI, VAS score, EQ VAS, EQ-5D index. Mean pre and post-operative scoliosis and lumbar lordosis in localised deformity was 11, 23.6 degrees and zero, 28.6 degrees respectively. In generalised deformity group, pre and post-operative scoliosis, lumbar lordosis and pelvic tilt were 27, 14.7, 37 degrees and 12, 34, 16.3 degrees respectively. There were 11 complications (26.8%), including two femoral nerve palsies and one death from pulmonary embolism. The reoperation rate was 4.8% (2 patients) for non-union. **Conclusions:** XLIF can be used as surgical tool in MiSLAT types II, III and IV deformities, whereas for MiSLAT types V and VI, XLIF can be used in conjunction with open techniques to correct deformity. MiSLAT algorithm can be used safely to guide management plan in adult degenerative deformity of spine. In addition, XLIF has lower complication rates compared to other open surgeries mentioned in literature to date.

A026: Do Different Types of UIV Instrument Impact Acute Proximal Junctional Failure (Acute PJF) following Adult Spinal Deformity Surgery? PS vs. Hook

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Introduction: Some studies have indicated PS fixation at UIV is thought to be a possible risk factor of PJF. The purpose of this study was to retrospectively compare the incidence of acute PJF between transverse hook fixation at UIV and PS following ASD surgery. **Methods**: Forty-seven ASD patients who underwent corrective surgery by a single surgeon were retrospectively reviewed with a minimum 1-year follow-up. The mean age was 67.6 years old (42-83) and the follow-up period was 36.9 months (12-95). T9 as UIV was selected in 17 patients and T10 in 30 patients. Transverse hook was used in 26 patients, and PS was used in 21 patients. Radiographic parameters including SVA, PI-LL, PT, and proximal junctional angle (PJA) were measured before surgery (PreO) and latest follow-up period (PO). Fracture risk was also evaluated using FRAX (WHO Fracture Risk Assessment Tool) before surgery. Acute PJF was defined as UIV and UIV+1 fracture, implant failure or PJK > 15° within the first six months. We compared the several data between the hook group and the PS group with

statistical software. **Results:** The hook group had an acute PJF rate of 19.2% compared to 28.5% in the PS group ($P = .20$). The mechanisms of acute PJF are as follows; there were 4 patients with UIV fracture and 1 patient with implant failures in the hook group, and there were 6patients with UIV fracture in the PS group. Radiographic parameters in the hook group (PreO/PO) were following; SVA; 119.1/39.1 mm, PI-LL; 46.4/4.6°, and PT;35.8/21.9°. Those in the PS group were as follows; SVA; 92.3/37.3 mm, PI-LL; 37.6/4.5°, and PT;31.9/21.8°. FRAX were 13.7% in the hook group and 13.4% in the PS group. There were no differences in baseline data between the two groups. However, the changes of PJA in the PS group were significantly higher than those in the hook group (7.4/2.9°; $P = .05$). To analyze the PJA data in the patients with Acute PJF, the changes of PJA were significantly higher in the PS group than those in the hook group (17.0/6.3°; $P = .04$). **Conclusion:** Our study doesn't show that transverse hook as UIV instrument can prevent acute PJF. However, using hook at UIV can prevent the vertebral collapse if UIV fracture occurs. The increased risk of collapse of UIV fracture in the PS group in this study may due to higher mechanical load to UIV using PS. Further biomechanical study should be necessary to clarify our results.

A027: Towards Global Standardisation of Measuring Outcomes in Adult Spinal Deformity Surgery

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Introduction: Adult Spinal Deformity (ASD) causes severe functional disability, reducing the overall quality of life. In view of the growing ASD population, routine monitoring of outcomes covering the overall quality of life, functioning, and disability from a patient's perspective, will play an important role in future reimbursement and healthcare systems.[1,2] In this era of value based care, healthcare providers are putting more emphasis into assessing the value (health gain per unit cost) of treatment provided. In particular for ASD surgery, where a tremendous treatment variability exists, outcome monitoring by means of outcome registries would be of value. However, outcome registries are most valuable if they are comparable between countries and include outcomes that are relevant to the patient population of interest.[3] Standardising patient-reported outcomes (PROs) is a key first step; however, this can only achieve its maximum benefit when the measures used are uniform, valid, reliable and risk-adjusted. Therefore, the aim of this study is to highlight the current strengths, weaknesses and gaps in PROs used for assessment of ASD, to provide recommendations for future improvements, and to serve as a foundation for the process of seeking global consensus on standardising outcomes measures in future clinical trials and spine registries worldwide. **Material and Methods:** This study ultimately consists of three phases: 1) a systematic review of patient-reported outcome used to evaluate outcomes after ASD surgery. We used the domains of the WHO International Classification of Disability, Functioning and Health (ICF) as a framework. 2) a modified five-round Delphi study among international experts starting April 2017, and 3) validation with patient focus groups. **Results**: Phase 1. The systematic review identified 144 papers that met inclusion criteria, and nine frequently used PROs were identified, such as the ODI, SRS-22 and VAS. These measured 29 potential ICF outcome domains, which could be grouped into 3 of the 4 main ICF chapters: body function (n = 7), activity and participation (n = 19), and environmental factors (n = 3). The three most frequently measured outcome domains are: 'sensation of pain', 'recreation and leisure', and 'walking'. **Conclusion:** Outcome domains related to 'mobility' and 'pain' are represented well by PROs used in the current literature. Outcomes related to 'neurological function' and 'pulmonary function', both significantly affected by ASD surgery, are currently not reported.[4,5] These findings indicate that currently used PROs may be inadequate to measure all relevant outcomes in ASD patients. In order to achieve a standardised approach and improvement of individual patient evaluation, consensus on a core set of outcome domains for ASD is urgently needed. In phase 2, using a modified Delphi method, the results of this preparatory study will provide the foundation for the development of a global set of core domains, measurement instruments (patient-reported and clinician-based) and contributing factors to these outcomes. The development of this core outcome set will facilitate comparisons across studies, registries, and nations in order to improve the quality of daily clinical practice in this increasing group of patients, with an increasing burden on society.

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Deformity Surgery: Minimum Two-Year Follow-up. *J. Bone Jt. Surg.* 97, 32–39 (2015).

A028: Outcomes in Primary Adult Deformity Surgery: What Happens to Patients Who Are Lost to Follow-up?

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Introduction: Loss to follow up is highly prevalent after orthopedic surgery. Measuring clinical outcomes after surgery is important to guide an evidence-based approach to care. Loss to follow-up in randomized control trials or clinical registries may present a bias to assessing the efficacy of treatments and reduce the statistical power of study results. Current literature fails to demonstrate the effect of loss to follow up in clinical outcomes studies for ASD. The purpose of this paper is to report the reasons that patients lost to follow-up did not follow-up and the outcomes of care in these patients. **Material and Methods:** A survey was administered remotely to study a consecutive series of patients who were lost to follow up at greater than one year after being treated with primary multilevel spinal fusion with pelvic fixation for ASD. Patients were excluded if they declined participation or were deceased. Demographic, surgical, and health related quality of life data were collected directly from administrative and medical ontologies. All records were chart reviewed and source verified for accuracy. Four patients were excluded from the study as they were deceased and three patients declined participation in the phone survey. **Results:** The cohort included 38 patients who were not seen in clinic at one year or greater from their index surgery and 45 patients who followed-up routinely. There was no significant difference in patient reported outcomes between those who followed up and those who were lost to follow up ($P = .97$). The average improvement in EQ-5D utility score for those lost to follow up was 0.15 while those who followed-up regularly experienced a mean change of 0.17. Mean length of follow up for all patients was 911 days. Patients lost to follow up had significantly lower revision surgery rates than those who followed up ($P = .03$). All elective revision surgeries on patients lost to follow up were performed by the same surgeon within one year of their index operation. One emergency revision surgery was performed at an outside hospital after a patient was admitted directly from their local ED. ASA scores were significantly higher in patients who were lost to follow up ($P = .01$). BMI was also a significant predictor of loss to follow up ($P = .05$). Reasons for not following up in clinic included: I was not offered an appointment (n = 8), I feel good (n = 7), I stay in touch remotely (n = 7), I live too far away (n = 7), I plan to come in soon (n = 6), I was disappointed with my results (n = 5), my surgeon left the institution (n = 4), I see a doctor at home (n = 3), and I didn't want to find out I need another surgery (n = 1). **Conclusion:** There are many barriers to follow up from both a patient and a provider's point of view. Patients who are lost to follow up at greater than one year have similar outcomes as those who follow up in clinic at routine intervals. Advances in telehealth should be directed towards facilitating patient monitoring and the collection of patient reported outcomes after surgery.

A029: Complication Rate in Adult Deformity Surgical Treatment: Safety of the Posterior Osteotomies

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Introduction: The treatment of adult scoliosis is a continuous challenge even for expert spinal surgeons especially in patients over 50 years old. In some adult patients who present with severe, rigid curves, the use of vertebral osteotomies may be necessary to achieve adequate correction of the deformity. Several general and neurologic complications have been reported, in particular associated with PSO. The aim of this study was to report and analyse the perioperative complications and radiographical results in elderly patients undergoing vertebral osteotomies for spinal deformity correction. **Materials and Methods:** Our population was composed of 72 consecutive cases of kyphoscoliosis with different sagittal imbalance situations. All patients were classified according to *Berjano-Lamartina classification*; they were divided into two groups according to the corrective osteotomies they underwent: we only practiced SPO and/or PO in patients that composed group A; we practiced also PSO in patients that composed group B. We retrospectively reported and analysed the perioperative complications. An independent observer collected for each patient on X-rays the following data: Cobb angle, pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), lumbar lordosis (LL), thoracic kyphosis (TK), C7 plumb line (C7PL). The average follow-up was 30 months. **Results:** The mean age of our study group was 60.7 ± 10.2 years and the median age of 62 years (range: 42 – 82 years old). We had 50 cases of degenerative (spinal) segment diseases (DSD) Type III, 13 cases of Type IVa DSD and 9 cases of Type IVb DSD. Our overall complication rate was 22.2% (16/72 patients). Patients we treated with SPO and/or PO had a complication rate of 16.9% (10/59 patients) wile patients we treated also with PSO had a complication rate of 46.2% (6/13 patients). The mean Cobb primary curve angle of the cohort was $41.75° \pm 18.06$, residual scoliosis after surgery was $15.41° \pm 10.7$; the difference between the pre-operative and post-operative Cobb angles

was statistically significant ($P < .001$). We found a pre-operative C7PL average value of 4.49 cm ($\pm$4.82), while the post-operative one was 2.08 cm ($\pm$3.44), with statistically significant difference. **Discussion:** The surgical treatment of adult deformities is a challenge also because of the high incidence rate of general and mechanical complications reported in the literature. The posterior surgery necessitates a major multilevel arthrodesis procedure be performed also by using different osteotomies techniques. Previous studies have shown increased complication rates with fusion procedures in elderly patients and our experience support this evidence. Our clinical and radiographic study demonstrates an high incidence of intraoperative complications rate in elderly patients underwent a PSO. **Conclusions:** PSO is a very useful technique to treat rigid high-grade spinal deformity of the adult but patients who undergo a PSO are at high risk of complications. Our experience demonstrates that patients over 60 with degenerative spinal deformity and sagittal imbalance candidate to a pedicular subtraction osteotomy have 46% of complications rate. PSO is a demanding technique to be considered in very selected and motivated patients who must be carefully informed about the risks of the procedure.

A030: Adult Spinal Deformity over 70 Years of Age: A Two-Years Follow-up Study

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Introduction: Decision making in adult spinal deformity (ASD) is one of the most difficult issue in estimating the effects of complications on the outcomes of treatment, especially for surgery in elderly population. The aim of this study was to analyze the decisive factors leading to the specific treatment modalities (i.e., operative vs. non-operative) by comparing the baseline characteristics of operative vs. non-operative patients with ASD over 70 years of age. Moreover, to evaluate the safety and efficacy of surgery; and to compare operative and non-operative management of patients with ASD over 70 years of age even with the setting of complications with a follow-up period of 2 years. **Materials and Methods:** A retrospective review of collected data from a multicenter database on ASD was performed. Patients over 70 years of age with spinal deformities who were scheduled to undergo surgical treatment and who were treated and/or followed without surgical intervention, participated in this study. Demographic, clinical, surgical, radiological features and HRQOL (SF-36 MCS, SF36-PCS, SRS-22 and ODI) parameters of such group of patients were evaluated pre and post-treatment. Peri/postoperative complications, classified as major (life threatening or requiring additional surgery) and minor were also investigated for their effects on HRQOL parameters at 2 years follow-up. **Results:** The database had 181 patients (F: 151, M: 30) entry for both operative (n = 85) and non-operative (n = 96) group over 70 years of age with ASD. Of these, 90 of them (F: 71, M: 29; operative: 61, non-operative: 29) had 2-years follow-up. The comparison between operative and non-operative group for demographic, clinical, radiological and HRQOL parameters at baseline showed statistical significance for all the HRQOL parameters, some of the radiological features including; major coronal Cobb angle, proximal thoracic, main thoracic, thoracolumbar and lumbosacral curves; and SRS-Schwab Curve type ($P < .05$). The calculated optimal cut-off values to diverge operative and non-operative groups for COMI, ODI, SF-36 PCS and SRS-22 were 5.7, 37.0, 37.5 and 3.2, respectively ($P < .05$). All operative patients (n = 61; F: 46, M: 15) were treated with posterior surgery. A total of 39 osteotomies and 24 interbody fusions were performed. Overall, 135 complications (71 major, 64 minor) and 1 death were observed. The reoperation rate was calculated as 62.3% at the end of 2 years. For all HRQOL parameters except SF-36 MCS, surgically treated patients significantly improved by means of HRQOL parameters two years after the surgery even with the setting of complications ($P < .05$). **Conclusion:** This study has demonstrated that surgery provides significant improvements in pain, disability and body perception in patients with ASD over 70 years of age with a follow-up of 2 years, even with the setting of complications.

Navigation

A031: Comparison Peri-operative Factors during Minimally Invasive Pre-psoas Lateral Interbody Fusion of the Lumbar Spine using Either Navigation or Conventional Fluoroscopy

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Introduction: The OLIF has widely been applied in the treatment of degenerative diseases of the lumbar spine. In this operation, fluoroscopic guidance is most often used; however, navigation has been shown to improve the accuracy of implant

placement and reduce radiation exposure. The aim of this study is to compare intraoperative conditions and clinical results of patients undergoing pre-psoas oblique lateral interbody fusion (OLIF) using navigation or conventional fluoroscopy (C-ARM) techniques. **Material and Methods:** Patients underwent the OLIF procedure at two tertiary care medical centers, and records were reviewed. Forty two patients were identified; 22 patients underwent the OLIF with navigation, and 20 underwent the procedure with fluoroscopy. Operating time, estimated blood loss, length of hospitalization, surgery-related complications, total radiation exposure and total radiation time were recorded and compared between the 2 groups. Clinical outcomes according to the Smiley-Webster Scale were evaluated. Patients were followed up with a range of 6 to 24 months. **Results:** There were no significant differences between groups with respect to mean age, gender, weight, primary diagnosis and surgical procedures. The navigation group had zero radiation exposure to the surgeon and radiation time compared to the C-ARM group, with total radiation exposure of 44.59 $\pm$ 26.65 mGy and radiation time of 88.30 $\pm$ 58.28 seconds ($P < .05$). For the radiation exposure to the patient, it was significantly lower in the O-ARM group (9.38 mGy) compared to the C-ARM group (44.59 $\pm$ 26.65 mGy). Operating room time was slightly longer in the navigation group (2.49 $\pm$ 1.35 h) compared to the C-ARM group (2.30 $\pm$ 1.17 h) ($P > .05$), although not statistically significant. No differences were found in estimated blood loss, length of hospitalization, surgery-related complications and outcome scores with an average of 8 month follow up. **Conclusion:** Compared with C-ARM techniques, using navigation can eliminate radiation exposure to surgeon and decrease radiation exposure to the patient, and it had no significant effect on operating time, estimated blood loss, length of hospitalization, or peri-operative complications in the patients with OLIF procedure. This study shows that navigation is a safe alternative to fluoroscopy during the OLIF procedure in the treatment of degenerative lumbar conditions.

A032: Cervical Pedicle Screw Instrumentation: Analysis of Placement Accuracy with O-Arm Based Navigation

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Introduction: Despite superior biomechanical properties, the use of pedicle screws in cervical spine remains limited due to technical difficulties and high complication rates. The purpose of this study is to evaluate the usefulness and limitations of navigation technologies incorporating intra-operative 3D-imaging with O-arms in accurate placement of cervical pedicle screws. **Material and Methods:** A total of 38 patients who underwent cervical pedicle screw instrumentation by single surgeon were included in the study. All the pedicle screws were placed using the same 3D-Navigation system. Intraoperative 3D-images were obtained before and after placement of screws and results were evaluated. **Results:** The study included analysis of 202 cervical pedicle screws inserted in 38 patients. The indications for surgery included trauma, degenerative spine disease, tumor and infection. Out of the 202 screws, 170 (84.16%) were inserted at the level of C3-C6 vertebrae, followed by 20 (9.9%) and 12 (5.94%) screws at C2 and C7 vertebrae, respectively. After analsysis of screw placement as per Gertzbein Classification, the overall breach rate was found to be 8.4% (17 screws) with 58.82% grade I, 41.18% grade II and nil grade III screw breaches. All the breaches were lateral with highest breach rate at C5 (12.5%) followed by C6 (11.9%) vertebral level. Despite breaches, there were no neurovascular complications due to placement of any of the pedicle screw. **Conclusion:** The use of intra-operative 3D scans for navigation can make cervical pedicle screw placement more accurate. Better accuracy and intra-operative control can increase surgeon's confidence in using cervical pedicle instrumentation on more regular basis.

A033: Computer Assisted Robotic Surgery in the Octogenarians: A Case Controlled Study

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Introduction: The proportion of population over the age of 80 is growing undergoing spinal surgery is growing. The use of computer assisted surgery in these patients is challenging due to poor bone quality and at times complex anatomy. We here present a consecutive series of octogenarian patients who underwent robot guided spine surgery robotic (planning of entry point and trajectories, drilling and cannulation of the pedicles). **Methods:** Prospective data in a spine referral center for robot guided spine surgery was retrospectively analyzed. All patients who were 80 years old or older at the time of surgery were identified. These patients were matched to 120 patients under the age of 80 (a 3:1 ratio). Patients' age, sex and indication for surgery were documented. Procedure time, accuracy, fluoroscopy usage time, and any instrumentation related complication were documented. **Results:** Between 2007 and 2013, 192 trajectories were executed in the octogenarian patients and 568 levels in the younger patients. The average age was 83.9 years vs 61.2 ($P < .05$), 12 patients were males in the octogenarian vs 50 in the younger patients. The highest instrumented in both groups vertebra was T5 and the lowest was S1. MIS was performed in 25 octogenarian patients and 73 younger patients. Average robotic usage time was 6 min and 40 seconds compared to 5 min and 5 seconds in patients under the age of 80 ($P < .05$); Total fluoroscopy exposure time per screw was 16.3 seconds in the octogenarian's vs 9.3 seconds in the

younger patients ($P < .05$). 182 (94.5%) executed trajectories were accurate vs 545 (95.9%) accuracy in patients under the age of 80 (NS). No intraoperative complications related to robot usage occurred. **Discussion:** Spine surgery in the octogenarians is challenging. The combination of osteoporotic bone and multiple spine pathologies in robot guided procedures results in longer procedures and in higher fluoroscopy usage compared to younger patients. However, procedure accuracy and safety is identical to younger patients, allowing optimal instrumentation in these frail patients.

A034: Surgical Outcomes of Robotic-Guidance vs. Freehand Instrumentation: A Retrospective Review of 705 Adult Degenerative Spine Patients Operated in Minimally Invasive (MIS) and Open Approaches

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Introduction: Minimally invasive spinal fusion surgeries (MIS) are becoming more common as hardware and computer guidance systems evolve. Yet MIS is still the exception rather than the norm with several barriers to adoption that focus on the learning curve, increased radiation exposure and contested clinical value to the patient. In recent years, robotic-guidance has become available for spinal surgeries, aiding surgeons in shortening the learning curve of MIS techniques and reducing the intraoperative exposure to harmful radiation. However, few data were presented on its impact on clinical outcomes, especially in the hands of experienced MIS surgeons. **Materials and Methods:** Data were collected retrospectively from 4 surgeons for patients operated with robotic-guidance in a MIS approach (RGM), and compared with patients operated with fluoroscopic-guidance MIS (FGM) or open (FGO) approaches. All cases were instrumented fusions using either a minimally invasive technique with pedicle screws inserted in a percutaneous para-median approach, or a classic open approach through a median dissection. Logistic regression analysis was used to assess the odds ratio of complications and surgical revisions. **Results:** Altogether, data from 705 patients were collected, 403 RGM patients, 224 FGM and 78 FGO. There were no significant differences in age, sex or BMI between arms or surgeons, except for 1 of the 4 groups in RGM that was significantly older by about 6 years. The complication rates were 4.0%, 5.4% and 12.8% for RGM, FGM and FGO respectively. The revision rate for RGM was 3.8% while for both FGO and FGM it was 7.7%. A logistic regression was performed and demonstrated that the odds ratio for surgical complications were 3.0 for FGM ($P = .014$, 95% confidence interval (CI95) = 1.2-7.1) and 3.1 for FGO ($P = .009$, CI95 = 1.3-7.3). The odds ratio for surgical revisions was 3.8 for FGM ($P = .006$, CI95 = 1.5-10.0), and 1.9 for FGO but it was not statistically significant (small sample size). Surgeon, age, gender, BMI, or length of surgery, were non-significant parameters in the regression model. **Conclusions**: This retrospective analysis demonstrates that use of robotic guidance MIS can significantly reduce surgical complications and revision surgeries when compared to fluoro-guided MIS in the hands of experienced MIS surgeons.

A035: Spinal Intra-operative Three-Dimensional Navigation: Correlation between Clinical and Absolute Engineering Accuracy

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Introduction: Spinal intra-operative computer-assisted navigation (CAN) may guide pedicle screw placement. CAN techniques are reported to reduce pedicle screw breach rates across all spinal levels. However, definitions of screw breach vary widely across studies, if reported at all. The absolute quantitative error of spinal navigation systems is theoretically a more precise and generalizable metric of navigation accuracy. It has also been computed variably, and reported in fewer than a quarter of clinical studies of CAN-guided pedicle screw accuracy. The aim of this study was to characterize the correlation between clinical pedicle screw accuracy, based on post-operative imaging, and absolute quantitative navigation accuracy. **Material and Methods:** We reviewed a prospectively-collected series of 209 pedicle screws placed with CAN guidance, in 30 patients undergoing first-time posterior cervical/thoracic/lumbar/sacral instrumented fusion $\pm$ decompression. Each screw was graded clinically by multiple independent raters using the Heary and 2 mm classifications. Clinical grades were dichotomized per convention. The absolute accuracy of each screw was quantified by the translational and angular error in each of the axial and sagittal planes. **Results:** Acceptable screw accuracy was achieved for significantly fewer screws based on 2 mm grade vs. Heary grade (92.6% vs. 95.1%, $P = .036$), particularly in the lumbar spine. Inter-rater agreement was good for the Heary classification and moderate for the 2 mm grade, significantly greater among

radiologists than surgeon raters. Mean absolute translational/angular accuracies were 1.75mm/3.13° and 1.20mm/3.64° in the axial and sagittal planes, respectively. There was no correlation between clinical and absolute navigation accuracy. **Conclusion:** Radiographic classifications of pedicle screw accuracy vary in sensitivity across spinal levels, as well as in inter-rater reliability. Correlation between clinical screw grade and absolute navigation accuracy is poor, as surgeons appear to compensate for navigation registration error. Future studies of navigation accuracy should report absolute translational and angular errors. Clinical screw grades based on post-operative imaging may be more reliable if performed in multiple by radiologist raters.

A036: Intraoperative Computed Tomography versus iso-C 3D C-Arm for Navigated Spinal Instrumentation

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Introduction: Recent meta-analysis have evidenced the superior accuracy of navigated spinal instrumentation compared to non-navigated techniques. However, the benefit of intraoperative computed tomography (iCT) compared to intraoperative iso-C 3D C-arm (3D C-arm)-based navigation remains unclear. The aim of the present study was to report our experience and accuracy of navigated pedicle screw insertion with intraoperative CT or 3D C-arm-based spinal imaging in 254 consecutive patients. **Materials and Methods:** After exposure and attachment of the navigation tracking device, a first iCT or 3D C-arm scan was performed with automatic patient/image co-registration and navigated screw insertion. Screw positioning was then intraoperatively assessed by a second iCT or 3D C-arm scan, based upon which the *intraoperative* accuracy was determined. In cases that required intraoperative screw revision, navigated repositioning was performed based on the second iCT or 3D C-arm scan. Thereafter, a third iCT or 3D C-arm scan was performed to confirm repositioning. In cases with 3D C-arm navigation, a postoperative CT scan was routinely performed, based upon which the *final* accuracy was determined compared to the final iCT scan. The general intraoperative screw placement assessability through iCT or 3D C-arm and the *intraoperative* and *final* accuracies were retrospectively reviewed and analyzed by an independent observer. **Results:** Between 2013 and 2016, an implantation of 1359 pedicle screws was performed in 254 patients with either iCT (1063 screws) or 3D C-arm (296 screws) based spinal navigation and automatic patient/image co-registration. The indications for surgery were degenerative disease (155/254; 61%), infectious disease (28/254; 11%), tumors (33/254; 13%) and trauma (38/254; 15%). Direct intraoperative screw assessment with iCT was successfully accomplished for each screw in all patients. In contrast, 19.2% (57/296) of the screws assessed by 3D C-arm imaging were intraoperatively not clearly assessable due to hardware artifacts and limited image quality. Also, 3D C-arm-based spinal navigation yielded lower precision rates compared to navigated instrumentation performed with iCT imaging (*intraoperative* accuracy: iCT 94.8% vs. 3D C-arm 89.7%, $*P < .01$; *final* accuracy: iCT 95.6% vs. 3D C-arm 90.9%, $*P < .01$). Regarding the immediate intraoperative performance, an analysis of the *intraoperative accuracy* based on the location of the instrumentation confirmed a significantly higher precision rate of iCT-based screw insertion in the cervical (iCT 98.8% vs. 3D C-arm 84.6%, $*P < .0001$) and thoracic (iCT 96.4% vs. 3D C-arm 83.3%, $*P < .0001$) spine, whereas no difference was detected in lumbar-sacral instrumentations (iCT 91.8% vs. 3D C-arm 90.0%; $P > .05$). **Conclusions:** Both iCT and 3D C-arm-based spinal navigation solutions with automatic patient/image co-registration are able to provide high pedicle screw accuracy rates. However, immediate intraoperative screw placement assessability and screw placement accuracy in the cervical/thoracic spine appear to be limited with intraoperative 3D C-arm imaging alone.

Lumbar Disc Herniation

A037: Clinical and Radiological Factors Affecting Motor Recovery Following Neurological Deficit in Lumbar Disc Herniation

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Introduction: Neurological recovery after surgery is not uniform and varied recovery rates between 61 and 88% have been reported in literature. Existing literature is not clear on the reasons resulting in such discrepancy and possible clinico-radiological factors that affect neurological recovery. The current study is a prospective, large scale case-control study to analyse the role of clinical and radiological parameters in the determining recovery of motor deficit in patients with LDH. **Materials and Methods:** A prospective study was conducted among 556 consecutive microdiscectomy surgeries performed for lumbar disc herniation (L1-2 to L5-S1) during the study period of 15 months.70 consecutive patients who underwent lumbar microdiscectomy for neurological deficit following disc herniation, were followed up for a period of 1 year and assessed for neurological recovery. Presence of motor deficit was considered when clinical examination demonstrated a motor power <3/5 (MRC grading) in any myotomes (L2-S1). Clinical parameters studies included- demographic data, co-morbidities, number of symptomatic episodes, duration of symptoms and neurodeficit, completeness of deficit, presence of bowel and bladder dysfunction and precipitating events. Radiological parameters evaluated included- number and

location of herniation level, nature of herniation, presence of migration, bony canal dimension, percentage of canal compromise and dimensions of herniated disc fragment. **Results:** Of these 70 patients with neurodeficit, 5 were lost to follow-up during. 41 out the remaining 65 patients (63%) had completely recovered by 2 months (mean 7.2 weeks). Of the 24 patients (37%) who did not recover in the initial 2 months, 4 (16.7%) patients had a delayed recovery beyond 2 months. Patients with diabetes (p 0.025), longer duration ($\geq$120 days) since initial symptom (p 0.048), greater number ($\geq$2) of previous symptomatic episodes (p 0.006), complete initial deficit (p 0.0001), complete sensory loss (p 0.042), areflexia (p 0.009) and multilevel disc prolapse (p 0.006) showed poorer recovery. The presence of two or more of the risk factors should raise suspicion for poor motor recovery (Sensitivity of 75%, Specificity of 70.7%). Age (p 0.766), sex (0.94), occupation (p 0.75), smoking (p 0.87), onset of symptoms (0.16), precipitating factors (p 0.88), bladder involvement (p 0.265), bilaterality of symptoms (p 0.41), presence or absence of anal reflex (p 0.48), level, type and location of disc herniation, primary canal stenosis (p 0.79) and disc dimension (p 0.96) did not affect the neurological outcome. **Conclusion:** A prospective, consecutive, large series assessing factors contributing to neurological recovery patterns following motor deficit resulting from lumbar disc herniation has not been reported previously. Patients with diabetes, longer duration since initial symptom ($\geq$120 days), greater number of previous symptomatic episodes ($\geq$2), complete initial motor and sensory deficit, areflexia and multi-level disc herniations are predisposed to delayed or poor neurological recovery post-operatively.

A038: Treatment of Pain Due to Nerve Root Compression: Irrational, Ineffective and Inefficient

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Introduction: Radicular pain is common (but exactly how common is uncertain) and surgery is known to be effective. However, Surgery is usually preceded by various "conservative" treatments for which there is often unclear rationale and little evidence of efficacy. Hence, the primary objective of this study was to determine the range and frequency of treatments experienced by people eventually having surgery for lumbar and cervical root compression. The secondary objective was to use existing literature to compare the effect size of these treatments on pain compared to that of surgery. **Material and Methods:** Prospectively collected data on consecutive people undergoing surgery by one spinal neurosurgeon for sciatica or brachalgia between January 2007 and July 2015 in a UK teaching and private hospital. People were asked to record their symptom duration, details of previous treatments received, pain severity (Visual Analogue Scale, VAS) and self-reported functional limitations caused by their symptoms. **Results:** Participants preoperative questionnaires were obtained from 93% (n = 1110) of people having surgery for sciatica or brachalgia over nearly 9 years from January 2007 to June 2015. The average age was 58yrs (range 17-94). Half were female (n = 544). The mean duration of symptoms was 35.0 months (sd 70.5; range 0.2-620). 88.7% of people were taking analgesic medication with a mean of 3.3 (sd 2.7) per day; 82% had at least 1 physical therapy; 23.4% had at least 1 injection therapy. Pre and post op VAS pain scores were 7.46 (sd 1.87) v 2.89 (sd 2.72). The improvement in pain was highly significant statistically (t = 36.4; $P < .001$) and clinically (Cohen's Effect Size = 2.44). **Conclusion:** People with cervical or lumbar nerve root compression can wait years before receiving surgery that is associated with substantial treatment benefits. During this time, they are in pain, have limited function and receive a range of treatments that are not based on a diagnosis and are predictably ineffective. The literature also shows no convincing evidence to support the non-surgical treatments as effective treatments for cervical and lumbar nerve root compression. Our results indicate that the manifestations of nerve root compression are poorly understood, therefore the threshold for referral and investigation should be lowered, and guidance needs revising.

A039: Clinical and Radiological Factors Associated with Development of Motor Deficit in Lumbar Disc Prolapse: A Prospective Analysis of 70 Consecutive Cases with Neurological Deficit

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Introduction: Neurological deficit is a rare, but serious complication following lumbar disc herniation. There are currently very few large scale studies in the literature discussing the correlation of different clinico-radiological factors associated with development of this complication. We aimed to correlate clinical and radiological parameters in the development of motor deficit in patients with lumbar disc herniation in a large scale case-control study. **Materials and Methods:** We conducted a prospective, consecutive analysis, among a total of 556 cases with lumbar disc herniation (L1-2 to L5-S1) treated with microdiscectomy. During the study period of 15 months, 70 consecutive patients who had presented with motor deficit (with or without bladder symptoms) were included under group 1 (cases). The control group (group 2) which included 70 patients without any pre-operative neurological deficit were selected through random allocation Motor deficit was defined as the occurrence of motor power $\leq$3/5 (MRC grading) in L2, 3, 4, 5, S1 myotomes. Radiological parameters evaluated included- number and location of herniation level, nature of herniation, presence of migration, bony canal dimension, percentage of canal compromise and dimensions of herniated disc fragment. Clinical parameters studied included- demographic

data, co-morbidities, symptomatology, number of symptomatic episodes, Oswestry scores, visual analogue scores, occupational profile and precipitating events. **Results:** Patients with diabetes (p 0.004), acute onset of symptoms (p 0.036), L3-4 discs (p 0.001), sequestrated discs (p 0.004), superiorly migrated discs (p 0.012) and central discs (p 0.004), greater antero-posterior disc dimension (p 0.023), primary canal stenosis (p 0.0001); and greater canal compromise (p 0.002) had a significant correlation with the development of neurological deficit. When four of more of these risk factors are present, the chance of occurrence of motor deficit is high (Sensitivity of 74%, Specificity of 77%). Age of patient (p 0.067), sex (p 0.999), previous precipitating events (p 0.379), severity of pain (p 0.605), smoking (p 0.309); and number of herniation levels (p 0.266) did not affect the occurrence of deficit. The patients with associated bladder symptoms were similar to the other subset (without bladder symptoms) with respect to all clinico-radiological parameters. However, the time delay since the occurrence of deficit was significantly shorter in patients with bladder involvement (p 0.001). **Conclusion:** This unique prospective, consecutive analysis of clinic-radiological factors impacting neurodeficit stands out as one of the largest cohort analysis for this complication following lumbar disc herniation. Patients with diabetes, acute presentation of symptoms, central, sequestrated and superiorly migrated discs, high lumbar disc prolapse and greater spinal canal compromise are predisposed to the development of motor deficit.

A040: Management of Symptomatic Lumbar Disk Herniation: An International Perspective

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Introduction: Sciatica is a common diagnosis in the general population. Sciatica is most frequently caused by lumbar disk herniation (LDH). Multiple surgical techniques and treatment modalities are available to threat LDH, albeit some with small effect sizes or without compelling evidence. The aim of this survey is to evaluate the current practice patterns and attitudes of surgeons regarding both the surgical and nonsurgical management of LDH worldwide. **Material and Methods:** A survey including questions on the application of physical examination, expectations regarding different surgical and nonsurgical techniques, factors influencing the outcome of surgery and the documentation of PROMs, was distributed among members of AOSpine International and the EANS. **Results:** 817 surgeons from 89 countries completed the questionnaire These surgeons perform a total of 62.477 discectomies yearly. Pain medication and steroid injections were expected to be the most effective nonsurgical treatments. The severity of pain and/ or disability and failure of conservative therapy were the most important indications for surgery. A period of 1-2 months of radiculopathy was regarded as a minimum for indicating surgery. Unilateral transflaval discectomy was the procedure of choice among the majority and was expected to be the most effective technique with the lowest complication risk. Almost a third of the surgeons did not register any PROMs. **Conclusion:** Unilateral transflaval discectomy was expected to be the most effective surgical technique. Techniques described as minimally invasive, were expected to give the lowest postoperative low back pain. However, these techniques were also expected to give the highest risk of recurrent disk herniation. Documentation of PROMs in the treatment of LDH is warranted.

A041: Rare Presentation of Disc Prolapse: Lumber Intradural Disc Herniation

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Study Design: Case series. **Objective:** The aim was to look for preoperative clinical and radiological features of intradural disc. **Methods:** We present prospective analysis of 6 cases of intradural disc herniation at L4-L5 level diagnosed on the basis of intraoperative findings with their clinical, intraoperative and retrospective MRI analysis. **Results**: All our cases on preoperative MRI findings were reported as having diffuse annular bulge with large posterocentral extrusion at L4-L5 compressing the nerve roots. Our study comprised of males in age group of 30 to 60 years. 4 out of 6 presented with cauda equina syndrome. In 3 cases, cauda equina was associated with sudden deterioration in the power of lower limb muscle groups. We suspect that intradural herniation of disc was synchronous with cauda equina syndrome in these cases, which was very well documented in one of the cases. On retrospective analysis, MRI findings of mass effect in the form of displacement of the traversing nerve roots due to large central disc with *crumble disc sign* was suggestive of early evidence of intradural disc herniation. *Y sign* in ventral dura due to splitting of ventral dura and arachnoid mater by disc material was a good diagnostic sign to suspect intradural extra-arachnoid disc. **Conclusion:** Based on our series and literature review we propose three stages of intradural disc herniation on MRI: Stage 1- Stage of Effacement, Stage 2- Stage of focal discontinuity and Stage 3- Stage of Intradural herniation. We also suggest that sudden deterioration in the power of lower limb muscle groups with cauda equina syndrome in patients having large central disc on MRI especially at L4-5 levels should raise suspicion of intradural herniation of disc.

A042: Is There a Standard of Magnification in Lumbar Discectomy? A Propensity Scoring Study

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Introduction: Numerous methods of magnification are available for spinal surgeons when performing simple discectomy from conventional, loupes and operative microscope. Advantages exist for the use of magnification in clearer operative field and with the operative microscope enhanced illumination of the operative field. There have been reports which have suggested that there is an increase in wound infections with the operative microscope. We ask if there is any evidence to favour magnification compared with conventional methods in the performance of simple discectomy. **Methods:** A retrospective review of a multi-centred internationally kept database was performed (SpineTango). The database was searched for primary discectomies. The results were then stratified into conventional magnification; loupe magnification or operative microscope. These were then compared for the rate of dural lesions during surgery and complications from the surgery**. Results:** We included 6662 operative patients. 1810 were treated by decompression using conventional magnification, 384 by loupe magnification and 4468 by operative microscope. The overall rate of dural lesion was 4.56%. The lowest rates of dural lesions were seen in the conventional group (3.09%) and the highest rate was seen in the Loupes group (8.07%). There was a 1.85 times higher rate of incidental durotomy with the use of surgical loupes. The conventional group had worse outcomes for length of stay, wound infections, surgical time and blood loss. **Conclusion:** Our results fail to show a true standard in the use of magnification for simple discectomy. It would suggest an increase in the use of magnification may reduce blood loos, wound complications and length of stay. The reason for higher dural lesions in the magnification arms may be the use of magnification after a lesion has been created. Further prospective analysis is required to confirm this however.

Basic Science Growth Factor

A043: Histological Analysis of Bone Regeneration with Different Doses of rhBMP-2 in an Ovine Lumbar Interbody Fusion Model

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Introduction: The objective of this study was to investigate the effects of different doses rhBMP-2 on bone healing in an ovine lumbar interbody fusion model. **Materials and Methods:** In this study 22 sheep underwent two level lumbar interbody fusion using a ventrolateral approach with secondary dorsal fixation at L1/2 and L3/4. After randomization in one level a PEEK-cage was implanted filled with one of three doses rhBMP-2 (0,5 mg; 1 mg; 2 mg) delivered on an ACS. The other level received an empty PEEK-cage or ACS filled cage. Animals were sacrificed after 3 and 6 months and decalcified histology was performed. This included histomorphological analysis as well as histomorphometry of the tissues within the cage. **Results:** At 3 months after surgery the groups treated with rhBMP-2 showed higher amounts of bone tissue within the cage. At 6 months the amounts of bone tissue increased in all groups, but were still lower in the groups without growth factor. At 3 months there was only one active osteolysis in the cage/ACS. 7 of 8 segments of the rhBMP-2 groups had a compromised bone structure around the implant. These areas were filled with fibrous tissue and fibrocartilage. This finding was not detected in the groups without rhBMP-2 at 3 months. At 6 months most of the segments with an empty cage or cage/ACS showed a chronic inflammation. Predominant cells were macrophages and giant cells. The groups treated with rhBMP-2 showed only a few mild chronic inflammatory reactions. **Conclusion:** The well-known dose dependent effect of rhBMP-2 on bone healing could also be recognized in our study. Attention has to be payed for the proinflammatory properties of the growth factor. Consistent with other studies we found 2 strong inflammatory reactions, each one in the lowest and highest dose group. Also the potential for causing transient bone resorptions, according to the results of others, was demonstrated. At 3 months 7 of 8 segments treated with rhBMP-2 showed compromised peri-implant bone. Osteoblasts, but not osteoclasts, were seen in the periphery of these areas. It can be concluded that there where bone resorptions which already merged into an increased osteoblastic activity. Usually resorptions occur between 2 and 12 weeks and are followed by a period of increased osteoblastic activity. This finding wasn't recognized at 6 months anymore. Striking is that at 6 months most of the segments without rhBMP-2 showed a compromised bone structure around the implant with a mild to mainly moderate chronic inflammatory reaction. This cannot be attributed to the growth factor. Also the ACS is degraded at 6 months and is unlikely a possible explanation. Therefore, the cage as a reason must be considered and it has to be questioned whether PEEK is the optimal material for interbody cages.

A044: A Comparison of the Efficacy of Adipose-Derived vs. Bone Marrow-Derived Stem Cells in Combination with a Clinical-Grade Bone Graft Substitute in a Rat Model of Spinal Fusion

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Introduction: Adipose-derived stem cells (ADSCs) have been demonstrated to form vascularized bone in various animal and pre-clinical models. While bone marrow-derived stem cells (BMSCs) have been widely used in spinal fusion studies, adipose offers a number of advantages as an alternative clinical cell source, including a larger available tissue volume, higher stem cell concentration, and reduced donor site morbidity. In this study we compare the efficacy of ADSCs vs. BMSCs in achieving successful spinal fusion when combined with a clinical-grade bone graft substitute in a rat model. **Materials and Methods**: Adipose-derived stem cells (ADSCs) and bone marrow-derived stem cells (BMSCs) were isolated from the inguinal fat pads and long bones, respectively, of female Lewis rats (6-10 wk old) and cultured *in vitro* until passage 2 (P2) for subsequent transplantation in our spinal fusion model. The frequency of colony forming unit fibroblast (CFU-F) colonies was also assessed *in vitro* for both ADSCs and BMSCs. Posterolateral spinal fusion surgery at L4-5 was performed on 36 female Lewis rats (6-10 wk old) divided into 3 experimental groups: [1] Vitoss (Stryker) clinical-grade bone graft substitute only (VO) (n = 12); [2] Vitoss + 2.5 x 10^6 P2 ADSCs /side (n = 12); and [3] Vitoss + 2.5 x 10^6 P2 BMSCs /side (n = 12). Fusion was assessed at postoperative week 8 via micro-computed tomography (MicroCT) analysis and manual palpation. Manual palpation scoring was conducted by blinded researchers as follows: 0 = non-fused; 1 = some motion across operative joint but not as mobile as adjacent segments; 2 = fused, no motion across the operated joint. **Results:** The average fusion volume in the ADSC group was significantly larger than the BMSC and VO groups (44.3 mm^3 vs. 27.6 and 30.0 mm^3, respectively, $P < .01$). The mean manual palpation score was the highest in the ADSC group compared with the BMSC and VO groups (1.5 versus 0.7 versus 0.8 $P = .03$). As has been found in previous studies, ADSCs exhibited a faster proliferative rate and a higher frequency of CFU-F colonies *in vitro* than BMSCs. **Conclusions**: When combined with a clinical grade bone graft substitute in a rat model, adipose-derived stem cells yielded increased fusion mass volume and more robust fusion than bone marrow-derived stem cells. Ongoing studies will explore whether this trend holds for freshly isolated and P1 ADSCs as well as in larger animal models.

A045: The Osteogenic Effects of Photo-Immobilization of Bone Morphogenetic Protein-2 using Different Carrier Systems in a Rat Calvarial Defect Model

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Introduction: As a preliminary study, we photo-immobilize the BMP2 on the collagen sheet with an UV-light reactive azidophenly-natural polymers (Gelatin, O-carboxymethly chitosan, Low molecular weight chitosan), and determine the optimal density of azidophenyl-natural polymers and UV treatment time. The purpose of this study is to confirm the usefulness of photo reactive Az-gel on collagen sheet for the BMP-2 as a carrier in the rat calvarial defect animal model. **Material and Methods:** Fifty-six male Sprague-Dawley rats, 8 weeks of age, were chosen, randomized into following four groups; Group A as a control group comprising a collagen sheet only cast BMP-2; Group B comprising a collagen sheet with photo-immobilized BMP-2 on azidophenyl-gelatin (Az-Gel); Group C comprising a collagen sheet with photo-immobilized BMP-2 on azidophenyl-O-carboxymethyl chitosan (Az-OCM); and Group D comprising a collagen sheet with photo-immobilized BMP-2 on azidophenyl-low molecular weight chitosan (Az-LMC). The animals were anaesthetized for all surgical interventions, 8-mm defect was made using a trephine burr at animal's calvaria, and 8-mm collagene sheet, treated according to group) was implanted. Seven animals from each group, a total of 28 animals, were sacrificed at 4 weeks; the remaining 28 animals were sacrificed 8 weeks after implantation. MicroCT analysis and histological assessment involving H&E stain and immunohistochemical stain (RUNX2, osteopontin) were done for qualitative and quantitative evaluation of each group. **Results:** 1) MicroCT: At 4 weeks, the bone volume fraction was highest in Group at B but difference between the groups was not significance. However, the bone volume fraction at 8 weeks was highest with significant difference ($P = .017$). At 4 weeks, the trabecular pattern factor and structure model index, the bone microarchitecture parameter, were lowest at Group B with significant difference ($P < .01$), indicate that there was more trabecular connectedness in Group B. At 8 weeks, the trabecular number per unit lenght was highest at Group B with significant ($P = .01$). In the 3-D reconstruction image, the new bone generated in the control group and Group D appeared to be located along the defect rim, and was contradistinctively centrally located bridging the entire major axis of the defect in the Group B and Group C. 2) Histology: The results from the H&E staining, the new bone generation tended to occur at the center of defect, relatively independent site from the host bone in the Group B and Group C. The graft resorption and well maturated trabeculae were observed in all groups. The RUNX2 staining showed a significantly highest positively expressed cellular ratio in Group B at

4 and 8 week ($P < .01$). The expression intensity of osteopontin was strongest in Group B, followed by Group C, compared with week to moderate in control group and Group D. **Conclusion:** Among the azidophenyl natural polymers, photo-immobilized BMP-2 using Az-Gel on a collagen sheet significantly enhanced new bone formation quantitatively and qualitatively compared with non-photo-immobilized BMP-2 on a collagen sheet. In conclusion, photo-immobilization using Az-Gel on a collagen sheet is a promising technique for the creation of BMP-2 carriers.

A046: A Comparison of Syngeneic Iliac Crest and Femoral Allografts with Iliac Crest Autograft in the Rat Model of Spinal Fusion

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Introduction: Autograft iliac crest bone remains the "gold standard" in lumbar spinal fusion procedures, including within animal models. However, inbred rodent strains allow for the use of syngeneic allografts in place of autograft bone. Given that larger volumes of bone are available in the femur and since femoral head allografts have been successfully used in a number of clinical spinal fusion studies, we compared the use of autogenous iliac crest with syngeneic femoral and iliac crest allograft bone in the rat model of lumbar spinal fusion. **Materials and Methods**: Single-level bilateral posterolateral intertransverse process lumbar spinal fusion surgery was performed on 45 female Lewis rats, divided into three experimental groups: [1] iliac crest autograft (n = 15); [2] syngeneic iliac crest allograft (n = 15); and [3] syngeneic femoral allograft bone (n = 15), all consisting of corticocancellous bone. Eight weeks postoperatively, fusion was evaluated via microCT analysis, manual palpation and histology. Bone marrow-derived cells were isolated from the illia and femurs of female Lewis rats, enumerated and cultured *in vitro* for 10 days in order to determine the frequency of colony unit fibroblast (CFU-F) colonies. **Results:** Pre-implantation femoral syngeneic allografts were the largest at 0.42 $\pm$ 0.10 g, followed by iliac crest allografts at 0.35 $\pm$ 0.13 g and finally iliac crest autografts at 0.15 $\pm$ 0.10 g. However, 8 weeks post-surgery there was no statistically significant difference in fusion mass volume via micoCT analysis. Upon manual palpation, allograft iliac crest bone resulted in the highest fusion rates with 37.5% bilaterally fused, 37.5% unilaterally fused and 25% non-fused, compared to 15% bilaterally fused, 54% unilaterally fused and 31% non-fused in the autograft group and 7%, 40% and 53% in the femoral allograft group. While the total bone marrow-derived cell yield was significantly higher from femurs as opposed to ilia, preliminary limiting dilution CFU-F assays suggest that the frequency of CFU-F colonies is higher in ilia compared to femurs. **Conclusions**: Although femoral syngeneic allografts yielded the largest pre-implantation grafts, this did not translate into larger fusion mass volumes eight weeks later, compared to iliac crest grafts. Interestingly, femoral allografts showed lower rates of solid fusion, via manual palpation, than both iliac crest autograft and allograft groups. Preliminary *in vitro* assays suggest that this difference is associated with an increased frequency of CFU-F forming mesenchymal progenitor cells in the iliac bone marrow compared to femoral bone marrow. As in previous studies, CT fusion scores did not necessarily correlate with manual palpation fusion scores.

A047: The Effects of Topical Intraoperative Administration of Vancomycin or Tobramycin on Fusion Rates in a Rat Model

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Introduction: Local intraoperative use of antibiotic powders in spinal fusion surgery, particularly vancomycin, has become an increasingly common prophylactic measure in an attempt to reduce rates of post-surgical infection. While some clinical studies have suggested that the use of vancomycin in spinal fusion procedures is safe and may reduce the rate of infection, localized intraoperative use of vancomycin powder remains controversial. More importantly, the effects of localized antibiotic delivery on spinal fusion outcomes remain unclear. We thus aim to examine the effects of local intraoperative delivery of vancomycin powder and tobramycin powder, an antibiotic commonly used in orthopaedic bone grafting surgeries, in a rat model of posterolateral intertransverse process lumbar fusion. **Materials and Methods**: Single-level (L4-5) bilateral posterolateral intertransverse process lumbar spinal fusion surgery was performed on 60 female Lewis rats (6-8 week old) using syngeneic iliac crest allograft mixed with the clinical bone graft substitute Vitoss (Stryker) and varying concentrations of antibiotics. More specifically, five experimental groups were studied: [G1] low concentration (14.3 mg/kg) vancomycin (n = 12); [G2] high concentration (71.5 mg/kg) vancomycin (n = 12); [G3] low concentration (28.6 mg/kg) tobramycin (n = 12); [G4] high concentration (143 mg/kg) tobramycin; and, [G5] controls with no antibiotics (n = 12). Eight weeks postoperatively, fusion score and fusion volume were evaluated via microCT analysis (CT scoring per side: 2 = robust fusion; 1 = some narrowing of fusion mass; and, 0 = discontinuity of fusion mass; total score = average of sum of both sides), and manual palpation and histology were performed. **Results:** Preliminary microCT results revealed that the high-dose vancomycin group [G2] exhibited a significantly lower fusion score and fusion mass volume than controls (preliminary fusion scores: [G1]1.8, [G2]1.2, [G3] 1.6, [G4] 3.0, and [G5] 2.3, respectively, $P = .045$; preliminary fusion mass volumes; [1]20.7, [2]15.5, [3]22.9, [4]34.9, and [5]31.5 mm^3,

respectively, $P = .002$). Manual palpation and histological analysis are currently being performed. **Conclusions:** Preliminary data suggest that the intraoperative local application of vancomycin at supraphysiological doses may have detrimental effects on spinal fusion. The results of this study potentially indicate that caution is required when considering the amount of intraoperative vancomycin powder to employ when conducting spinal fusion surgery in certain patient populations. Future clinical studies examining the effects of vancomycin dosage on fusion rates would thus be of great interest.

A048: Effect of Oxy133, an Osteogenic Oxysterol, and rhBMP2 on New Bone Formation in Rat Posterolateral Fusion Model

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Introduction: Oxysterols play an important role in inflammation, apoptosis, cell differentiation and other processes. Recent studies demonstrated that several oxysterol analogues including Oxy133 promote osteogenic while inhibiting adipogenic differentiation of progenitor cells, and simulate cranial bone regeneration and solid fusion in animal models. The aim of our study was to determine the effect of Oxy133 and rhBMP2 on fusion rates and new bone formation in a rat posterolateral fusion (PLF) model. Furthermore, we examined whether Oxy133 could inhibit the adipogenesis that is often present in rhBMP2 induced fusion. **Materials and Methods:** Sixty four male Lewis rats underwent PLF at two levels L3-4 and L4-5 with control vehicle, Oxy133 and/or rhBMP2. All animals were randomly divided into 8 groups based on the test compound that they received: control (vehicle –DMSO), low dose rhBMP2 (0.5 μg), high dose rhBMP2 (5 μg), rhBMP2 (0.5 μg) plus Oxy133 (20 mg), rhBMP2 (5 μg) plus Oxy133 (20 mg), high dose Oxy133 (20 mg), low dose Oxy133 (5 mg), and rhBMP2 (0.5 μg) plus Oxy133 (5 mg). Eight weeks after surgery animals were euthanized and L2-L6 segments were harvested. In each group, fusion rates were assessed with manual palpation and plain radiographs. Bone parameters including tissue volume (TV), bone volume (BV), BV/TV ratio, trabecular thickness and separation were measured using microCt. Histology was used to evaluate adipogenesis. **Results:** No fusion was observed in the control group. Based on the manual palpation, 100% fusion was observed in all groups except low dose rhBMP2 group (69%). Based on X-rays 100% fusion was observed in groups: high dose rhBMP2 (5 μg), low dose Oxy133 (5 mg), and rhBMP2 (0.5 μg) plus Oxy133 (5 mg). For other groups fusion rates were between 95-97%, except for the low rhBMP2 group (28%). We observed similar values in BV/TV ratio at L3-4 when Oxy133 groups were compared to rhBMP2 groups alone (44.62%, high Oxy133 vs. 41.47%, high rhBMP2; and 47.18%, low Oxy133 vs. 54.98%, low rhBMP2). Trabecular thickness was slightly lower in Oxy133 groups compared to rhBMP2 (118.44 μm for high Oxy133 vs. 122.39 μm for high rhBMP2; and 123.51 μm for low Oxy133 vs. 135.74 μm for low rhBMP2). At the same time trabecular separation was lower in Oxy133 groups compared to rhBMP2 groups. For groups where Oxy133 and rhBMP2 were used together BV/TV ratio was 40.19%-46.33% and trabecular separation 342.5 μm - 405.13 μm. Similar trends in bone parameters were observed at L4-5 level. Fusion masses with high dose Oxy133 had significantly less adipocytes than rhBMP2 groups that showed robust adipocyte formation. **Conclusions:** In our study both low dose and high dose Oxy133 produced solid fusions with bone densities similar or higher than in the BMP2 groups. High dose Oxy133 group had significantly less adipocytes than high or low dose rhBMP2 groups. Furthermore, high dose Oxy133 was able to significantly inhibit high dose BMP2 induced adipogenesis when combined together. Consistent with previous reports, our preliminary findings suggest that Oxy133 has a significant potential as an alternative to rhBMP2 in spine fusion.

Tumor I

A049: Patterns of Failure of Fixation In Metastatic Spinal Tumour Disease

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Introduction: Spinal column is the commonest site for osseous metastasis. Indications for surgery includes neurologic deficit, obvious or impending instability and/or intractable pain; rarely local tumour control. Patients with spinal metastases have a median survival of 10months and effective palliation of symptoms is principle clinical objective. Many studies have focused on decision making, surgical management and postoperative complications, few focusing on the failure of fixation (FOF) and factors leading to it. This study presents the results of patterns of FOF in metastatic spine tumour surgery (MSTS), clinical presentation before surgery, after failure and factors leading to failure. **Methods:** This is a retrospective study involving 165 patients undergoing MSTS in a tertiary referral institution between 2005-2015. Data were collected from case notes/hospital electronic records and radiological investigations Centricity Web. Radiological data included SINS score, type of lesion (lytic, mixed, sclerotic, none) and levels of fixation. Surgical data included minimally invasive surgery or open

fixation & revision after FOF, levels and type of stabilisation. FOF was defined as breakage of the rod or screw, screw back out or cut out, lysis around the screw, increase in angular deformity, reduction in anterior column height, tilting or subsidence of anterior cage. The endpoint of the evaluation was up to last follow-up or death. The level of fixation was considered as anchor in a vertebra (anterior or posterior) by spine implants. Construct length was categorised as short (1-7 level), intermediate (8-12) or long (>12). Vertebra within the construct without anchor was considered as a level. We excluded patients with previous spine surgery, infection of implant leading to failure, survival <30 days post-op and/or age <18yrs. **Result:** Out of 165 patients, 15 died in <30 days postoperation and 12 lost to follow-up, leaving 138 for final analysis. Lung (23.2%) was the most common primary followed by breast (16.7%). Most common symptoms on presentation were instability pain followed by weakness associated with pain. The average follow-up was 11 months (1-92months). FOF was found in 26.8% (37/138). The most common failure was asymptomatic change in angular deformity 86.5% (32/37), back out 5%(2/37), cut out 5% (2/37), lysis 8%(3/37), cage tilt 2.7%(1/37), All FOF cases were recorded in the SIN score range of 7-14, 54% of the patient with FOF had SIN score >9, while no failure was noticed in patients with SIN score <7. Only 4 cases required revision of fixation, who presented with progressive neurological deficit & pain; and were associated with back out or cut out of screw in adjacent disc space with subcutaneous prominence of the screw head. One patient with anterior column reconstruction develops an increase in angular deformity which was resultant of the cage insertion in diseased body. **Conclusions:** We conclude that most of FOF cases showed increase in angular deformity and reduction in anterior column height. Most of the patients with increased angular deformity or loss of height were associated with SIN score >7. Most are asymptomatic and do not require revision though it may be the early sign of the failure of construct.

A050: Symptomatic Spinal Metastasis: A Systematic Literature Review of the Preoperative Predictive Factors for Survival, Neurological, Functional and Quality of Life Outcomes in Surgically Treated Patients

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Introduction: While several clinical prediction rules (CPRs) of survival exist for patients with symptomatic spinal metastasis (SSM), these have variable predictive ability and there is no recognized CPR for health related quality of life (HRQoL). We undertook a critical appraisal of the literature to identify key preoperative predictive factors of clinical outcomes in patients with SSM who were treated surgically. The results of this study could be used to modify or develop new CPRs. **Material and Methods:** Seven electronic databases were searched (1990 – 2015), without language restriction, to identify studies that performed multivariate analysis of preoperative predictors of survival, neurological, functional and HRQoL in surgical patients with SSM. Individual studies were assessed for class of evidence and the strength of the overall body of evidence for each factor was evaluated using GRADE. **Results:** Among 4,818 unique citations, 17 were included, all were rated Class III and focused on survival, revealing a total of 46 predictive factors. The strength of the overall body of evidence was *very low* for 39 and *low* for 7 predictors, with the latter including 3 negative predictors for all types of primary tumors (radioresistant primary tumor, Charlson comorbidity index score $\geq$2 and non-ambulatory status) and 4 for breast cancer (shorter time from cancer diagnosis to surgery, emergency hospital admission, primary with undifferentiated histologic grade and negative progesterone receptors). **Conclusion:** The quality of evidence for predictors of survival was at best *low*. We failed to identify studies that evaluated preoperative predictive factors for neurological, functional, or HRQoL outcomes in surgical patients with SSM. Further high-quality evidence is needed to accurately estimate predictor effect sizes, for patient education, surgical decision-making and development of CPRs.

A051: Stereotactic Body Radiotherapy followed by Surgical Stabilization for Patients with Unstable Spinal Metastases: First-in-Man Study according to the IDEAL Recommendations

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Introduction: Standard treatment of unstable vertebral metastases consists of stabilizing surgery, followed by external beam radiotherapy, a minimum of two weeks later. This two-week interval, required for wound healing, delays the time before radiotherapy-induced pain relief and local tumor control can be achieved. Furthermore, multiple hospital visits are needed for most radiotherapy fractionation schemes and moreover, currently 30-40% of the patients experience incomplete pain relief. From the patient's perspective, an alternative treatment

strategy that would lead to better and faster pain relief while requiring less hospital visits would be highly desirable. Stereotactic body radiotherapy (SBRT) may be used in combination with surgical stabilization to increase the local dose on the spinal metastasis for better response while actively avoiding irradiation of the surgical area to prevent disturbed wound healing. Therefore the aim of this phase I/II study is to assess the safety and feasibility of combining single fraction SBRT followed by pedicle screw fixation within a 48-hour window for the treatment of painful unstable spinal metastases. **Materials and Methods**: The present study will be conducted according to the IDEAL recommendations, a framework for systematic evaluation of complex interventions consisting of five stages: Innovation, Development, Evaluation, Assessment and Long term evaluation. A total of 13 patients will be included in two stages. In stage 1, three patients will be included in whom the new procedure will be tested first. In stage 2, ten patients will be included, the main focus is technical feasibility and safety. Information on demographic and clinical characteristics, treatment, toxicity (according to the CTCAE4.0 within 60 days), complications and survival will be systematically collected. Patients with painful spinal metastases from a solid tumor needing surgical stabilization will be included. SBRT is simulated first on a planning CT to deliver a dose of 18 Gy on the metastasis and 8 Gy on the rest of the vertebra while actively avoiding exposure to the posterior surgical area. After SBRT is performed, patients will undergo surgical stabilization within 48 hours according to routine practice. **Results**: The first ten patients, five males and five females, have successfully been treated according to this new treatment protocol. A posterior approach was used for all surgical procedures, with two conventional open and eight percutaneous procedures. The mean operating time was 82 minutes ($\pm$SD33) with a median blood loss of 50 millilitres (range 50-300). The median length of hospital stay was 5 days. None of the patients experienced a wound complication or other study related complication. One patient suffered a grade 3 surgery related complication, which resolved after re-operation. Combination of the procedures was feasible and the patients experienced no discomfort during the SBRT procedure before stabilization of the spine. We expect to be able to present the results of all 13 patients at the time of the conference. **Conclusion:** The preliminary results suggest that the combination of SBRT and surgical stabilization within 48 hours is safe and feasible. Hereby a new and promising one-stop treatment strategy may have been developed for a difficult to manage, vulnerable patient category.

A052: Selective Endovascular Embolization in Pediatric Patients with Hyper-vascular Mono-segmntal Thoracic and Lumbar Spine Tumors

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Introduction: The hyper-vascular component in spinal tumor significantly increase technical difficulties and post-op complications risks, including perioperative blood loss which could reach a few liters. The selective vascular embolization is effective to decrease blood loss in adult patients, but it effect is not completely clear in pediatric patients. **Material and Design:** 13 patients aged from 4 till 16 yrs were investigated during 2005 – 2016 period due to suspicion on monovertebral spinal lytic tumors with a hyper-vascular component in its structure. 11 patients were included into study due to the cervical (1), thoracic (6) and lumbar (4) vertebrae bodies lesions; 2 ones were excluded because of isolated neural arch affect. The back pain was the prominent sign of tumors in all patients; motors or bladder and bowel disorders were in 3. Bone scan with Tc99 was in all cases, the vascular component was suspected by MRI. ABC was diagnosed initially in 5 patients, after surgery one of them was identified as high differentiated low grade angiosarcoma; cavernous hemangioma was in 4, one more case diagnosed as hemangiogenic variant of Gorham-Stout disease («angiogenic octeolysis"). Percutaneous pre-op trepan-biopsy was in 8/13 cases, cytology was equal with post-op histology in 4 (50%). Pre-op selective angiography done in 7/13 patient followed by embolization in 6. The embolization was not performed in one case because of the anastomosis between the tumors' and spinal cord vessels. The embolization-related complication were not in our series. The blood loss volume was estimated as at the end of surgery as 24-hour after it. The blood loss volume estimated according to hematocrit (Ht) rate due to the Moore's formula. Two groups of patients (*with* and *without* embolization) were compare according to statistic Mann-Whitney U-test with $P \leq .05$ significance level. **Results:** Embolization had reached complete disappearance of clinical signs in patient with Gorham-Stout syndrome: the indication for surgery was cancel, the patient continued effective bisphosphonates treatment next 3 years and was cancel from the final analysis. 5 patients with pre-op embolization and without it underwent surgery with complete vertebral body replacement. In was not find significant different in blood loss between compared groups which was counted as 29% and 24% of the volume of circulated blood ($P \geq .05$, Mann-Whitney U-tests 12.5. The early post-op wound infections was in 2 cases (one in each group), both in patients with operative blood loss exceeded 1000.0 ml. **Conclusions:** It has detected that perioperative blood loss in pediatric patients with spinal tumors included hyper-vascular component in its structure significantly less than in adult patient. It wasn't confirmed the dependence of perioperative blood loss in such patients from the fact of pre-op endovascular embolization. Perhaps, this negative result could connected with as a small number of cases as a more detailed hemostasis in non-embolized patients. From other side, it is detected that the duration of surgery was shorter and visual control was significantly better in patients after embolization.

A053: Retrospective Analysis of Preoperative Embolization of Patients with Primary and Secondary Spinal Tumors

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Introduction: Investigate the safety and efficacy of transarterial embolization in patients with hypervascular spinal metastases and primary tumors before surgical resection. **Material and Methods:** Thirty nine patients with spinal metastases and primary tumors underwent angiography and preoperative transarterial embolization with spherical particles, coils and the liquid cohesive composition before surgical resection. The following parameters were evaluated: types of tumor, sex, time interval between embolization and surgery, the influence of these parameters on intraoperative blood loss, surgical content, safety for the patient. **Results:** Intraoperative blood loss in patients undergoing embolization was up to 500 mL - 29 (74.4%), to 1000 mL - 2 (5.1%), to 2000 mL - 3 (7.7%), 2000 mL – 5 (12.8%). Average value of blood loss for RCC 546.2 mL., for other metastases – 373.5 mL., for primary tumors – 2488.8 mL. There have been no in-hospital mortality related with the intraoperative blood loss. All patients received standard supportive care, emergency blood transfusion was not performed. Three (7.7%) patients after endovascular interventions had complications in the form of temporary neurological deficit, fifteen (38.5%) had postembolization syndrome. **Conclusion:** In the embolization group, intraoperative blood loss was correlated with type of tumor and type of surgical resection. Preoperative embolization is safety and effectively to decrease intraoperative blood loss for patients with hypervascular spinal tumors.

A054: Surgical Treatment of Spinal Cord Intramedullary Tumors in Adult

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Introduction: The incidence of intramedullary tumors is much lower compared to brain intraparenchymal tumors. Surgery of spinal intramedullary tumors has own tricks during approach and removing process. The Burdenko Neurosurgical Institute has a well-established practice of surgical treatment of intramedullary tumors. **Materials and Methods:** Burdenko Neurosurgical Institute has experience of treatment more than 1000 patients with spinal intramedullary tumors of all ages. In this research we report results of spinal department for treatment of 385 adult patients with spinal intramedullary tumors between 2000 and 2016 years. We identified following histological types: ependymomas, astrocytomas, hemangioblastomas and other types. All patients underwent microsurgical tumor resection with application of ultrasound suction device and electrophysiological monitoring. In some cases, we used a metabolic navigation from 5-aminolevulinic acid to precisely identify the borders of astrocytomas (Grade II, III, IV). This allowed us resections tumors more radically with minimal postoperative deficits. Novalis and Cyber Knife were used as a treatment options for patient requiring. McCormick scale was used for evaluation neurological status. **Results:** Histological distribution were: 57% – ependymomas, 18% – astrocytomas, 35 10% – hemangioblastomas, and 15% had other histological type of tumors (cavernous malformation, glioblastomas, cancer metastasis and other). Follow-up period was one year, and the post-surgery recovery period took 3 to 6 months. Among the 320 patients under analysis, 33% showed some neurological improvement, 51% had no change, and 16% was revealed neurological deficiency. **Conclusions:** Using technology of metabolic navigation and electrophysiological monitoring simultaneously allows more radical resection spinal intramedullary tumors with less complications. Radiosurgical treatment of intramedullary tumors allows preventing recurrence.

Trauma Cervical I

A055: An Economic Case for the Surgical Treatment of Type-II Odontoid Fractures in the Elderly: A Markov Cost-Utility Analysis based on the Prospective AOSpine Geriatric Odontoid Fracture Study

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Introduction: Type-II odontoid fractures are the most common cervical fractures encountered in the elderly, with an overall incidence that appears to be rising. Substantial uncertainty continues to surround optimal management of these injuries; while non-operative treatment is associated with a high rate of non-union, surgery is more costly and may be associated with high complication rates in this age group. To provide further evidence on this topic, we performed a value based assessment comparing costs and health gains between these treatment strategies. **Material and Methods:** We constructed a Markov cost-utility model, with a life-long time horizon, comparing quality-adjusted survival and costs of surgical vs. non-operative treatment (external orthosis), from the perspective of the payer, for the base case of a 75 year-old person with a type-II odontoid fracture. Mean utility values, corresponding to the health states of interest, were calculated from primary data (SF-6D scores) prospectively collected during the AOSpine GOF Study. Probability rates for mortality, complications, failure/fusion were estimated based on a systematic review of the literature. Per patient treatment costs, presented in 2016 US dollars, were obtained from the Healthcare Cost and Utilization Project, National Inpatient Sample, averaged over a 7 year period (2003-2010). Incremental Cost Effectiveness Ratios (ICERs) were evaluated relative to a Willingness to Pay (WTP) threshold of 50,000USD/QALY. One- and two-way sensitivity analyses were performed to identify threshold values for age, cost, utility and probability values. Finally, probabilistic sensitivity analysis, using Monte Carlo Simulation with 1,000 sample iterations, was performed to generate ICER scatterplots and cost-effectiveness acceptability (CEA) curves. **Results:** Over a lifetime, as compared to non-operative treatment, surgery was associated with an average gain of an additional 0.81 QALYs and additional costs of 12,788USD, resulting in an ICER of 15,725USD/QALY for the base case analysis. With increasing age, surgery became less cost-effective, with age 96 representing the threshold beyond which the ICER exceeded the WTP threshold (ICER at age 85:26,069USD/QALY; ICER at age 95:46,049USD/QALY). Results were also found sensitive to variation in year 1 post-op mortality rates, with surgery becoming less cost-effective as surgical mortality increased and as non-operative treatment morality decreased (Figure 1). Model results were less sensitive to variation in costs or fusion and complication rates for each strategy. Probabilistic sensitivity analysis revealed surgery to be the most cost-effective strategy in 79.3% of the 1000 iterations sampled, as depicted in the ICER scatterplot (Figure 2). Generation of CEA curve demonstrated surgery to the preferred strategy above a WTP threshold of 20,000USD. **Conclusion:** Surgical treatment for type-II odontoid fractures in the elderly appears to provide better value with respect to costs and health gains compared to non-operative management with external orthosis. However, surgery becomes less cost effective with increasing patient age and increasing probability of early postop death. This implies that while surgery is likely to be the preferred approach for the younger healthier patient, conservative management may be more appropriate for the older patient with a higher probability of short-term mortality. Further studies are needed to confirm the findings presented here.

A056: Bicortical Facet Screws as a New Option for Posterior C2 Fixation: Anatomical Study and Clinical Experience

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Introduction: Many different techniques of C1-C2 arthrodesis have been developed and screw and rod constructs are actually the most commonly used. However, C2 pedicle or isthmic screw placement is technically demanding and carries the risk of neural and vascular injury. The inferior articular process (IAP) of the axis can be a safe alternative for screw placement in patients with bone or vascular variants of C1-C2 anatomy. We report the results of a CT study of C2 IAP anatomy, which can provide useful parameters for screw placement. We also present the preliminary clinical experience of 25 patients operated with this technique. **Material and Methods:** *Morphological study*: 50 CT angiographies of the vertebral arteries (VA) were used for this study, and therefore 100 IAP were considered. We measured on the axial and sagittal planes the length of the facet, the distance between the anterior cortex and the VA and the distance between the screw entry point and the VA. We also measured the angle between the sagittal plane passing through the entry point and the external tangent line of the VA. *Clinical report*: 25 patients (mean age 63) were treated with C2 IAP screws at the Spine Surgery Department of the University Hospital in Lyon, France, from January 2014 to Jun 2016. The screw entry point was located in the middle of the C2 IAP, and bicortical screws were inserted with a perpendicular trajectory on the sagittal plane and a lateral inclination of 15-20° on the axial plane. **Results:** *Morphological study*: the mean length of C2 IAP was 12 $\pm$ 2 mm, the mean distance between the anterior cortical layer and the VA was 5.2 $\pm$ 1,4 mm, and the mean distance between the screw entry point and the VA was 15.7 $\pm$ 1.9 mm. The mean angle we found was 0.2 $\pm$ 5.3°, with minimum and maximum values of $-$13.5° and 14.5° respectively. *Clinical report*: 13 women and 12 men were treated with C2 IAP screws. 15 of the 25 patients presented post-traumatic C1-C2 instability, 7 patients presented degenerative disease, 1 patient was treated for pseudoarthrosis, 1 for OPLL and 1 for rheumatoid arthritis. There was no post-operative neurological aggravation in this group. All the screws were correctly positioned and there was no VA injury. Among the 5 patients with post-operative complications, only the 3 wound infections were directly related to surgery. No mechanical complication (screw migration or pull-out) was noted post-operatively. **Conclusion:** C2 screw placement carries the risk of VA injury, and some anatomical condition such as narrow pedicles can increase this risk or even impede the procedure. IAP screws represent a safe alternative option for C2 fixation in some

cases, and the morphological and clinical data we present in this study demonstrated that it is a feasible procedure.

A057: Halo Vest Immobilization and Surgical Fusion for Pediatric Cervical Spine Injuries

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Introduction: Treatment options for pediatric cervical injuries include external immobilization and surgical fusion. Differences in the operative vs. non-operative treatment outcomes of different cervical injury locations (atlantoaxial vs. subaxial) has not been adequately addressed among pediatric patients. In this study, we performed a retrospective analysis using the Nationwide Inpatient Sample (NIS) database to compare complication rates for cervical injuries after external fixation or spinal fusion in the pediatric population. **Material and Methods:** Patients under the age of 18 with a discharge diagnosis of cervical spine fracture without spinal cord injury or cervical spine subluxation were identified in the NIS database. Patients who were treated with internal fixation or external immobilization between 2002-2011 were included for analysis. Patients who did not undergo treatment and patients with unspecified fracture level were excluded. Discharge weights were applied and used to produce national estimates. Outcome data included length of stay, in-hospital mortality, discharge disposition, total hospital charges, and development of in-hospital complications. **Results:** A total of 2,878 pediatric patients with cervical spine injury were identified after application of discharge weights; 1,462 patients (50.8%) with atlantoaxial injury and 1,416 (49.2%) with subaxial spine injury. There were 1,037 atlantoaxial injury patients (70.9%) treated with external immobilization and 425 patients (29.1%) who underwent internal fixation. Significant differences between groups included total charges ($73,786 $\pm$ $107,108 for immobilization and $98,158 $\pm$ $86,548 for surgery, $P = .040$), and development of at least one complication (1.9% for immobilization and 6.8% for surgery, $P = .029$). Mortality ($P = .363$), length of stay ($P = .221$) and non-routine discharges ($P = .106$) were not different between groups. Among patients with subaxial injuries, there were 542 patients treated with external immobilization (38.3%) and 874 patients treated with surgery (61.7%). When comparing external immobilization to surgery for suabxial injury patients, there were no significant differences in sex (68.2% male vs. 65.4%, p = 0.622), primary payer ($P = .493$), injury mechanism ($P = .234$), length of stay (6.4 $\pm$ 6.7 days vs. 5.5 $\pm$ 5.2, $P = .196$), mortality ($P = .430$), non-routine discharges ($P = .117$), complication occurrence ($P = .334$), or total charges ($69,042 $\pm$ $83,614 for external immobilization vs. $83,123 $\pm$ $66,491 for surgery, $P = .142$). Patients with subluxation alone were treated more often with surgical fusion than with external immobilization (2.2% vs. 1.2%, $P < .001$). **Conclusion:** The management of cervical spinal injuries in pediatric patients must be informed by the location of the injury. In patients with atlantoaxial injuries, the lower overall complication rate and decreased cost may warrant initial consideration of external fixation for treatment. Complication rates for subaxial injuries did not vary by treatment in this study, leaving both external immobilization and surgical fusion as two viable options for treatment. These results will help guide clinicians in their treatment decisions and support more cost-effective methods for managing cervical injuries.

A058: Trends in Incidence and Treatment of Odontoid Fractures

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Introduction: There is little information on the incidence of odontoid fractures in recent years and on the current treatment patterns amongst spine surgeons for these fractures. The purpose of the present study was to elucidate recent trends in surgical and nonsurgical treatment of odontoid across patient demographics. **Material and Methods:** Patients diagnosed with an odontoid fracture from 2005 to 2011 were identified in a national database of records from Medicare (PearlDiver Patient Record Database) using International Classification of Diseases, Ninth Revision (ICD-9) and Current Procedure Terminology (CPT) codes. Treatment groups were stratified as operative or nonoperative. The operative group consisted of fusion and fracture fixation. The nonoperative group included all other treatment modalities including cervical collar and halo vest. Results were analyzed by year, age group, gender, and geographic region. **Results:** There were a total of 56,230 odontoid fractures identified from 2005 to 2011. There was a 26.2% increase in fracture incidence over this period ($P < .0001$). The incidence of odontoid fractures increased with each successive age group with a 6.8-fold increase in patients over age 85 years compared to those under age 65 years ($P < .001$). Incidence was higher in females than males ($P < .001$) and in the Midwest compared to all other geographic regions ($P < .001$). There was a trend towards increased operative treatment over the study period from 6.7% in 2005 to 8.0% in 2011 ($P < .001$). Operative treatment was more common in males (12.0%) than in females (7.1%) ($P < .001$). Rate of surgery was highest in the West (10.9%) followed by the South (9.3%), Midwest (8.9%) and the Northeast (8.1%) ($P < .001$). Surgical treatment was most common in the 65-69-year and 70-74-year age groups (12.4% and 12.6% respectively) and least common in the >85-year age group (5.4%). **Conclusion**: Incidence of odontoid fractures steadily increased over the study period. Patients greater than 85 years were at the highest risk with a nearly

7-fold increase in patients younger than 65 years. There was a slight increase in the overall rate of surgical treatment over the study period; however, nonoperative treatment remained the dominant treatment modality across all years and patient groups. Operative treatment was most common in patients between 65- and 74-years-old and significantly less common in patients over 85-years-old. Although females accounted for a greater percentage of odontoid fractures, males were more likely to be treated operatively. The information on current trends in incidence and treatment of odontoid fractures may serve as a reference for future studies in light of recent evidence that operative treatment may be more cost-effective than nonoperative treatment in select patients.

A059: Application of AOSpine Subaxial Cervical Spine Injury Classification System as Predictor of Injury Severity and Neurological Outcome in Simple and Complex Cases

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Introduction: Cervical spine injury classification systems should be simple, easy to remember, related to injury severity, a guide surgical planning, reliable, and a predictor of outcome in clinical settings. Neither the mechanistic classification of Allen et al nor the conceptually simple classifications of TJ Harris et al have been capable of satisfying those objectives. We investigated whether the AOSpine subaxial cervical spine classification system predicted injury severity and neurological outcome. **Material and Methods:** We analyzed relevant clinical, imaging (preoperative CT, MRI, and postoperative MRI), management, and 6-month follow-up ASIA motor score of 92 AIS grades A-C patients with subaxial cervical spine fractures and spinal cord injury. Subaxial cervical spine injuries were classified according to the AOSpine Injury Classification System: A4 fractures are vertebral body fractures with both end-plates protruding into the spinal canal; B2 injuries are hyperflexion with intact anterior elements; B3 injuries are distraction injuries with intact posterior elements and no translation; and C type injuries are fracture dislocations with translation in any axis (X, Y, or Z) with disruption of the discoligamentous complex. We correlated morphology class to age, injury severity score (ISS), follow-up ASIA motor score (AMS), intramedullary lesion length (IMLL), and AIS grade conversion at 6 months post injury. **Results:** Mean age was 39.3, 83 patients were male, and 69 patients were injured during an automobile accident or following a fall. AOSpine Class was A4 in 8, B2 in 5, B2A4 in 16, B3 in 19, and C in 44 patients. Mean ISS was 29.7 and AMS was 17.1 (A4 = 17.6, B2A4 = 13.9, B2 = 9.8, B3 = 21.8, and C = 18 NS). AIS grade was A in 48, B in 25, and C in 19 patients. IMLL on postoperative MRI was 72 mm [(SD = 37.8): A4 = 68.1 (SD = 25.8); B2A4 = 86.5 (SD = 43.1); B2 = 59.3 (SD = 32.2); B3 = 46.8 (SD = 21.7); and C = 79.9 (SD = 39.1)]. At a mean follow-up of 6 months, mean ASIA motor score was 39.6 [SD = 31.9(A4 = 41.3, B2 = 54.3, B2A4 = 36.2, B3 = 53.9, and C = 33.1)]. Compared to Class B3 patients (simple hyperextension with intact posterior arch and no translation), Class C patients (with translation in any plane) were significantly younger ($P < .0001$), had longer IMLL ($P < .002$), and were less likely to have AIS grade conversion to a better grade ($P < .02$). **Conclusions:** AOSpine subaxial cervical spine injury classification system successfully predicted injury severity (longer IMLL) and chances of neurological recovery (AIS grade conversion) across different class subtypes.

A060: Complex Type II Odontoid Fractures: Our Management

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Introduction: Type II odontoid fracture is the most common fracture of CVJ which is often treated surgically. Incidence of non-union is high in cases managed conservatively due to complex nature of these fractures especially type IIA. Anterior odontoid screw fixation is useful in preserving the movements at C1-C2 whereas fixed arthrodesis achieved through posterior approaches lead to loss of motion at C1- C2. Anterior odontoid screw fixation is traditionally contraindicated in type IIA odontoid fractures, unstable odontoid fractures (ruptured transverse ligament, associated Hangman's fracture or AAD), difficulty in screw placement (severe angulation/translation, anterior oblique fracture line, body habitus) and in cases with high risk of non-union (displaced and irreducible fractures, osteoporosis). **Material and Methods:** We are reporting 22 patients with type II odontoid fractures. All the patients were surgically treated with anterior odontoid screw. In 4 cases, of which 3 cases, due to severe displacement/angulation and irreducibility of the fracture fragment and 1 case due to difficult trajectory in screw placement, anterior odontoid screw fixation was thought to be contraindicated. Pre operatively, patients underwent X-ray, NCCT and MRI of CVJ to classify the fracture, to know the status of ligaments and rule out other injuries of the cervical spine. We attempted anterior odontoid screw fixation to preserve the neck rotation at C1-C2. In 3 cases out of 4 complex cases, skeletal traction was applied in extension. However, the fracture fragments were not reducible. So we performed anterior odontoid screw fixation (which is otherwise contra indicated) with trans-oral continuous controlled pressure over the posterior pharyngeal wall to realign the fracture in 2 cases. In one case, as the realignment was not possible by pressure over the posterior pharyngeal wall, via transoral - trans pharyngeal

microscopic approach, fracture fragment was reduced. All trans oral procedures were done under neuromonitoring. Out of 4 complex cases, in one case of ankylosing spondylitis due to difficult trajectory in screw placement, projecting osteophytes over C2 and C3 were drilled and anterior odontoid screw fixation was done. All patients were followed up till 6 months post operatively with x-rays. In all the 4 complex cases, CT scan was done at 3 months post op. **Results:** 21 patients had successful fusion in the follow up and maintained normal cervical rotation. In one patient among the 4 complex cases, due to failure of alignment and screw back out after anterior odontoid screw fixation, a second procedure was planned and posterior C1-C2 fusion was done. **Conclusion:** The rotation at C1-C2 is most important movement at CV junction for human daily activities especially in young individuals. Every attempt should be made to reduce the fracture fragment to do anterior odontoid screw fixation before converting it to posterior fusion. Understading the mechanism of injury and fragment mobility helps in changing contraindication of anterior odontoid screw fixation in patients with complex odontoid fractures to an indication. However, experience & close follow up helps in preserving the C1-C2 rotation.

Novel Technologies and Diagnostics

A061: 9.4 T MRI Complements the Pfirrmann Grade through Better Differentiation of the NP/AF

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Introduction: MRI is the gold standard for visualization of intervertebral disc (IVD) degeneration. The 9.4 T MRI provides superior resolution and anatomical detail, however it has not yet been applied to the study of lumbar degenerative disc disease. The Pfirrmann1 and the Modified Pfirrmann2 grades, developed on 1 T and 1.5 T MRI respectively, do not take into consideration much of the detail now visible with the 9.4 T MRI. An updated and enhanced MRI grading system of IVD degeneration is therefore required. We developed a 9.4 T MRI grading system accounting for the enhanced definition of the annulus fibrosus (AF) lamellar architecture, nucleus pulposus (NP) and the NP/AF differentiation. We further developed a NP/AF distinction score to investigate whether this would correlate with the 3 T Pfirrmann grade. Additionally, we utilised a simple IVD degeneration classification accounting for the Pfirrmann grade and the new 9.4 T MRI grading system. **Materials and Methods:** 3 T and 9.4 T MRI (Agilent Technologies) lumbar spine studies were obtained at necropsy of 90 IVDs in 18 ewes involved in an IVD cellular therapy study. Disc degeneration was initiated in the ewes six months prior to necropsy via surgical intervertebral disc injury. The newly developed 9.4 T MRI grading system, evaluating for the AF signal intensity, NP signal intensity, AF lamellae structure, NP/AF differentiation and hypointensities in AF and NP, was applied to the 9.4 T T2 MRI images. Pfirrmann grades were calculated for the 3 T and 9.4 T MRI studies for comparison. A NP/AF distinction score was calculated on the 9.4 T MRI and compared with the overall 3 T Pfirrmann grade. **Results:** The 9.4 T MRI images demonstrated exceptional resolution and anatomical detail of the intervertebral discs. The 3 T and 9.4 T MRI Pfirrmann grades demonstrated a very strong correlation (R2 1). The NP/AF distinction score also demonstrated a significant correlation with the overall 3 T Pfirrmann grade (R2 0.92, $P < .0001$). The new 9.4 T MRI grading system did not demonstrate a strong correlation with the 3 T or 9.4 T Pfirrmann grades, R2 0.78 ($P < .0001$) and R2 0.77 ($P < .0001$) respectively. However, when the discs were stratified into mild degeneration (Pfirrmann grades 1-2; 9.4 T MRI grades 1-4), moderate degeneration (Pfirrmann grade 3; 9.4 T MRI grades 5-7) and severe degeneration (Pfirrmann grade 4-5; 9.4 T MRI grades 8-10), the new MRI grading system correlated very well with the 3 T and 9.4 T Pfirrmann grades (R2 0.92, $P < .0001$). An assessment of inter-observer and intra-observer reliability demonstrated acceptable levels of agreement. **Conclusion:** The 9.4 T MRI Pfirrmann grade demonstrated a strong correlation with the 3 T Pfirrmann grade, with good inter-observer reliability. The NP/AF distinction score correlated well with the overall 3 T Pfirrmann grades suggesting this could be a potential predictive measure of IVD degeneration. The poor correlation observed between the new 9.4 T MRI grading system and existing Pfirrmann grades likely reflects the wider range of scores possible with the new grading system. The new 9.4 T MRI grading system is a reliable tool that is better able to appreciate the subtle changes in IVD degeneration.

A062: Horizontal Rod and Band: A Novel Surgical Technique for Isthmic Repair

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Introduction: Many techniques are described for the surgical reconstruction of isthmic spondylolisis. Technical difficulties with some constructs have been described (wire breakage and cutting-through-bone with metal wire, bone lesions with directs screwing, difficulty to bend the rod and bone erosion with U-shaped rods under the spinous processess), but the healing of the underlying pseudarthrosis is not always achieved. We describe a new technique of fixation that allows for the application of progressive compression force over the pars interarticularis with a non-rigid device. **Material and Methods:** The surgical technique consists of the following steps: exposure of the pars defect, preparation and bone grafting; positioning of two polyaxial pedicle screws at the lythic vertebra with standard technique; a rod is inserted connecting horizontally the two screws and piercing the interspinous ligament above the lythic vertebra; commercially available sublaminar bands are passed from the right under base of the spinous process of the lythic vertebra, around the left side of the rod, again under the base of the spinous process from left to right and finally connected to the right side of the rod; tensioning of the band results in compression across the reconstruction, providing stability. A 14 year-old male with severe low back pain associated with a L5 isthmic lysis underwent surgical treatment after 10 months of unsuccessful conservative treatment. The case illustrates the technique. **Results:** The intraoperative fluoroscopy and the post-operative X-ray demonstrate reduction of the defect and effective compression provided by the fixation system. The patient was mobilized the day after surgery without a lumbar corset and discharged the following day. Physical activity was restricted for the first 6 weeks postoperatively. The patient presented to clinic at a month and half follow-up referring no lumbar pain during rest or light sports activity. **Conclusion:** The purpose of isthmic reconstruction is to stabilize the vertebral segment in the most anatomical manner with a safe and reproducible technique. Achieving isthmic healing will significantly improve the quality of life of the patient in terms of low back pain allowing for prompt recovery and return to sports activity, as well as reduce the rate of early degeneration of intervertebral disc.

A063: Intraoperative Neurophysiological Monitoring in Cervical Myelopathy

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Introduction: Intraoperative neurophysiological monitoring (IONM) is not used as a routine in spine surgery in many centers, although it is a standard of care in scoliosis procedures. Although there are many papers claiming that IONM is not needed in cervical procedures. Indeed, irreversible changes during IONM are predictive of severe adverse neurological outcomes (level of evidence class A) which is why it is becoming more popular in cervical spine procedures because it seems to be producing better functional result. **Material and Methods:** 191 consecutive patients (121male / 70 female; mean age of 60.15, SD = 15.1) who were undergoing cervical spine surgery fpr myelopathy from 2013 -2016 were recruited for the study. Anterior approach 109, posterior approach 82. Total intravenous anesthesia (TIVA) was used in all patients. No muscle relaxant after intubation. IONM was performed by SSEP and TcMEP in all patients. **Results:** IONM warnings were detected in 14 (7.3%) patients. 9/14 in presurgical cervical positioning of the patients (8/14 in posterior approach), all of them recover after repositioning. 3/14 for reversible hypotension. 2/14 during surgical procedure (one of them didnt recover IONM and woke up with severe tetraparesis). TcMEP were more sensitive than SSEP detecting warnings. **Conclusion:** Positioning during cervical procedures is a potentially damaging manoeuvre that may require an adequate neurophysiological monitoring technique in order to prevent damage to the spinal cord and consequently, the development of new postoperative neurological deficits.

A064: Predictive Accuracy of SurgimapTM Surgical Planning for Sagittal Imbalance: A Cohort Study

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Background: Surgical planning to correct sagittal spinal imbalance is recognized as a key component of the surgical strategy, ensuring better patient outcomes. Surgimap™ is a software designed to simplify surgical planning in patients with adult spinal deformity. **Purpose:** To evaluate the predictive value of surgical planning using Surgimap™ regarding postoperative sagittal alignment. **Methods:** We conducted a retrospective evaluation of a prospective cohort to compare the predicted sagittal alignment with a Surgimap™ computer simulation of the surgical correction and real post-operative X-rays. The study involved 40 non-consecutive patients who underwent surgery for sagittal misalignment in a single Orthopedic center between June 2009 and April 2013. Postoperative alignment measured by sagittal vertical axis (SVA) and pelvic tilt (PT) was considered the gold standard. Surgimap prediction of final alignment was considered the test. Planning and postoperative films were classified as properly and improperly aligned. Sensitivity, specificity, and positive and negative predictive values of Surgimap planning [using two different methods of preoperative planning: direct simulation (method A) and simulation after correction of pelvic tilt to 20° (method B)] to detect postoperative improper alignment were calculated. **Results:** Seventeen (42.5%) of 40 patients

had proper post-operative alignment. According to method "A" a proper alignment was achieved in 13 patients [S = 76.5%, Sp = 73.9%, RR = 2.93 (95% CI 1.40; 6.12), $P < .001$]; According to method "B" a proper alignment was achieved in 15 patients [S = 88.2%, Sp = 60.9%, RR = 2.25 (95% CI 1.32; 23.86), $P < .001$]. Kappa statistics indicate moderate agreement between actual post-operative alignment and computer prediction. In particular, when compared to method "A", method "B" demonstrates better performance regarding the ability to predict proper postoperative sagittal alignment (Negative Predictive Value -NPV- of method "B" was 88% vs. 81% by method "A"). **Conclusions:** The ability of Surgimap™ to predict proper post-operative sagittal alignment was excellent (NPV 81% to 88%) in this cohort. Its ability to predict proper alignment was improved by correction of PT to 20° during planning (Method "B", NPV 88%).

A065: Evaluation of Techniques to Determine Rotational Alignment of the Vertebral Body in Minimally Invasive Spine Surgery: A CT Analysis of Lumbar Spine Symmetry

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Introduction: Minimally invasive spine surgery relies heavily on fluoroscopic guidance. Rotational alignment of the vertebral body (VB) is typically assessed using two different techniques. The first involves assessment of the pedicles to ensure that they are symmetrical in size and proximity to the lateral wall of the VB. The second method evaluates the position of the spinous process (SP) to ensure it falls in the center of the lateral walls of the VB. The precision of these techniques may be confounded by anatomic variation and deformation of these structures. This paper aims to evaluate the reliability of these techniques by evaluating the symmetry of these structures on CT scan. **Materials and Methods:** One hundred lumbar spine CT scans from patients complaining of back pain, without evidence of scoliosis or spondylolisthesis, were reviewed; a total of 500 lumbar vertebrae. Measurements included pedicle height and width, distance from the pedicle to the lateral wall of the VB and the angle of the SP measured from the perpendicular of a line running through the widest point of the VB. The length of the SP was also measured and these values allowed us to calculate the offset from midline of the tip of the SP as would be seen in an AP fluoroscopic image. Considering the measurement error of a Cobb angle is quoted at 5 degrees, we labeled SP angles less than this as relatively perpendicular to the VB. **Results:** There was no statistical difference appreciated comparing bilateral pedicle height and width or pedicle-lateral wall distance for each VB from L1 to L5. The SP angle was found to deviate relatively equally to the right or left and this varied from level to level even within the same patient. Notably, the deviation of the SP was greater than 5 degrees in 14.4% of the vertebrae. In the L1 body, SP angle was greater than 5 degrees in 12% with the average deviation in these of 5.73 degrees, correlating to an offset of 3.1 mm. L2 SP deviation was greater than 5 degrees only 4% of the time, averaging 6.05 degrees meaning an offset of 4 mm. The L3 the SP deviated 16% of the time averaging 6.36 degrees meaning an offset of 3.7 mm. The L4 SP also deviated 16% of the time, averaging 7.3 degrees with an offset of 3.7 mm. The L5 SP deviated 24% of the time averaging 8.48 degrees meaning an offset of 4.9 mm. **Conclusion:** Our CT guided anatomical study of the lumbar vertebrae shows that pedicle dimensions and pedicle-lateral wall distance are symmetrical and therefore reliable measures of VB rotation. The novel finding is that the SP is not an accurate marker of midline as it may significantly deviate to one side 4-24% of the time by a margin of 3.7 to 4.9 mm. This occurs more frequently as we move caudal in the lumbar spine. Using the SP to determine midline of the VB may lead to misalignment during localization, increasing the risk of medial or lateral breach of the pedicle wall.

A066: Extra Foraminal Selective Nerve Root Block: A Novel Technique for Management of Lumbar Radiculopathy

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Introduction: Selective nerve root blocks (SNRB) play an important role in treating cases with lumar radiculopathy. Traditionally since describing its reported outcomes transforaminal SNRB was being considered as a standard route for lumbar radiculopathy. Technically the transforaminal route of SNRB is a difficult procedure with many reported complications. We here in the study propose a novel technique in SNRB's. **Material and Methods:** A clinical study of 100 individuals with lumbar nerve root radiculopathy of spinal origin who does not fit into the surgical management category. Nerve root compression was confirmed by MR Images. Pre-block Visual Analogue Scale(VAS) and ODI scores were taken. Extraforaminal SNRB was given by fellows in spine surgery at our institute in the OT setup under the fluoroscopic guidance. A 23-guage spinal needle was inserted at the junction of pars and transverse process. After feeling the bone at the other end, needle was made to advance few mm laterally (sliding from pars). Contrast dye made from salts of diatrizoic acid was injected. Track of nerve root was visualised and confirmed under c-arm followed by administering 3 cc of 2% xylocaine and 40 mg methylprednisolone acetate through the same needle. Post block VAS score and after 3 weeks ODI score were taken. **Results:** Pre block VAS score of the cases was 7.6 $\pm$ 1.4. ODI score was

found to significantly change before (68 ± 17) and 3 weeks (37 ± 12) after the procedure. Immediate post-block the visual analogue score decreased to 2 ± 1. There were no reported complications of neural or vascular deficit. **Conclusion:** Selective nerve root blocks (SNRB) have gained a larger aspect of importance for the pain physicians. Transforaminal route of SNRB has been the mainstay till date. But we propose a novel technique of SNRB in the lumbar region as it is safe without any major complications and can be learned/ practised easily.

Surgical Outcomes

A067: Incidence and Influence of Depression and Anxiety on Clinical Outcome Before and One Year after Spine Surgery for Degenerative Disc Disease

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Introduction: It is widely accepted that psychiatric comorbidities have a negative influence on clinical outcome following spine surgery for degenerative disc disease. However, most published data is restricted to postoperative measurements and data from preoperative settings in lacking. We previously demonstrated that mental comorbidities at 3 months follow up are very common and negatively influence clinical outcome. Aim of this study was to assess the incidence and influence of mental comorbidities on clinical outcome one year after surgery. **Methods:** A prospective study of patients undergoing elective spine surgery performed. Evaluation for depression (ADS-K score) and anxiety (STAI-S, STAI-T and ASI-3 scores) were done before and one year after surgery. In addition SF36 physical composite score (PCS), Oswestry Disability Index (ODI), EuroQOL 5D and pain visual analog scale (VAS) were completed preoperatively, 3 and 12 months follow up. Incidence and influence of these psychiatric comorbidities on clinical outcome were examined. **Results:** 184 patients met the inclusion criteria. 52.7% were male, mean age was 59.4 years. Abnormal anxiety scores were observed in 59.2%, 36.8% and 40.1% of cases before, at 3 and 12 months follow up, respectively. 25.0% of the patients showed abnormal ADS-K scores preoperatively compared to 10.5% and 14.5% at 3 and 12 months follow up, respectively. However, only 10.6% and 6% of patients developed anxiety and depression only following surgery, respectively. At one year follow up patients with abnormal anxiety scores showed a reduced clinical outcome compared to their counterparts (SF36 PCS: 34.7 vs 41.0, $P = .005$; EuroQol Index: 0.66 vs 0.82, $P = .001$; ODI: 30.3 vs 17.8 $P = .008$). Moreover abnormal ADS-K scores at one-year follow up were also associated with reduced clinical outcome (SF 36 PCS: 33.5 vs 39.7, $P = .01$; EuroQol Index: 0.55 vs 0.79, $P = .001$; ODI: 34.3 vs 19.4 $P = .008$). **Conclusion:** The incidence of depression and anxiety disorders in patients undergoing elective spine surgery is very high. This was also associated with unfavourable outcome one year after surgery. The standard scores for mental health seem highly nonspecific in the preoperative period. Spine specific screening tools are needed.

A068: AOSpine Needs Assessment at the Spine Surgery Department, University Hospital Basel

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Introduction: All planning for the design and development of educational events and resources for the continuing professional development of clinicians should be based on a solid needs assessment process. In the area of spine surgery, many tools have been used to gather information on educational needs and gaps. These include surveys (both online and at events), literature reviews, analysis of hospital data, diaries of questions, and interviews or focus groups, conducted either alone or in combination. **Material and Methods:** AOSpine designed a 4-phase needs assessment process to collaboratively conduct a hospital-based needs assessment at the University Hospital Basel. 1. Identify the participants and the surgeon leaders, 2. Agree a project plan with the team, 3. Gather needs assessment data through online questionnaires, interviews and focus groups, diaries of questions asked in daily practice, and any available statistics from the hospital, and 4. Analyze the data, identify the key findings, and create a plan to address the largest needs and gaps. **Results:** All 21 residents and practicing surgeons who are actively involved in treating spinal pathologies in the department completed the online questionnaire. Nine participated in a follow-up interview and 4 kept a diary of questions over a 1-week period. Analysis of the data created many observations and ideas for delivering education to meet the gaps and perceived needs. For the 12 neurosurgery and orthopedic residents, the 3 highest-rated (weighted average of all responses) pathologies where respondents had a "need for education in the next 2 years" were cervical trauma (4.0), thoracolumbar trauma (3.92), and adult deformity (3.83). For the 9 practicing surgeons, the 3 highest-rated needs were infection (3.00), adult deformity (3.00), and secondary tumors (2.89). In addition to many specific needs being identified for individual pathologies, there was also a high level of interest in surgical approaches and MISS techniques. For 5 specific nontechnical skills, the following gap scores between current and desired level of ability were reported (for residents and practicing surgeons respectively): Use effective communication strategies to gather and share information with patients and their families (0.55, 0.56), Collaborate with other healthcare professionals to

implement the treatment plan (0.82, 0.56), Manage your roles as an individual healthcare provider, a member of teams in the hospital or practice, and a leader within healthcare systems (1.18, 1.22), Commit to Lifelong learning, teaching, and mentoring others (1.91, 1.11), and Ensure the best possible outcomes for patients and communities through ethical behavior and adhering to high standards of practice (1.45, 0.67). **Conclusion:** Inviting all surgeons and trainees from the spinal department to participate in this needs assessment resulted in a high level of engagement and a full online response rate. Using mixed methods and analyzing the data in two groups provided an optimal approach to review the information and to identify key findings. Several plans are now being implemented to meet the identified needs.

A069: Successful Lumbar Surgery Results in Long-Term Improvement in Psychological Well-Being

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Introduction: Patients undergoing lumbar surgery often have depressive and anxiety symptoms. Long-term effects of surgery on these psychological symptoms have not been rigorously evaluated. This longitudinal study compared pre- and 2-year postoperative psychological symptoms in 276 lumbar surgery patients and assessed whether change in symptoms was associated with success of surgery. **Material and Methods:** Several days preop patients completed two psychological surveys, the Geriatric Depression Scale (GDS) (possible score 0-30, $\geq$11 is positive screen for depression) and the Spielberg State Anxiety Inventory (STAI) (possible score 20-80, population norms are used for comparison). Patients also completed the Oswestry Disability Index (ODI) measuring disability from low back pain (possible score 0-100) and a validated Lumbar Surgery Expectations Survey measuring expected improvement for symptoms, function, and mental health (possible score 0-100). Medical comorbidity was obtained according to a standard index. Two years postop patients again completed the GDS, STAI, and ODI from the perspective of their current condition, and pre- to postop changes in score were calculated. Patients also reported new/worse comorbidity since surgery, and amount of improvement obtained for each expectation from which an overall proportion of expectations fulfilled was calculated (range 0 -1, higher = greater fulfillment). Improvement in GDS and STAI was defined as better psychological well-being. Success of surgery was defined as greater proportion of expectations fulfilled and improvement in ODI scores. **Results:** Mean age was 55 years, 56% were men, 78% had chronic spine conditions, 28% had major comorbidity preop, 19% reported new/worse comorbidity postop. Mean GDS scores were 9.8 (preop), 5.1 (postop), and 4.8 (within-patient change, $P < .0001$). More improvement in GDS scores was associated with a greater proportion of expectations fulfilled ($P < .0001$) and greater improvement in ODI scores ($p<.0001$). 41% preop screened positive for depression versus 16% postop ($P < .0001$). Compared to those who screened positive, those who screened negative postop had a greater proportion of expectations fulfilled (.33 vs .75, $P < .0001$), and a greater change in ODI scores (13 vs 34, $P < .0001$). Mean STAI scores were 40 (preop), 31 (postop), and 9 (within-patient change, $P < .0001$). More improvement in STAI scores was associated with a greater proportion of expectations fulfilled ($P < .0001$) and greater improvement in ODI scores ($P < .0001$). 59% preop had anxiety symptoms above population norms versus 26% postop ($P = .002$). Compared to those who were above population norms, those who were below population norms postop had a greater proportion of expectations fulfilled (.40 vs .79, $P < .0001$) and a greater change in ODI scores (15 vs 36, $P < .0001$). All associates persisted when controlled for pre- and postop comorbidity. **Conclusion:** Traditionally, preoperative psychological symptoms have been assessed as predictors of outcomes of lumbar surgery. Our study demonstrated that outcomes of lumbar surgery, in turn, predict postoperative psychological well-being. The strengths of this study are its longitudinal design, use of within-patient change in scores for all measurements, use of patient-centered measurements, and control for pre- and postoperative comorbidity. This study provides evidence that successful lumbar surgery not only improves physical symptoms and function, but also improves psychological well-being.

A070: Habitual Smoking in the Young Employees, Alcohol Intake, Depressive Mood and Non-Sedentary Work Demand have Associations with LBP: A Survey of Employed Workers in a Medical Factory of Japan

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Introduction: Understanding of the associated factors with low back pain (LBP) and implementing effective prevention strategies are crucial. If the modifiable associated risk factors (for example, smoking) which develop prevalence and disability due to LBP is uncovered in the working generations, primary care, educational program and so forth could be recommended. Furthermore, potential saving costs for workers' care system and the society is highly anticipated as well. The purpose of the current cross-sectional survey is to identify a prevalence of present LBP and to analyse modifiable risk factors associated with LBP. **Material and Methods:** A questionnaire could be collected from 1452 out of 1489 workers of a medical factory in November 2015 (collection rate: 97.5%). A

self-administration questionnaire was used in the current survey. Age, gender, body height, body weight, and the type of the work demand were also ascertained in the questionnaire, for evaluation of mental condition. The medical component summary score (MCS) from Medical Outcome Study Short-Form 36-Health Survey (SF-36®) was used for evaluation of mental condition. Associations between LBP and age, gender, BMI, smoking, alcohol intake, regular exercise, work demand and mental condition was evaluated by a multiple logistic analysis ($P < .05$ = significant). **Results:** The mean age of the participants was 38.8 ± 12.8 (mean ± standard deviation). The prevalence of LBP in the present week (pwLBP) was 27.7% (28.1% in men, 26% in women). The odd ratio (OR) for aging was 1.40 (95%CI 1.03 -1.90) in the participants with the age 50 to 59 years referring to age 20 to 29 years. The habitual cigarette smoking (the mean dose: 11.9 ± 6.4 cigarettes/day) has an association with pwLBP in young adults, whose age was 37 years or less, and the OR was 2.07 (95%CI 1.47 -2.93). The alcohol intake (the mean dose: 23.4 ± 37.4g/day) also has a mild association with pwLBP and the OR was 1.33 (95%CI 1.05 -1.68, $P < .019$). The OR of pwLBP was 1.34 (95%CI 1.02 -1.78, $P < .044$) in the participants with the light to moderate work demand. The OR in the participants with MCS score less than 35 was 2.64 (95%CI 1.96-3.56). **Conclusion:** Habitual cigarette smoking in the young generation whose age was 37 years or less, alcohol intake, non-sedentary work demand and depressive mood are associated with pwLBP of the employed workers. Therefore, reduction of smoking and alcohol intake, less demand of the non-sedentary work and improvement of depressive mood has a possibility to decrease the present LBP.

A071: The Relationship between Gastric Esophageal Reflux Disease and Spinal Sagittal Alignment in Elderly Patients

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Introduction: It is known that the QOL for aging patients who have spinal kyphosis deformity is frequently impacted by symptoms of gastric esophageal reflux disease (GERD). There is scattered mention in case study literature where refractory GERD has been seen to improve rapidly after correction of sagittal deformity. The purpose of this study was to evaluate the relationship between gastric esophageal reflux disease and spinal sagittal alignment. **Material and Methods:** 888 consecutive patients seen at our osteoporosis outpatient clinic between 2009.9 and 2015.7 were asked to complete frequency scale for the symptoms of GERD (FSSG) and Questionnaire for the Diagnosis of Reflux Disease (QUEST) questionnaires. After excluding scoliosis patients, 726 patients (111 males, 615 females) remained who had completed both questionnaires and for whom whole spine radiographs were available. Patients who scored positively on both questionnaires (8 or more on the FSSG and 4 or more on the QUEST) were assigned to the GERD group. On the other hand, non-GERD group was determined as a negative of both questionnaires. Spinal sagittal alignment was evaluated using measurements of thoracic kyphosis (TK: T2-T12), low thoracic kyphosis (T5-12), thoracolumbar sagittal angle (T10-L2), lumber lordosis (LL: T12-S), pelvic tilt (PT), sacral slop (SS), pelvic incidence (PI), and sagittal vertical axis (SVA). From DEXA scan data we calculated total bone mass density from L2-5, and used multiple regression analysis to compare each of the sagittal parameters between the GERD and non-GERD groups. **Results:** 98 of 726 patients (13.5%) (10 males, 88 females) were included in the GERD group. Non GERD group was 446 patients (66 males, 380 females). Averages were 41.7°/41.5°TK, 34.6°/33.8°T5-12, 21.9°/16.2°at T10-L2, 36.4°/34.5°at T12-S, 28.6°/27.0° SS, 28.5°/26.4° PT, 53.6°/48.3° PI and 52.6mm/45.6 mm SVA for the GERD group and Non-GERD groups respectively. Significant correlation to GERD was found only for TK at T10-L2 and PI ($P < .001$). Mean BMD (g/cm2) was 0.701/0.736 at L2-5. **Conclusion:** The diagnostic reliability of the FSSG and QUEST questionnaires individually is reported to be about 60% so studies with endoscopic findings are planned. However, with the combined use of both questionnaires as criteria for this study's GERD group, reliability is thought to be high. We detected the level of sagittal alignment related GERD. Since the vertebra at the thoracolumbar junction are at high risk for fractures, early detection and treatment of osteoporosis is also important in the prevention of GERD.

A072: Cross-cultural Adaptation and Validation of the Turkish Version of the Core Outcome Measures Index for Low Back Pain

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Introduction: Patient based outcome measures have been recommended for evaluation of patients with spinal disorders and outcome of treatments. Several measurement tools are available in different languages, encouraging multinational studies and the use of international spine registry systems. The Core Outcome Measure Index (COMI) is a self-administered multidimensional questionnaire intended to evaluate the affect of LBP on daily life. It has six core questions about pain (back and leg), function, symptom-specific well-being, quality of life, work and social disability. It is the recommended outcome instrument in the Spine Society of Europe Spine Tango Registry. The aim of this study was to produce a cross-culturally

adapted and validated Turkish version of the COMI Back questionnaire. **Material and Methods:** A cross-cultural adaptation of the COMI into Turkish was carried out using established guidelines. Ninety-six Turkish-speaking patients with nonspecific LBP were recruited from orthopedic and physical therapy outpatient clinics in a public hospital. They completed a booklet of questionnaires containing Turkish version of COMI, adjectival pain scale, Roland Morris disability questionnaire (RM), European 5 Dimension Questionnaire (EQ-5D) and brief version of World Health Organization Quality of Life Questionnaire (WHOQOL- BREF). Within following 7-14 days, 67 patients, reported no or minimal changes in their back pain status, completed the Turkish COMI again to assess reproducibility. **Results:** Data quality was good with very few missing answers. COMI summary index score displayed %3 floor effects and no ceiling effects. The correlations between the COMI summary index score and the each of the full instrument whole scores were found to be excellent to very good (Rho = −0.81−0.74). Reliability expressed as intraclass correlation coefficient (ICC) was 0.95 (95% CI 0.91-0.97. Standard error of measurement ($SEM_{agreement}$) was acceptable 0.41 and the minimum detectable change (MDC95%) was 1.14. **Conclusion:** Turkish version of the COMI has acceptable psychometric properties. It is a valid and reliable instrument and cross culturally adapted, in accordance with established guidelines, for the use by Turkish speaking patients. It can be recommended for use in evaluation of patients with chronic LBP in daily practice, in international multicenter studies and in spine registry systems.

Lumbar Spondylolisthesis

A073: Decompression Versus Fusion for Grade I Degenerative Spondylolisthesis: A Meta-Analysis

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Introduction: Degenerative spondylolisthesis (DS) remains one of the most common indications for spine surgery. Although large multi-institutional trials supported surgical treatment for this pathology, and recent meta-analysis has compared different fusion techniques, the best surgical management option for patients with only grade 1 disease has not been determined. Therefore, the purpose of this study is to compare decompression and fusion with decompression alone for the treatment of grade 1 degenerative spondylolisthesis. **Material and Methods:** Following PRISMA guidelines, the MEDLINE, Embase, and Ovid electronic databases were systematically reviewed to assess for studies evaluating patients with grade 1 spondylolisthesis published from January 1996 until July 2016. Within these studies, we stratified all patients into two cohorts; the first group had patients who underwent a decompressive-type surgery and the second cohort consisted of patients who also underwent a fusion procedure. We specifically looked at clinical outcomes, complications, reoperations, and additional surgical details such as blood loss. Descriptive statistics were used to describe both cohorts; then, random effect models were used to determine the rates of the specified outcome metrics, with its 95% confidence intervals. **Results:** A total of 17 studies met our criteria. There were 9 studies (N = 591 patients) who were part of the decompression cohort, with a mean age of 67 years (range, 62-69 years), a mean BMI of 24 kg/m^2 (range, 23-26 kg/m^2), and 54% were women. The fusion cohort had 14 studies (N = 434 patients) with a mean age mean 60 years (range, 49-70), had a mean BMI of 24 kg/m^2 (range 23-26 kg/m^2) and 71% were female). In both cohorts, the pain (leg and low back) significantly decreased, the physical component of the Short Form 36 (SF-36), and overall increased the outcome metric scales. In terms of complications, the decompression cohort had a 7.5% complication rate (95% CI of 2 to 16%) and the fusion had a 9.2% complication rate (95% CI of 7 to 12). In contrast, the reoperation rate was higher in the decompression cohort with a 6% rate (95% CI of 1 to 15%) than in the fusion cohort with a 4.4% rate (95% CI of 2 to 7). **Conclusion:** With the current literature, it does not appear to be any advantage of one procedure over the other. Patients undergoing decompression alone tended to be older and had a higher percentage of leg pain while fusion patients tended to be younger and have more low back pain. The decompression cohort had fewer complications but a higher revision rate. Future studies specifically assessing patients with low grade DS are needed to determine the benefits and cost effectiveness of one procedure versus another.

A074: Re-admission, Re-operation, and Patient Reported Outcomes after Lumbar Fusion Surgery for Spondylolisthesis in 480 Patients from the QOD Registry

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Introduction: The American Association of Neurological Surgeons launched the National Neurosurgery Quality and Outcomes Database (QOD), a prospective longitudinal registry utilizing patient reported outcome instruments and includes data to measure the safety and quality of spinal surgery. In the present study, the authors analyzed 12-month outcomes data for patients undergoing lumbar fusion surgery for grade 1 degenerative spondylolisthesis. **Material and Methods:** The prospective QOD dataset from top enrolling sites was retrospectively queried and we found 480 patients undergoing elective spine surgery for one, two, or three level degenerative grade 1 lumbar spondylolisthesis. Baseline, 3-month, and 12-month follow-up readmission rates, re-operation rates, and patient reported outcomes [Oswestry Disability Index (ODI) and back and leg pain Numeric Rating Scale (NRS)] were collected. The absolute differences between 12-month post-operative and baseline ODI and back and leg pain NRS scores were evaluated. **Results:** The 30-day readmission rate was 3.3%. The 90-day readmission rate was 4.6%. The 30-day re-operation rate was 3.1%. The baseline ODI scores differed from the 12-month scores by an absolute difference of 12.1 $\pm$ 8.8 ($P < .001$). The baseline back and leg-pain NRS scores differed from the 12-month scores by an absolute difference of 3.9 $\pm$ 3.1 and 4.0 $\pm$ 3.6, respectively ($P < .001$). **Conclusion:** This prospectively collected data is uniquely generated through the spine surgeon's office directly from the patients. Lumbar fusion surgery for grade 1 degenerative lumbar spondylolisthesis is associated with low 30-day re-operation rates and 30- and 90-day readmission rates. Fusion surgery was associated with significant improvements in patient-reported outcomes at one-year follow up.

A075: The Effect of Surgical Wait Time On Patients With Degenerative Lumbar Spondylolisthesis: A Canadian Spine Outcomes and Research Network (CSORN) Study

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Introduction: Study Design: Ambispective review of the Canadian Spine Outcomes and Research Network (CSORN) registry cohort. **Objective:** To investigate the effect of surgical wait time (SWT) on the baseline and postoperative patient reported outcome (PRO) metrics in surgical patients with degenerative spondylolisthesis (DS), and to identify independent predictors of outcome in surgical patients with DS. **Summary of Background Data:** DS is the most common form of lumbar spondylolisthesis. Surgery is considered with failure of non-operative management and persisting symptoms. From a patient perspective, rapid access to spine specialist care is preferred. However SWT to initial spine specialist consult and elective surgery can be prolonged, especially in a single-payer health care system. **Material and Methods:** Surgical DS patients treated between 2013 and 2015 were identified in the CSORN registry. SWT was defined as the period from surgical wait listing to day of surgery, with study population dichotomy to: (1) SWT < 3-months; and (2) SWT $\geq$ 3-months. Baseline and post-operative (3-month, 1-year) demographic and PRO metrics were analyzed using bivariate and multivariate modeling. **Results:** At baseline, the SWT < 3-months cohort had 158 patients while the SWT $\geq$ 3-months cohort had 146 patients. Both SWT groups had similar distributions of age, gender, symptom duration, and smokers. The SWT < 3-months cohort however had more compensated patients ($P < .01$). Both groups were also similar in terms of baseline PROs and spine specific metrics except for the SWT $\geq$ 3-months cohort who were more depressed ($P < .01$). At 3-months, the SWT $\geq$ 3-months cohort showed greater satisfaction (96.2% vs. 86.2%, $P < .01$). This effect was not maintained at 1-year. All other PRO metrics were similar at 3-months and 1-year. Multivariate modeling showed that both surgical wait times and symptom duration were not independent predictors of outcome in surgical DS patients. Subgroup analysis of symptom duration showed indifference in outcomes at 3 months but superior results at 1 year for those with shorter duration of symptoms. **Conclusion:** Prolonged surgical wait time was not detrimental on the post-operative outcome in surgical patients with degenerative spondylolisthesis. Subgroup analysis however showed better results in patients with shorter duration of symptoms.

A076: Surgical Outcome of Pedicle Screw-Lamina Hook Plus Isthmic Bone Grafting through Wiltse Approach for Lumbar Spondylolysis in Children and Adolescent: An Over 5 Years Follow-up

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Introduction: To investigate the long-term effect of pedicle screw-lamina hook plus isthmic bone grafting through Wiltse approach for lumbar spondylolysis in children and adolescent. **Material and Methods:** From July 2005 to May 2009, 43 patients (31 males, 12 females; 9-25 years old, average 17.2) with lumbar spondylolysis combined with or without slippage were enrolled in our study. All of the patients were treated with the pedicle screw-lamina hook plus isthmic bone grafting and followed up at least for 5 years. There were 33 Single level spondylolysis and 10 double level spondylolysis. The symptom status were evaluated by Visual analogue scale (VAS) score and Oswesty dysfunction index (ODI) preoperatively and at 3days, 3 months, 6 months, 1 year after surgery and the final follow-up. The surgical outcome was assessed by Henderson method. AP view, flexion and extension view, oblique X-rays were performed at every time point. 3D-CT scan was taken 1 year after surgery to assess the bone fusion. Modified Pfirrmann grade was used to evaluate the disc degeneration. And the adjacent segmental degeneration was assessed by the UCLA grade on the X-ray of the final follow-up. **Results:** All patients were follow-up over 5 years (68-122 months, average 83.3). The surgery was successful, the average operation time was 125 min (85-155 min), the average intraoperative blood loss was 120 ml (80-160m1), and the post-operative drainage was 54m1 (35-85m1). No complication was observed. The VAS and ODI score of postoperative was significantly different from that pre- operation ($P < .05$). The bone fusion was observed in 39 patients after 1-year follow-up, the fusion rate was 90.7%. There was no detachmented the pedicle screw-lamina hook and intervertebral altitude loss. UCLA grade showed no adjacent segmental degeneration occurred. 8 cases had degeneration of lumbar intervertebral disc on the MRI images at the final follow-up. **Conclusion:** Compared with the multi-segmental fixation and interbody fusion, the pedicle screw-lamina hook plus isthmic bone grafting is a single-fixation, and this operation is technically simple and no sacrifices of lumbar motion ranges, and it is proved to be effective.

Novel Technologies and Sacral Joint Fusion

A077: Twelve-Month Outcomes from a Multicenter Randomized Controlled Trial of Minimally Invasive Sacroiliac Joint Fusion with Triangular Titanium Implants vs Conservative Management

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Introduction: The sacroiliac joint (SIJ) is a common cause of chronic, unremitting Lower Back Pain (LBP). A significant number of patients do not respond to Conservative Management (CM). New Minimal Invasive SIJ fusion procedures were developed. **Material and Methods:** 103 Adults with chronic SIJ pain at 9 sites in 4 European countries were randomly assigned to either minimally invasive SIJF using triangular titanium implants (N = 52) or CM (N = 51). CM was performed according to the European guidelines for the diagnosis and management of pelvic girdle pain and consisted of optimization of medical therapy, individualized physical therapy (PT) and adequate information and reassurance as part of a multifactorial treatment. Subjects assigned to CM not benefitting from it for at least 6 months, were allowed cross over to any other treatment, including minimally invasive SIJF. Endpoints included low back pain and leg pain scores, quality of life using EQ-5D-3 L, disability using ODI, SIJ function using ASLR, mental state using Zung depression scale and adverse events. **Results:** Results. At 6 months, the improvements in LBP and ODI were higher in the SIJF group vs. CM group (both $P < .0001$) and well exceeding the Minimal Clinical Important Difference (MCID). ASLR, EQ-5D-3 L, Zung depression scale, walking distance and satisfaction were statistically superior in the SIJF group. The frequency of adverse events did not differ between groups. One case of postoperative nerve impingement occurred in the surgical group. In the surgical group, the 12-month improvements in pain, disability and quality of life were similar to those seen at 6 months. 37 (76%) of the subjects assigned to CM and still participating at 6 months had a change of $\leq$20 in LBP VAS, 21 (43%) of them crossed over to SIJ fusion. Amongst crossovers, changes in pain, ODI and QOL at 6 months after crossover were similar to those in the group initially assigned to surgical care. **Conclusion:** This study demonstrates that in patients with chronic SIJ pain, minimally invasive SIJF using triangular titanium implants was safe and more effective than CM in relieving pain, reducing disability, improving function, and improving quality of life. The response to minimally invasive SIJF was maintained at 12months. The majority of subjects assigned to conservative management did not benefit (change in LBP VAS $\leq$20) from it for at least 6 months.

A078: Is Kambin's Triangle Safe for Lumbar Interbody Fusion? Minimally Invasive Extraforaminal Lumbar Interbody Fusion (ELIF)

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Introduction: We introduce a minimally invasive extraforaminal lumbar interbody fusion (ELIF) that is the novel lumbar approach, a newly emerging minimally invasive technique for treating degenerative lumbar disorders. **Materials and Methods:** 23 patients who received minimally invasive ELIF through the Kambin's triangle included in this study, retrospectively. ELIF performed through the Kambin's triangle. We checked the radiologic result as following: 1) implant related complications, and 2) fusion status. Clinical result checked as following: 1) Surgery related neurologic complications 2) Visual Analogue Scale (VAS) and 2) Oswestry Disability Index (ODI). **Results:** The mean age was 58.96 years and the mean follow-up period was 29.96 months. According to the result, implant related complications were 4 cases (17.39%) and fusion failures were 5 cases (21.74%). We experienced 5 cases (21.74%) of surgery related neurologic complications and all patient's neurologic complications recovered within 1 month after operation. The mean VAS (Back) prior to surgery was changed as following: Preoperative: 6.43, and 2 years after operation: 3.04. The mean VAS (Leg): Preoperative: 7.70 and 2 years after operation: 2.91. The mean ODI score: Preoperative: 76.78 and 2 years after operation: 29.91. **Conclusion:** According to the result, we obtained excellent clinical results using the minimally invasive ELIF without any serious traversing or exiting nerve injury. But, fusion rate and cage subsidence remained still overcome issue. If we developing this novel surgical technique, we will obtain the excellent clinical result using the minimally invasive percutaneous procedures.

A079: A Patient-Specific Image-Based Computational Model for Biomechanical Evaluation and Design of 3D Printed Polycarbonate Fusion Cages

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Introduction: Spinal fusion surgery is accepted as the gold standard for the treatment of degenerative disc diseases when a conservative approach fails. The most commonly used devices for this procedure are interbody cages made of metals such as titanium, tantalum or polymers as polyether ether ketone. The mismatch in mechanical properties between the implant and surrounding bone has been largely suggested as a cause of implant subsidence and therefore suboptimal outcomes. While it is largely recognized that the geometry of the interbody cage is crucial in restoring the load patterns, the optimal implant design still remains debatable. Standard implants and instrumentations may be unsuitable for some surgical cases. Hence, patient-specific designs can potentially improve clinical outcome in spinal surgery by creating an optimal match for each anatomy. Recent advances in computational models combined with additive manufacturing technology can be now used to optimize existing device and develop novel implant designs with control over the architecture, which may facilitate cell adhesion and bone in-growth.[1,2] Moreover, 3D printable biomaterials such polycarbonate have recently shown feasibility to spinal cages that provide appropriate mechanical properties to withstand the physiological loading configuration and support the process of osteointegration[2-4]. This study aims to use a particular computational technique such as finite element analyses (FEA) to optimise existing device and design more effective solutions for spinal fusion implants. **Material and Methods:** Standard FEA were set up to simulate different loading conditions such as compression, flexion, extension and bending on a conventional cage design. Furthermore, a novel cage was designed to match the pre-operative vertebrae derived from computed tomography (CT) images of a patient. Two materials were modelled: titanium and polycarbonate. Titanium was used as control materials during the computational analysis, due to its wide applications in spinal implants. Polycarbonate was included as widely available within additive manufacturing techniques. The influence on the performance of four different filling densities (25%,50%,75%,100%) of 3D printed polycarbonate was studied through mechanical testing. Micro computed tomography (CT) was used to assess structural reproducibility and generate 3D models of the additive manufactured polycarbonate porous structures. For each of the cages, all four filling densities were simulated through a patient-specific two-level model of the spine within a physiological load distribution. **Results:** Computational results in terms of stress results showed different mechanical responses when using different materials for the spinal cage, manufacturing technique, cage architecture and filling density. In particular, stresses increased with reducing material density. In addition, stress peak values were lower than the respective risk of failure in all the simulated cases, confirming the feasibility of polycarbonate implants. The patient-specific design showed an even stress distribution consistently within anatomical constraints. **Conclusion:** The process suggested the feasibility of a lighter, affordable and patient-specific interbody cage for spinal fusion. Computational analyses may be utilized to balance the complex

requirements of load transfer and porosity to avoid stress-shielding effects and support implant osteointegration.

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A080: Minimally Invasive Sacroiliac Joint Fusion Using Triangular Titanium Implants: Pooled Analysis of 3 Prospective Clinical Trials

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Introduction: The sacroiliac joint (SIJ) is a contributing factor in 15-30% of patients evaluated for chronic low back pain. A variety of non-surgical treatments are commonly provided for SIJ pain, including physical therapy, SIJ steroid injections and radiofrequency neurotomy. So far, no high-quality evidence supports long-term pain relief from any of these treatments. Over recent years, minimally invasive SIJ fusion (SIJF) has been introduced as a potential treatment alternative. Despite a large number of commercially available devices, very little outcome evidence exists for devices other than triangular titanium implants (TTI). There are three currently ongoing prospective trials on TTI and their preliminary results have shown concordant improvements in pain, disability and quality of life after SIJF. Two of these trials are randomized controlled trials comparing SIJF to conservative management (CM). Herein we pool the current data of the three relevant prospective trials to examine treatment outcome after SIJF using TTI. **Material and Methods:** The trials included in this pooled analysis are the Investigation of Sacroiliac Fusion Treatment (INSITE) trial, the iFuse Implant System Minimally Invasive Arthrodesis (iMIA) trial and the Sacroiliac Joint Fusion With iFuse Implant System (INSITE) trial. Data from these trials were combined on an individual patient basis and analyzed using mixed modeling taking into account expected variation of patient characteristics and outcomes across sites. Pain was quantified using the visual analogue scale (VAS, range 0-100), disability was assessed using the Oswestry disability index (ODI) and the quality of life was described using the EuroQuol score (EQ-5D-3 L). **Results:** We included 423 subjects from two geographies (US and Europe). Mean age was 50 years and 70.4% of subjects were women. Mean duration of pain prior to enrollment was >5 years. SIJ pain averaged 80 VAS points at baseline. In the SIJF group, pain levels dropped by 48 VAS points (44-52) at 12 months and 52 VAS points (47-56) at 24 months. Mean reductions in ODI in the SIJF group were 26 (22-29) and 26 (22-30) points at 12 and 24 months, respectively. In the CM groups, changes in pain and ODI scores were minimal. Effect sizes (i.e., the differential in improvement in scores observed with surgery as opposed to CM) were 37.8 points (95% CI 32.4-43.2) for VAS, 18.4 points (95% CI 14.3-22.4) for ODI, and 0.24 points (95% CI 0.17-0.30) for EQ-5D-3 L. Wound-related complications (eg, infection) occurred in 2.1% (95% CI 0.3-4.4%). The early surgical revision rate was 1.2% (0.4-2.5%) and the late revision rate was 1.6% (0.1-5.1%). **Conclusion:** This pooled analysis provides evidence that in patients with pain originating from the SIJ, SIJF using TTI may lead to early and sustained improvements not only in SIJ pain but also in disability and quality of life. Treatment effect sizes were comparable to those known from prospective trials of other commonly performed spine surgeries. The rates of procedure-related wound problems and early revisions were low and consistent with the minimally invasive nature of the procedure.

Endoscopic and Minimally Invasive Spine Surgery

A081: The Safety Profile of Percutaneous Minimally Invasive Sacroiliac Joint Fusion: A Systematic Review and Meta-Analysis

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Introduction: Sacroiliac joint (SIJ) fusion is gaining popularity amongst spine surgeons for treatment of SIJ dysfunction. SIJ fusion can be accomplished by open or minimally invasive (MI) surgery. The MI technique has increased in popularity as it is believed to be associated with minimal blood loss, less surgery time, and decreased length of hospital stay. This is a systematic review of the existing literature to determine the safety of MI SIJ fusion through the determination of the rate of procedural and device related intraoperative and postoperative complications. **Material and Methods:** A systematic review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. PubMed and Scopus were searched using the terms "sacroiliac joint AND fusion". All original English language retrospective and prospective studies of at least five patients with reported adverse event or complication rates for MI SIJ fusion were included for analysis. Complications were defined as procedural if reported as most likely or definitely due to the MI surgery and device related if secondary to the implant device. Random effects meta-analysis was performed for pre-operative and post-operative Visual Analog Score (VAS) pain ratings and Oswestry Disability Index (ODI) to quantify the efficacy of MI fusion in studies providing both mean scores and standard deviations (SD). Post-operative VAS and ODI scores were from last recorded follow-up. **Results:** Fourteen studies met our inclusion criteria. Seven studies reported VAS scores while five studies provided ODI values. Twelve of the studies investigated triangular porous titanium plasma spray coated implants while two studies used hollow modular anchorage screws packed with demineralized bone matrix. A total of 720 patients (499F/221 M) with a mean follow-up of 22 months were included in the analysis. 99 patients (13.75%) underwent bilateral SIJ arthrodesis resulting in a total of 819 SI joints fused. There were 90 documented procedural-related complications (10.99%) with the most common adverse events being surgical wound infection/drainage (n = 13), trochanteric bursitis (n = 11), and hematoma formation (n = 9). 25 adverse events were attributed to be directly caused by the implant device (3.05%) with nerve root impingement (n = 13) being the most common. The rate of revision was found to be 2.56%. The association between the type of implant and device related complications was not statistically significant ($P = .955$). MI SIJ fusion reduced VAS pain scores from 82.42 (95% CI 79.34-85.51) to 29.03 (95% CI 25.05-33.01) and ODI scores from 57.44 (95% CI 54.73-60.14) to 29.42 (95% CI 20.62-38.21). Patient satisfaction with outcomes was high at 93.14%, with 86.01% stating they would have the same surgery again. **Conclusion:** MI SIJ fusion reduces pain and improves functionality of accurately diagnosed SIJ dysfunction. Possible risks and complications of the procedure, including those requiring revision, are not uncommon; however patient satisfaction is high. Additional studies are needed to further enhance the safety of the procedure.

A082: Does the Addition of Either a Lateral or Posterior Interbody Device to Posterior Instrumented Lumbar Fusion Decrease Cost Over a 6 Year Period?

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Introduction: The economic burden of spine-related health care in the United States has been estimated at $100 billion dollars annually and a 65% increase in spine-related health care medical expenditures from 1997 to 2005 was reported. This emphasizes the importance of economic evaluation of surgical procedures. With an increasing system-wide focus on value-based health care, the goal of economic evaluation is to identify high quality of care which minimizes costs. Few studies have compared the costs of different approaches for lumbar fusion surgery. The purpose of this study was to compare the costs of single-level lumbar fusion, performed as (1) posterior instrumented fusion alone (PSF), (2) posterior interbody fusion with posterior instrumentation (PLIF), or (3) minimally invasive lateral interbody fusion with posterior instrumentation (MILIF), over a period of 6 years. **Materials and Methods:** Patient charts were retrospectively reviewed for demographic and surgical details. Patients were followed up with a telephone questionnaire to obtain information on reoperation status and satisfaction. In order to perform cost estimation from the payer's perspective, the average surgery-related Medicare reimbursement was calculated for the three treatment groups, for index procedures (PSF-$34,432, PLIF-$36,605, MILIF-$52,879) and reoperations (PSF-$35,098, PLIF-$29,292, MILIF-$43,870) as cost estimates. Using rates published previously, the mean cost for epidural injections per patient was estimated ($2,864). Survival analysis (Kaplan-Meier and multivariate Cox regression analysis) was performed to assess the time to elevated resource use (defined as greater than 90% of patients in this study or $68,672). Multivariate analysis was performed to assess overall satisfaction. **Results:** A total of 337 patients, 45, 222 and 70 in the PSF, PLIF and MILIF groups respectively, were included. Overall follow-up rate was 63% at 6 years. PSF patients were significantly older (PSF-72 $\pm$ 12 vs PLIF-59 $\pm$ 13 vs MILIF-65 $\pm$ 10 years, $P < .001$). Surgical time was lowest in the PSF group ($P < .001$), while blood loss was lowest in the MILIF group ($P < .001$) at index procedure. The length of stay after the index procedure was not significantly different among groups ($P = .369$). Kaplan-Meier analysis showed that PLIF patients were less likely to reach the cut-off compared to PSF ($P = .002$) and MILIF ($P = .006$) at an average follow-up of 6 years. Multivariate Cox regression analysis showed that PSF patients and MILIF patients were 3.3 and 3.4 times more likely to reach the elevated resource use cut-off (PSF-HR 3.280, $P = .017$,

MILIF-HR 3.370, $P = .017$). Multivariate logistic regression showed that MILIF patients were 3.3 times more likely to be satisfied compared to PLIF patients (OR 3.320, $P = .002$). **Conclusion:** Multivariate Cox regression analysis showed that patients undergoing MILIF or PSF were more likely to have higher resource utilization than those undergoing PLIF and thus incur greater costs to payers at an average follow-up of 6 years. The high cost estimate for procedures in the MILIF group and for reoperations for PSF patients led to greater costs compared to the PLIF group. Multivariate logistic regression demonstrated that patients in the MILIF group were more likely to be satisfied with the overall result of their surgery, compared to PLIF patients.

A083: Contralateral Keyhole Endoscopic Surgery (CKES) for Lumbar Spinal Stenosis and Lumbar Disc Herniation: Technical Note and Preliminary Results

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Introduction: The purpose of this study was to determine the feasibility and efficacy of contralateral keyhole endoscopic surgery (CKES) for treating lumbar spinal stenosis and lumbar disc herniation. **Material and Methods:** We performed percutaneous endoscopic sublaminiar decompression *via* the contralateral interlaminar approach in 95 patients with central canal stenosis or lateral recess stenosis and/or herniated disc. All procedures were performed under epidural anesthesia. Firstly, the epidural space was accessed under fluoroscopic guidance; the only tip portion of the handmade working sheath was located within the epidural space to prevent nerve compression injury by an instrument. And then we were partially removed the base of spinous process, the caudal edge of the upper lamina and the rostral edge of the lower lamina to make a keyhole using a 3.5-mm drill bit and punch, thereby allowing surgeon to more easily handle endoscope. After the drilling, the contralateral ligamentum flavum was removed by using punch. The lateral recess and the traversing nerve root were completely decompressed. Additionally, we performed selective fragmentectomy in patients with herniated discs. The mean age was 59.2 years and there were 47 men and 48 women. The mean follow-up period was 6.8 months. Clinical results were evaluated using Visual Analog Scale (VAS) and modified MacNab criteria. **Results:** The symptom was relieved immediately after the surgery. The mean operating time was 68.2 minutes. The VAS score improved significantly from 6.8 points preoperatively to 2.3 points after the surgery. 79 (83.1%) had a good or excellent result according to the MacNab criteria. Complications included two cases of epidural hematoma, three cases of transient dysesthesia and three cases of dura tear. **Conclusion:** CKES is a safe and effective minimally invasive surgical technique that extends the percutaneous endoscopic lumbar discectomy indications for lumbar disc herniation and is a novel and useful procedure in treating lumbar spinal stenosis

A084: Radiological Status of Paravertebral Muscles after Bi-portal Arthroscopic Spinal Surgery (BASS)

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Introduction: Surgery involving a microscope or uniportal endoscope is now one of the most common types of minimally invasive spine surgeries performed worldwide. However, the procedure still has drawbacks related to its narrow view, steep learning curve, and technical problems. Recently, many preliminary or technical reports regarding biportal arthroscopic spinal surgery (BASS) have been published and have demonstrated that BASS can resolve these drawbacks. However, it would useful to determine the degree of paravertebral muscle injury after BASS using two portals and saline irrigation during the entire procedure. Therefore, we examined the radiological status of the paravertebral muscles after BASS. **Material and Methods:** A total of 48 patients were reexamined by magnetic resonance imaging (MRI) due to the recurrence of neurological symptoms during the follow-up period after BASS using a unilateral inter-laminar approach between September 2015 and March 2016. Of these, 30 patients diagnosed with lumbar spinal stenosis or lumbar disc herniation were included in this retrospective study. Patients with more than the two lesions required for surgery, previous lumbar surgery, spinal infections, or who underwent BASS via a trans-foraminal approach were excluded. We assessed the radiologic status of the paravertebral muscles by grading the extension of paravertebral muscle high signal intensity on T2-weighted MR images (0: normal, 1: partial, 2: total). The MR images were checked and graded on three occasions: preoperatively (aMRI_1), at 1 day after surgery (aMRI_2), and at the time the MRI was re-taken due to the recurrence of neurological symptoms (aMRI_3). The third MRI was taken on the 26th day (range, 1–122 days), on average, after BASS, and then this day was sequentially subdivided into three groups (A: less than 2 weeks, B: 2–4 weeks, C: more than 4 weeks). Then we attempted to determine the critical period when the radiological muscle status was normalized. We also examined the operation time to assess its correlation with muscle status. **Results:** In the aMRI_1, all cases were graded 0. In the aMRI_2, no cases were graded 0, 29 were 1, and 1 was 2. In the aMRI_3, 12 cases were graded 0, 16 were 1, and 2 were 2. No significant differences were identified among the three groups in terms of age, sex, operation level, operation time, aMRI_1, and aMRI_2. However, in aMRI_3, a significant difference was found among the groups ($P = .002$, Kruskal-Wallis H test), and in the C group, in particular, the grade was significantly low ($P = .006$, Dunn multiple comparisons test). The average operation time was 111.3 ± 40.0 min (range, 45–210 min) and it was not significantly correlated aMRI_2 or aMRI_3. However, there was a significant negative correlation between the time when the MRI was re-taken and

aMRI_3 ($P = .0053$, rho $= -0.495$, Spearman correlation test). **Conclusion:** Paravertebral muscle injury after BASS was localized to a limited area and spontaneously normalized.

Basic Science Spinal Cord Injury

A085: Deleterious Effect of Methylprednisolone on Spinal Cord After Acute Traumatic Injury: Down-regulation of Acuaporine-4 Expression and Persistence of Blood-Spinal Cord Barrier Disruption

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Introduction: After spinal cord injury (SCI), primary damage starts with the contusion and hemorrhage and continues with an inflammatory process with glia reactivity, apoptosis, blood-spinal cord barrier (BSCB) disruption and consequently vasogenic edema. Spinal cord edema is a major clinical problem since this structure is contained by the dura and the spinal canal. Swelling leads to nervous tissue compression and ultimately to ischemia and cell death in the next few hours after trauma. The use of corticosteroids following acute SCI is a controversial practice, since the administration of high doses of methylprednisolone (MP) is justified by the work conducted by Bracken MB in the past 2 decades with the National Acute Spinal Cord Injury Studies (NASCIS I, II and III trials). However, the methodological quality of the NASCIS work has been extensively criticized. A new Clinical Practice Guideline recently published for the management of spinal cord trauma advises against the use of MP following SCI, highlighting that the indication has not been approved by the Food and Drug Administration and that currently there is no evidence of level I or II regarding its clinical benefit. Contrariwise, secondary effects have been extensively documented. Since this malpractice continues around the world, particularly in low-income countries, it is important to determine whether MP confers any beneficial effect that justifies its use in acute SCI. For this, we used an acute experimental model of SCI in rats administered with MP and determined the effects on spinal cord edema and the expression of acuaporine-4 (AQP4), a water channel involved in edema formation and resolution. **Material and Methods:** A total of 24 adult Long-Evans rats weighing 250-400 g were anesthetized with pentobarbital intraperitoneally (i.p.) (50mg/Kg). Rats were subjected to a severe spinal cord contusion at T9, which was generated using an impactor system. Rats treated with MP received an i.p. injection of 30 mg/Kg and an equivalent volume of isotonic saline solution was administered to control animals. Twenty-four h after SCI rats were killed and tissues were fixed and collected to analyze AQP4 expression by immunofluorescence and confocal microscopy, in a separate group of rats, an i.v. bolus of Evans blue was administered 30 min before killing the animals and fresh tissues were collected to assess BSCB integrity. **Results:** Spinal cord contusion parameters and neurological deficits generated after SCI were very consistent across groups. We observed a clear loss of AQP4 expression in astrocyte processes in the groups treated with MP, regardless of SCI. Spinal contusion seemed not to affect AQP4 expression. Consistently, we found more extravasation of Evans blue in the SCI group treated with MP, suggesting that loss of AQP4 resulted in a diminished capacity for edema resolution. **Conclusion:** Our results are consistent with the deleterious effect evidenced clinically when SCI patients are treated with MP during the first 24 h, since MP seems to worsen spinal cord edema due to AQP4 down-regulation and persistence of BSCD disruption in injured rats.

A086: Biomechanical Evaluation of Fusion and Non-Fusion Spinal Instrumentation used in Scoliotic Patients

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Introduction: Scoliosis is a three-dimensional deformity of the spine and trunk that affects individuals of all ages. Fusion spinal instrumentation is implemented for individuals with mature spines, while non-fusion spinal instrumentation is implemented for individuals with growing spines. Biomechanical testing of fusion instrumentation is commonly performed using ASTM F1717 standardized testing, but the effects of wedding-band connectors for non-fusion instrumentation has not been evaluated. Patients with a growing spine have fewer pedicle screws to share the load with the spine; therefore, there is a desire for non-fusion instrumentation to withstand greater loads across the instrumentation. The purpose of this study was to characterize the mechanical performance of fusion versus non-fusion instrumentation using ASTM F1717 methodology. **Material and Methods:** A uniaxial load frame was used to

biomechanically test fusion and non-fusion spinal instrumentation with ASTM F1717 methodology. Non-fusion instrumentation consisted of 5.5 mm titanium rods joined with wedding-band connectors at the middle of the 76 mm span between two polyethylene blocks. Rods were anchored to pedicle screws that had been placed in the blocks and offset appropriately for wedding-band connectors. Two experimental groups (fusion and non-fusion spinal instrumentation; n = 5/group) were tested in static compression bending (ie, flexion-extension). Stiffness, yield and ultimate strength were calculated from force-displacement data. Data were analyzed statistically using a Students t-test with the level of significance set at $P < .05$. **Results:** Stiffness of non-fusion instrumentation was significantly greater than fusion instrumentation at 48.0 $\pm$ 1.9 and 43.4 $\pm$ 0.3 N/mm, respectively ($P < .01$). Yield strengths were similar between non-fusion and fusion instrumentation at 475 $\pm$ 60 and 457 $\pm$ 17 N, respectively (not significant). Ultimate strength of non-fusion instrumentation was greater than fusion instrumentation at 1,080 $\pm$ 9 N versus 1,008 $\pm$ 6 N, respectively ($P < .01$). **Conclusion:** For non-fusion instrumentation there were significant increases in stiffness (11%) and ultimate strength (7%) when compared with fusion instrumentation. This study helped to establish a baseline for biomechanical testing of non-fusion spinal instrumentation, and show that non-fusion instrumentation can carry larger loads with a higher stiffness than fusion instrumentation.

A087: Spatial and Temporal Response of Myelinating Cells to Traumatic Spinal Cord Injury in Animal Studies: A Systematic Review

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Introduction: Damage to oligodendrocytes (OLs) and myelin are one of the major contributors to functional loss following spinal cord injuries (SCI). Understanding temporal and spatial response of OLs and other myelinating cells including progenitor cells and Schwann cells in animal models can help us comprehending complex pathophysiological responses in human. Here we conducted a systematic review to reach an evidence-based knowledge about myelinating cells fate after SCI. **Material and Methods:** We searched MEDLINE (1946 to January 2016) and EMBASE (1974 to January 2016) databases, without applying time or language limitation. In addition, we performed hand-search through the relevant papers. **Results:** After injury, a large number of oligodendrocytes (OLs) and progenitor cells die as early as 15 minutes post injury, initially due to necrosis and then through apoptosis. This loss then extends to the areas distal from lesion by two weeks. On the other hand, progenitor cells proliferate and peak around the first week after injury at the lesion borders to compensate the OL population. Followed by increased number of progenitor cells, they instigate to display OL properties. Until, almost the fourth week post injury when the number of OLs approaches the normal controls. For many years it has been thought that progenitors that express NG2 marker can only differentiate into OLs. However, evidences show a temporal and spatial transition in progenitor cells fate. Evidences based on real-time labelled progenitor cell show between 72 hours to 7 days, NG2+ cell give rise to a population of cells with phagocytic properties. **Conclusion:** Being post-mitotic, OL are not able to proliferate following SCI to preserve their population. However, a portion of progenitor cells in coordination of Schwann cells (in severe injuries) make up the OL population. Recapitulating this response could be an interesting avenue toward more efficient therapeutics.

A088: Efficacy of Hydrogels for Repair of Traumatic Spinal Cord Injuries: A Systematic Review and Meta Analysis

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Introduction: The disability of central nervous system (CNS) for regeneration imputed to inhibitory environment of CNS after injury. Hydrogels belong to a class of water-insoluble polymers and may be either homopolymers or copolymers. Hydrogel scaffolds are shown to assist in tissue regeneration by providing physical and chemical cues to direct axonal regeneration and cellular infiltration into the lesion, or implant site in the spinal cord. However, no optimum protocol has been developed for application of hydrogels for repair of TSCI. Here, we evaluated the efficacy of hydrogels for repair of TSCI through conducting a systematic review and meta analysis. **Material and Methods:** We searched PubMed and EMBASE with no temporal or linguistic restrictions. In addition, hand-search was performed in the bibliographies of relevant studies. Controlled animal studies used hydrogels without incorporation of cells or any other therapeutic agents were included. **Results:** The most common synthetic hydrogels has been studied for repair of TSCI are poly(2-hydroxyethyl methacrylate), poly[N-(2-hydroxypropyl)-methacrylamide], poly(ethylene glycol), poly(?-hydroxybutyrate), also, natural origin hydrogels including alginate, chitosan, collagen, fibrin, agarose, hyaluronic acid, starch, Matrigel and NeuroGel^{TM}. In addition, alginate, blends of agarose/methylcellulose and hyaloronan/methyl cellulose and self-assembling peptides are injectable hydrogels recently evaluated for regeneration of TSCI. The effectiveness of hydrogels on repair of TSCI after injury has been evaluated based on axonal regeneration, functional recovery and reduction of scar formation. In addition, the effect of hydrogels on angiogenesis as well as inflammation and integration of implanted scaffold with host tissue have been assessed. Improved functional recovery after implantation of hydrogels

was found to be higher in transection than contusion/compression injury model. Additionally, functionalized hydrogels were more efficient in repair compared to non-functionalized ones. **Conclusion:** Hydrogels may be an appropriate platform to encourage regeneration of the injured spinal cord. There is a hope that these gels along with our deepening understanding of the pathophysiology of TSCI will result in advances in the treatment of TSCI in human subjects in the next few years.

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Lumbar Surgery Complications

A089: Economic Impact and Clinical Outcomes of Liberal Blood Transfusion in Spine Surgery

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Introduction: Blood loss is a major concern in spine surgery. Blood transfusion promotes oxygen delivery and tissue perfusion during long, complex surgeries, yet carries with it rare but notable risks. The hemoglobin (Hb) trigger—the Hb value that initiates clinician administration of packed red blood cells (PRBCs)—is frequently used to evaluate physician compliance with existing transfusion guidelines. Randomized clinical trials have demonstrated similar or improved outcomes among patients receiving blood transfusions using a restrictive Hb trigger—defined as an intraoperative Hb level of <10 g/dL intraoperatively or <8 g/dL postoperatively—versus a liberal Hb trigger ($\geq$10 g/dL intraoperatively or $\geq$8 g/dL postoperatively) in cardiac and hip surgery. To the authors' knowledge, no study has examined the associated morbidity and financial impact of liberal transfusions within spinal surgery. We thus aimed to determine the perioperative clinical outcomes and costs associated with liberal versus restrictive transfusion triggers among spine surgery patients. **Material and Methods:** The surgical billing database at our institution was queried for inpatients discharged following spinal surgery between 2008 and 2015, yielding 33,043 patients. Patients were stratified into eight groups according to the spine surgical procedure performed. The values used were the reported institutional acquisition cost ($220/unit) and a mean estimated activity-based cost ($760/unit) based on a Society for the Advancement of Blood Management report. Outcomes considered included mortality, in-hospital morbidity, total costs, and length of stay. **Results:** A total of 6,931 patients met the inclusion criteria. PRBC transfusions occured in 2,374 patients (at least 1 unit of PRBCs), yielding an overall transfusion rate of 34.3%. Compared to the other surgical groups, most PRBC use occurred within posterior lumbar fusion patients. The mean intraoperative Hb trigger was 10.1 (SD = 1.7) g/dL and the mean postoperative Hb trigger was 10.1 (SD = 2.1) g/dL. For the 2,374 patients that were transfused with PRBCs, 1420 (59.8%) received a postoperative PRBC transfusion with a liberal postoperative Hb trigger ($\geq$8 g/dL) while 529 (22.3%) received an intraoperative PRBC transfusion with a liberal intraoperative Hb trigger ($\geq$10 g/dL). Logistic regression analysis revealed that patients with a nadir Hb of 8-10 g/dL transfused with PRBC had an independently higher risk of perioperative morbidity (odds ratio [OR] = 2.12; 95% confidence interval [CI], 1.24-3.64; P = .006). The additional cost when comparing restrictive and liberal transfusion triggers was estimated to be between $1,330,439 and $4,596,062 (58.7% of the estimated total cost of PRBC transfusion), with the cost varying by surgery type. When comparing liberal and restrictive PRBC transfusion triggers, an estimated additional $202,675 to $700,151 in institutional costs were incurred each year among patients undergoing spine surgery. **Conclusion:** Patients with a nadir Hb of 8 to 10 g/dL who were transfused had higher perioperative morbidity, even after adjusting for potential confounders. The additional cost incurred from liberal transfusion trigger reliance ranged from an estimated $202,675 to $700,151 annually. These findings point to a potential area for clinicians and institutions to improve patient outcomes and reduce costs.

A090: Obstructive Sleep Apnea is Associated with Increased Complication Rates in Elective Spine Surgery

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Introduction: Obstructive sleep apnea (OSA) is a significant sleep disorder that is often associated with poor health status. The prevalence of OSA is increasing in the United States. Some studies have shown it to be associated with poorer post-operative outcomes following surgical procedures. Little information exists characterizing inpatient outcomes in patients with OSA undergoing elective spine surgery.

Material and Methods: Utilizing data from the National Inpatient Sample from 2002 to 2012, an estimated 78,613 patients with OSA undergoing elective spine surgery for degenerative lumbar and cervical disease were selected and compared to 4,295,538 patients undergoing the same procedures. Post-operative outcomes including: complications of surgery, inpatient mortality, and length of stay were assessed for both groups. Complications were classified as major or minor. Major complications included acute myocardial infarction, cardiac arrest, septicemia, septic shock, stroke, and pulmonary embolism. Minor complications included deep vein thrombosis, pneumonia, surgical complications, post-operative anemia, and urinary tract infections. Finally, a comparison of total hospital charges between the two cohorts was made. **Results:** Patients with OSA were, on average, five years older than those without OSA ($P < .001$) and had a larger mean comorbidity burden (2.52 comorbidities compared to 1.16; $P < .001$). Procedures performed included primary and revision spinal fusions and posterior decompressions. OSA was associated with an increased rate of post-operative complications (3.2% compared to 1.4%; $P < .001$). OSA was an independent risk factor for major complications based on multivariate logistic regression analysis (OR = 1.31; 95% CI 1.25 to 1.38; $P < .001$). A slight increase in inpatient mortality rates was seen in the OSA group (0.3% compared to 0.2%; $P < .001$). Average length of stay was slightly longer for patients with OSA (3.7 days compared to 3.2 days; $P < .001$), and overall hospital charges were significantly increased in the OSA cohort (56,560$ compared to 37,405$; $P < .001$). **Conclusion:** Patients with obstructive sleep apnea often have multiple concomitant comorbidities and are at increased risk of experiencing a more difficult post-operative course following elective spine surgery. Both surgeons and patients should be aware of these risks while weighing the risks and benefits of surgery.

A091: Rates of Aspiration Pneumonia and Various Dysphagia Stages after Cervical Fusion Procedure

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Introduction: Dysphagia is a well-known complication after cervical spine surgeries but incidence reporting and risks vary. Although usually transient, dysphagia can be potentially life-threatening if it leads to aspiration pneumonia or upper respiratory tract infection. There is a significant need for more specific and reliable data locating the origin of the swallowing dysfunction. Using a large medical record database that more closely and accurately models the American population as a whole, the aim of this study was to analyze the incidence of aspiration pneumonia, specifying in which stage of swallowing—oral, pharyngeal or esophageal—the dysphagia was occurring. **Material and Methods:** Patients undergoing Anterior Cervical Discectomy and Fusion (ACDF) and Posterior Cervical Fusion (PCF) from 2007-2014Q2 were selected from records of the nationwide private insurance provider Humana within the Pearl Diver patient records database. ICD-9 diagnosis codes (International Classification of Diseases 9th edition) were used to reveal incidence of post-operative dysphagia by type—oral, pharyngeal and esophageal—within one year of surgery. Cases of pre-existing swallowing conditions were excluded from the analysis. The data was also examined for incidence of patients who developed aspiration pneumonia within one month after dysphagia. **Results:** From 21701 ACDF patients (11360 female; 10341 male) 15% developed postoperative dysphagia. Fourteen percent of women who underwent ACDF acquired some degree of swallowing dysfunction while 16% of men had dysphagia. Patients with postoperative dysphagia of any type were 13.7 times more likely ($P < .0001$) to develop aspiration pneumonia than ACDF patients who did not have dysphagia. Of the 3,261 patients who developed dysphagia 5% proceeded to aspiration pneumonia. Pharyngeal and unspecified dysphagia were the most contributable to aspiration pneumonia. With a chi-square statistic of 7.2 and $P < .5$, these dysphagia types were statistically independent, while other types of dysphagia did not occur alone. Among PCF patients (3255; 1419 female and 1835 male) 18% had postoperative dysphagia. Eighteen percent of men and women who underwent PCF had difficulty swallowing after surgery. PCF patients with dysphagia of any type were 9.3 times more likely ($P < .0001$) to develop aspiration pneumonia than patients who did not have dysphagia. Of the 575 patients who developed dysphagia, 12% went on to develop aspiration pneumonia. Unspecified and pharyngeal were the most common types of dysphagia leading to aspiration pneumonia, though they were not statistically independent. **Conclusions:** The results of this study illuminate that PCF is more likely than ACDF to cause some type of patient dysphagia. Furthermore, in our study among ACDF patients men were more prone to dysphagia than women, while there was no difference in gender for PCF patients. Pharyngeal and unspecified dysphagia types led to the most instances of aspiration pneumonia. These findings are critical for physicians evaluating the severity of their patients' dysphagia and should be considered when deciding if treatment is needed.

A092: Predictors of Blood Transfusion in Posterior Lumbar Spinal Fusion: A Canadian Spine Outcome and Research Network (CSORN) Study

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Introduction: The rate of posterior lumbar spinal fusion (PSF) surgery has increased significantly over the past few years. It remains the most common surgical procedure used to stabilize the spine for a variety of spinal pathologies; however, the impact of blood loss requiring blood transfusions remain a significant concern in this population. The purpose of this study was to identify patient related, disease related or procedure related predictors of postoperative blood transfusions. **Material and Methods:** This is an ambispective analysis of data from the Canadian Spine Outcomes and Research Network (CSORN). Patients who underwent PSF between 2008 and 2015 were identified. Multivariate analysis was used to identify predictors of blood transfusion from routinely collected patient information including both preoperative and intraoperative items. **Results:** Of the 772 patients identified to have undergone PSF, 18% required blood transfusion. Overall, there were 54.8% females and the mean age was 60 years. Multivariable logistic regression analysis revealed five significant predictors of blood transfusion: American Society of Anesthesiologist class (ASA), operative time, number of level fused, sacrum involvement and open posterior approach. The odds of transfusion for those with ASA class greater than 1 were six times the odds for those with ASA class 1 (OR 6.1, 95% CI 1.4-27.1, $P < .018$). For each 60 minutes increase in operating room time, the odds of transfusion increased by 4.2% (OR 1.007, 95% CI 1.004 -1.009, $P < .001$). Moreover, the odds of transfusion when more than one level were fused was 6 times the odds for one level fusion (OR 5.8, 95% CI 2.6-13.2, $P < .001$). Also, when the fusion was extended to the sacrum the odds for blood transfusion were three times higher (OR3.2, 95% CI 1.8-5.8, $P < .001$). Finally, the odds of transfusion for patients undergoing open posterior approach were 12 times the odds for those who had minimal invasive surgery (OR 12.5, 95% CI 1.6-97.4, $P < .016$). In addition, patients receiving transfusions who underwent lumbar fusion were more likely to have extended hospital stay. **Conclusion:** ASA > 1, prolonged operative time, multilevel fusion surgery, sacrum involvement and open posterior approach were significant predictors of blood transfusion in posterior lumbar spinal fusion.

A093: "After-Hours" Emergent Spine Surgery: Perhaps We Should Think Twice?

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Introduction: 'After-hours' emergent spinal surgeries are frequently necessary, and often performed under suboptimal conditions. The consequences of performing these often complex surgeries under such conditions on postoperative outcomes are unknown. **Methods:** One thousand four hundred and forty patients underwent emergent spinal surgery at a single institution between 2009-2013. Surgery was defined as 'In-Hours' if completed between 7h00 and 16h00. Surgery was defined as 'After-Hours' if more than 50% of the operative time was between 16h01 and 6h59, or if it was performed over the weekend. Data on demographics, diagnosis, surgical intervention, Spine Surgical Invasiveness Score (SSII), operative start time and end time, intraoperative blood loss (IOBL) and post-operative outcome measures (adverse events (AE), mortality, length of stay) were prospectively collected. **Results:** 664(46.1%) procedures were performed "After-Hours". OR time and IOBL were similar between groups ($P > .05$). % of the patients operated "After-Hours" experienced at least an AE compared to % for the "In-Hours" group ($P = .0$). The number of intra-operative AE/patient was significantly higher in the "After-hours" group (versus, $P = .0$). 'After-hours' designation was an independent predictor of AE on multivaria analysis (adjusted OR 1.30, 95% CI, 1.02-1.66, $P = .034$). In-hospital mortality doubled in patients who had surgery after hours (4.4% versus 2.1%, $P = .01$). On multivariate analysis, "After hours" surgery showed a borderline association with in-hospital death (adjusted OR 1.99, 95% CI 0.98-4.06, $P = .056$). Length of stay was longer in the "After-hours" group (median 1IQR 7-2 versus 1, IQR 7-2, $P = .014$). However, on multivariate analysis, association between LOS and "After-hours" was not significant (adjusted OR 1.63, 95% CI -0.83-4.10, $P = .194$). **Conclusion:** Emergent spine surgery performed 'after-hours' is associated an increased in peri-operative adverse events. Higher mortality System changes to facilitate 'In-Hours' surgery could mitigate against the adverse outcomes associated with'After-Hours' surgery.

A094: Post-Operative Venous Thromboembolic Events in Patients Undergoing Lumbar Spine Surgery

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Introduction: Venous thromboembolic events (VTEs) including deep vein thrombosis (DVT) and pulmonary embolism (PE) are preventable complications associated with significant morbidity and mortality after spine surgery. Previous literature focused on timing and incidence of post-operative VTEs after lumbar surgery is limited. The aim of this study was to investigate incidence and risk factors associated with venous thromboembolic events after lumbar spine surgery using a large nationwide sample group. **Materials and Methods:** Patients who underwent first time isolated lumbar surgery between 2007 and 2014 including any of five types of single or multilevel lumbar procedures were identified using the PearlDiver patient database (PearlDiver Technologies, Inc., Fort Wayne, IN, USA) from private insurance provider Humana Inc. ICD-9 diagnosis codes (International Classification of Diseases 9th edition) were used to search patient records and determine incidence of VTEs among surgery types, patient demographics and comorbidities. Complications including DVT and PE were queried each day from the day of surgery to post-operative day 7 and for periods 0 to 1 week, 0 to 1 month, 0 to 2 months and 0 to 3 months post-operatively. **Results:** 64,892 patients within the Humana insurance database received lumbar surgery between 2007 and 2014. Overall VTE rate of 0.9% (N = 608) was seen at 1 week, 1.8% (N = 1190) at 1 month and 2.6% (N = 1667) at 3 months postoperatively. Among patients that developed a VTE within one week post-operatively, 45.3% (N = 267) had a VTE on the day of surgery. Patients with one or more identified risk factors had a VTE incidence of 2.73%, compared to 0.95% for patients without risk factors ($P < 0.001$). Risk factors associated with the highest VTE incidence and odds ratios were primary coagulation disorder (10.01%, OR 4.33), extremity paralysis (7.49%, OR 2.96), central venous line (6.70%, OR 2.87) and varicose veins (6.51%, OR 2.58). **Conclusions:** This study identifies several patient comorbidities that were independent predictors of post-operative VTE occurrence after lumbar surgery. Clinical VTE risk assessment may improve with increased focus towards patient comorbidities rather than surgery type or patient demographics. Patients undergoing lumbar surgery may be at an increased risk of post-operative VTE occurrence on the day of surgery. We believe our findings on incidence and timing of venous thromboembolic events after lumbar surgery will provide useful information to clinicians when assessing patient risk in the pre- and post-operative periods.

Trauma Lumbar

A095: Is the Transpedicular Bone Grafting an Effective Technique for Prevention of Kyphosis in Thoracolumbar Fractures?

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Introduction: Fractures of the thoracolumbar spine represent 90% of all spine fractures, the thoracolumbar burst fractures (Type A fractures) are the most common in the spine and important cause of posttraumatic kyphotic deformity. The cause of this problem appears to be the structural and mechanical deficiency of the anterior column following indirect fracture reduction by posterior fixation. **Objective:** The objective of this study was to evaluate the effects of transpedicular intracorporeal grafting associated to short-segment transpedicular fixation, on kyphosis progression in patients with thoracolumbar burst fracture type A3/A4. **Methods:** Fifty-nine consecutive patients with thoracolumbar burst fracture treated with short-segment transpedicular mono-axial screw fixation. Patients were simply divided into transpedicular grafting (TPG) ($n = 35$, A3 = 20, A4 = 15) and non-TPG ($n = 24$, A3 = 19, A4 = 5). The average follow-up was 21.1 $\pm$ 4.2 (range 16–26) months for the entire study group: 22.1 $\pm$ 4.5 months for the TPG group and 20.2 $\pm$ 4.8 months for the non-TPG group ($P = .49$). **Results:** The global mean kyphosis angle before surgery was 21.93 $\pm$ 3.92°, with 22.06 $\pm$ 3.55° in the TGP group and 20.75 $\pm$ 4.68° for non-TGP; $P = .93$. The mean kyphosis angle after surgery for entire study was 9.21 $\pm$ 8.86°, with 8.70 $\pm$ 2.11° TGP and 14.08 $\pm$ 4.73° NON-TGP, (TGP vs non-TGP, $P = .010$). No obvious clinical complications in both group it was documented. **Conclusion:** Our findings demonstrate that transpedicular bone grafting associated to short-segment fixation in thoracolumbar burst fractures has cause a significant effect on prevention of kyphosis progression after surgery.

A096: Postoperative Evaluation of Vertebral Body Height Correction in Magerl A Thoracolumbar Fractures

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Introduction: Magerl A thoracolumbar fracture is caused by axial compression resulting in loss of vertebral body height (VBH). The main objective of treatment is to restore the VBH in order to limit the subsequent loss of correction, which occurs predominantly within the intervertebral disc space. The analysis of the quality of the reduction in the operating room is routinely made on plain radiographs only. Several studies have analyzed many preoperative parameters of interest including the Cobb angle. However, no prior study has prospectively assessed the postoperative correction of VBH. Our purposes were to (1) compare the relevance of measurements on plain radiographs and computed tomography (CT) scans to assess the postoperative correction of VBH, (2) analyze inter and intraobserver reliability of these two methods and (3) evaluate the correlation between radiographic Cobb angle, radiographic intervertebral disc space height and the VHB measurement using CT scan. **Materials and Methods:** We prospectively analyzed 40 Magerl A thoracolumbar fractures which required surgical treatment with posterior short-segment pedicle-screw fixation without fusion. Postoperative lateral radiographs and CT scans were reviewed independently by two spine surgeons and one musculoskeletal radiologist, and repeated at two separate times for one surgeon. The main measure was the "vertebral body reduction coefficient" (VBRC) defined as the ratio between the height under the maximal bone depression and the height in the middle of the vertebral body. Intraclass correlation coefficients (ICCs) were utilized to determine inter and intraobserver reliability. Spearman's correlation coefficients were used to assess the association between the Cobb angle, the disc space height and the VBH. **Results:** The average age at the time of fracture was 37 $\pm$ 19 years old. For each observer, the mean value of radiographic VBRC was significantly different from CT scan VBRC. For the spine surgeon 1, mean value of VBRC was respectively 0.82 $\pm$ 0.12 and 0.67 $\pm$ 0.1 for plain radiographs and CT scans ($P < .0001$). For the spine surgeon 2, in the first series of measurements, mean value of radiographic VBRC was 0.82 $\pm$ 0.07 and 0.69 $\pm$ 0.1 for CT scans ($P < .0001$). In the second series of measurements, it was respectively 0.81 $\pm$ 0.06 and 0.69 $\pm$ 0.1 for plain radiographs and CT scans ($P < .0001$). For the musculoskeletal radiologist, mean value of radiographic VBRC was 0.8 $\pm$ 0.12 and was 0.66 $\pm$ 0.1 for the CT scan VBRC ($P < .0001$). The interobserver reliability was fair for plain radiographs and substantial for CT scan. The intraobserver reliability was respectively moderate and substantial. Neither radiographic Cobb angle nor radiographic intervertebral disc space height is correlated to the CT scan VBH measurement. **Conclusion:** Radiographic evaluation of postoperative VBH is incorrect, unreliable and no radiographic parameter is correlated to CT scan measurements. Improvement regarding development of techniques of vertebral body reconstruction and imaging with three-dimensional reconstruction embarked in the operating room will greatly benefit this type of fracture.

A097: Impact of Fragments Displacement on Surgical Treatment of Thoracolumbar Fractures: A Retrospective Radiological Analysis

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Introduction: Thoracolumbar burst fractures represent an everyday challenge in the choice of the appropriate surgical strategy. The Load Sharing Classification (LSC) laid foundations for a scoring system able to indicate which fractures, fixed by short-segment posterior-only pedicle screws constructs, would need for longer instrumentations or an anterior column support. We retrospectively analyzed all the thoracolumbar fractures surgically treated, quantifying the vertebral body's comminution so as to identify an additional parameter which can highlight the need for an anterior support when posterior fixation alone may be inadequate. **Methods:** One-hundred-twenty-one patients undergone posterior fixation for unstable thoracolumbar burst fractures were clinically and radiologically assessed. Supplementary anterior fixations were performed in cases of posterior instrumentation failure, impending failure determined on radiological and clinical evidences or symptomatic loss of kyphosis correction. The segmental kyphosis angle was calculated according to the Cobb method. The displacement of fracture fragments was obtained from the sum of the adjacent endplates areas divided by two and subtracted to the area enclosed by the maximum contour of vertebral fragmentation. The percentage of displacement ("spread") derived from the ratio between this subtraction and the sum of the adjacent endplates areas divided by two. **Results:** In addition to the LSS the spread showed to be a quantitative measurement of vertebral body fragments displacement, which is easily reproducible with the current CT imaging technologies. There were no mechanical failures in those injuries treated only with posterior fixations showing a preoperative spread below 62.7%, while spreads superior to 100% required a supplementary anterior fixation. Most of the patients in the "grey zone" (between 62.7% and 100%) needed for an additional anterior support because a Grade of Kyphosis Correction (GKC) $\geq 10^{\circ}$ had to be reached. Analysis of variance (ANOVA) showed that the effect of preoperative kyphosis ($P < .001$), LSS ($P = .002$) and spread ($P < .001$) on the surgical treatment (posterior or circumferential) were significant. **Conclusions:** Together with the Load Sharing Score (LSS) ($P = .001$) and the preoperative kyphosis ($P < .0001$) the spread ($P = .005$) was found to be an additional tool which could help in addressing the surgical strategy, providing an objective, entirely quantitative, reproducible and distinctly preoperative indicator.

A098: Could Intermediate Screw in Thoracolumbar Fracture Fixation Save Motion Levels? Comparative Study between Long Segment and Short Segment with Intermediate Screw Fixation

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Introduction: Thoracolumbar fractures are commonly managed by posterior pedicle screw fixation. Controversy remains about the number of levels involved in the fixation as the stability of the short segment fixation remains questionable. Recently, it has been shown that application of intermediate screw in the fractured vertebra improves the biomechanical stability of the short segment construct. The aim of this study is to compare the outcome of long segment fixation (LSF) versus short segment fixation with intermediate screws (SSFIS) in the management of the thoracolumbar burst fractures. **Material and Methods:** Fifty patients with thoracolumbar burst fracture (T11-L2) type A3 and A4 AOSpine classification with a Thoracolumbar Injury Classification and Severity (TLICS) Scale of more than 4 were treated between 2009 and 2014 with posterior pedicle screw fixation. The patients were divided into two groups according to the number of instrumented levels. Group 1 included 25 patients treated with LSF (two levels above and two levels below the fractured level) while group 2 included 25 patients treated by SSFIS (one level above and one level below with 2 intermediate screws in the fractured level). The patients were evaluated for local kyphotic angle (LKA) correction and maintenance, anterior vertebral body height (AVH) compression, visual analogue scale (VAS) for back pain and treatment related complications. Construct failure was defined as screw pull-out or instrument breakage. **Results:** The two groups were similar as regard to age, sex, fractured levels, fracture type, TLICS score, pre-operative local kyphotic angle and anterior vertebral body height compression. Post-operative correction of the local vertebral compression assessed with LKA and AVH significantly improved in both groups compared to the pre-operative degree while there was no significant difference in the two groups in early post-operative or follow up regarding the degree of correction and its maintenance. No construct failure or major treatment related complication were encountered in both groups with significant reduction of VAS in both groups between early post-operative and late follow up. **Conclusion:** Intermediate screw applied in the fractured level in management of thoracolumbar burst fracture improves the correction and maintenance of local kyphosis in short segment fixation similar to long segment construct with saving vertebral motion levels from being fixed. More randomized controlled and multicenter studies are needed to support these findings.

A099: Influence of Insurance Status on the Outcome and Length of Work Incapacity in Patients with Surgically Treated Fractures of the Thoraco-lumbar Junction

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Introduction: Suffering a fracture of the thoraco-lumbar junction with need for combined dorsoventral stabilization constitutes an impairment for the patient. Neurological deficits and palsies are possible. Remaining disorders and pain are reported differently and lead to work incapacity for a certain length of time. **Material and Methods:** We analyzed 111 patients suffering a fracture of the thoraco-lumbar junction with need for combined dorsoventral stabilization. We studied outcome, remaining neurological deficits, pain and length of work incapacity. Subgroup study involved privately insured and patients with employer's liability insurance coverage (ELIC). **Results:** Patients with employer´s liability insurance coverage seemed to be more restricted than patients lacking this kind of insurance coverage. Work incapacity after surgery was 10,36 months, being 6,29 months more compared to other patients ($P < .0001$; T-Test). Additionally, pain was reported as being more intense than in the patients without ELIC. **Conclusion:** Insurance status seems to be a strong predictor for the duration of work incapacity following injuries to the thoracolumbar spine.

A100: Short-Segment Fixation in Type C AO Thoracolumbar Fractures with Neurological Deficit: Survival Time of Paraplegic Patients Under Workers' Compensation

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Introduction: Spine fractures are common injuries in trauma population and the thoracolumbar junction (T10-L2) is the most frequently affected segment. In general, neurological impairment as a result of a spine fracture implies surgical treatment, in order to achieve decompression of the neural elements, as well as fixation of the affected vertebral levels, due to traumatic or surgery-induced spinal instability. Short-segment posterior fixation allows us to obtain spinal stability and neural decompression preserving healthy mobile segments, with shorter operative times, reduced intraoperative blood loss and associated costs. There is a lack of information in the literature regarding the management and follow-up of paraplegic patients due to thoracolumbar spine fractures treated with

short-segment constructs. The purpose of this study is to describe the survival time of the short-segment fixation in patients under a workers' compensation program, who underwent surgery after a thoracolumbar spine fracture with neurologic impairment. **Material and Methods:** We reviewed the medical records and imaging of patients with AO Type C thoracolumbar (T10-L2) spine fractures, with severe motor neurological impairment (ASIA Impairment Scale (AIS) A, B and C), treated in our center with a short-segment spinal fixation (mono or bi segmental) between 1988 and 2011, with a minimum follow up of 5 years. We excluded patients operated with hybrid instrumentations (ie, combination of screws, hooks and/or cables), with incomplete clinical records, operated elsewhere and those who died during the initial admission after the accident. Survival time of the short-segment fixation was estimated through a Kaplan Meier analysis, considering as a response of interest, the time elapsed between the date of the surgery and the date of the reoperation due to failure of the construct. **Results:** A total of 17 patients met the previously described inclusion criteria and hence were included in our study. The mean age was 34.59 years (SD = 10.24) and 88.24% of the group were males. The average follow-up was 17.24 years (SD 6.18). The main mechanism of injury was fall from a height. The most frequently injured levels were T11-T12 and T12-L1 with nine and five cases, respectively, while T12 was the predominant neurologic level of injury (NLI), with nine cases. Fourteen patients presented complete paraplegia (AIS A) on admission, while two presented AIS B impairment and the remaining one had an AIS C injury. At the end of the follow-up period, only two patients with AIS B impairment presented neurological recovery to AIS C and D respectively. Eleven patients were able to return to some type of work activity. We identified no patients with failure of the short-segment construct during the studied period (100% survival in 14 years). **Conclusion:** The survival time of the short-segment fixation was a 100% in 14 years. We can hypothesize that short-segment constructs are a viable alternative for the treatment of thoracolumbar spine fractures, even in patients with severe neurologic impairment.

Novel Concepts

A101: Spine Sagittal Balance Characterization in Professional Soccer Players

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Introduction: Human spine is composed of physiological curvatures in the sagittal plane. Specific sports practices can modify these curvatures aiming a better adaptation. Non-harmonious changes in the spine sagittal plane increase the risk of spinal pathology. Soccer is the most practiced sport in the world. Low back pain (LBP) is one of the most frequent complaints in professional soccer players, with impact on the quality of training and the final performance. With this work, the authors aim to characterize sagittal balance in professional soccer players, compare them with the general population and establish a relation between the values of sagittal balance and spinal symptoms. **Material and Methods:** 37 soccer players of the 1st and 2nd Portuguese Soccer League and 20 individuals from the general population between 18 and 35 years old were recruited. In the clinical and physical activity evaluation were applied the Oswestry Disability Index 2.0 (ODI) and the International Physical Activity Questionnaire (IPAQ short-form), respectively. Radiographic evaluation consisted in the interpretation of radiographs of the spine in extra-long film in all participants. Surgimap ® software was used and the following parameters were measured: pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), sagittal vertical axis (SVA), lumbar lordosis (LL) and thoracic kyphosis (TK). Sagittal balance values were grouped into categories (low, normal, high) according to reference values for the general population. **Results:** Soccer players have lower radiographic values of sagittal balance compared to the control group. However, only the PT has a statistically significant difference and a practical impact ($t(55) = -2.64$ $P = .011$ g-Hedge $= -0.82$). The players subgroup with low PT does not have adaptive values of SS, LL and TK, as verified in the same control subgroup. LBP frequency is higher in soccer players (57% vs. 50%) but a statistical significant difference between the frequency of LBP and changes in the sagittal balance was not confirmed. LBP is more frequent in soccer players when there are changes (increased or decreased values) of PT, LL and TK. The ODI is negligible in both groups (soccer players, ODI = 5%; control group, ODI = 2.3%). **Conclusion:** Changes in physiological spinal curvatures are associated with an imbalance in the intervertebral stress distribution. In elite athletes, these changes are particularly important as they can have an impact in the final performance but also because athletes can have targeted functional training in order to prevent injuries. This study characterizes the sagittal balance in a group of soccer players. The reduction of PT verified, which results in the pelvis verticalization, can be explained by the large quadriceps femoris muscle core in this population. The frequency of LBP in soccer players is high when compared to the control group and the overall population (57%, 50%, 25%, respectively) and occurs more when the radiographic sagittal balance values are changed. However, it was not observed any association between radiographic values and low back pain.

A102: Biological Disc Replacement Combined with a Bio-resorbable Stabilization System: A Proof of Concept Study

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Introduction: Biological disc replacement using tissue-engineered intervertebral discs (TE-IVD) offers an alternative therapy to traditional treatments for degenerative disc disease (DDD). Recently a composite annulus fibrosus (AF) / nucleus pulposus (NP) disc-like construct has been manufactured and validated in rat tail and beagle cervical spine models *in vivo*. While cell viability and integration into host tissue was encouraging, the intrinsic biomechanical properties were inferior to native IVDs and implant displacement occurred in several cases. The aim of this study was to investigate the biomechanical responses of composite TE-IVDs combined with a bio-resorbable stabilization system (BSS) to static compression in an *ex vivo* model utilizing canine cervical spines. **Material and Methods:** Cervical IVDs from skeletally mature beagles were obtained, washed, and separated into AF and NP tissues. Upon further dissection into small fragments, the tissues were digested in collagenase Type II at 37°C for 12 hours prior to being filtered and centrifuged. NP and AF cells were cultured individually to confluence. Alginate (3% weight/volume) was then seeded with the cultured NP cells (2.5×10^6 cells/ml) and injected into a predesigned mold. Each of the molded NPs was placed in a well of 24-well culture plate as a neutralized collagen gel solution (4 mg/ml seeded with 3×10^6 cells/ml) was pipetted around the NP component. All components were gelled at 37°C to create the AF and TE-IVDs were kept in culture for 4 weeks, facilitating collagen fibril alignment and contraction. Whole cervical spinal motion segments from skeletally mature beagles were dissected and the mechanical compatibility was assessed for each motion segment at different time points: (1) intact, (2) after discectomy, (3) after implantation of the TE-IVD and (4) after implantation of the TE-IVD and application of the BSS ventrally. Unconfined stress relaxation tests were performed up to 15% strain and their instantaneous and equilibrium moduli were calculated and reported normalized to the intact motion segment. One-way ANOVA was performed to determine statistical significance. **Results:** Intact motion segments showed an equilibrium modulus of 174 $\pm$ 36 kPa and an instantaneous modulus of 1760 $\pm$ 430 kPa. Mechanical properties from motion segments after discectomy, TE-IVD implantation without BSS, and TE-IVD implantation with BSS were all significantly lower than the intact motion segments. Results from all treatment groups were then normalized to their corresponding intact motion segment mechanics (n = 12). Motion segments after discectomy resulted in 14% $\pm$ 6% of the intact equilibrium modulus and 13% $\pm$ 4% of the intact instantaneous modulus. Application of the BSS in combination with the TE-IVD revealed a 2-fold increase in the equilibrium modulus and a 2-fold increase in the instantaneous modulus ($P \leq .05$) over the groups with TE-IVD implantation only. **Conclusion:** The TE-IVD combined with a BSS prevents displacement of the TE-IVD while still allowing load sharing to the TE-IVD. Increasing the biomechanical properties of the TE-IVD can result in an implant with similar properties to native IVDs.

A103: A Correlation Analysis of Radiographic Spinopelvic Parameters in Health and Disease

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Introduction: The vertebrae and the pelvis act as an interconnecting chain of segments. Change at one segment leads to a compensatory change in the adjacent segments. The spinopelvic radiographic variables are useful in identifying these compensations. Analyzing the chain of correlations amongst these variables can help in improving our understanding of compensatory mechanisms adopted by the patient in some commonly encountered spine pathologies. In our study, we aimed to identify the relative significance of these radiographic spinopelvic parameters and how they correlate to each other in patients with chronic low back pain and spondylolisthesis when compared to normal population. **Material and Methods:** The study was approved by our institute review board and the ethical committee. We included all the patients visiting our OPD with complaints of LBP for more than three months and giving consent for the study. All patients underwent a thorough clinical and radiological examination, to rule out any apparent cause of LBP. A total of 67 patients with LBP without any deformity were thus included in the study. We also included a second group of 79 patients with LBP with spondylolisthesis deformity. We excluded patients with spinal deformity (other than spondylolisthesis), fracture, infection, malignancy and with a history of previous spine surgery. Another age and sex matched group of asymptomatic volunteers (n = 75) were also recruited as a control group. All the patients and volunteers underwent a standardized lateral sagittal digital radiograph of the whole spine. The sagittal spinopelvic parameters were measured using the Surgimap spine software version 2.1.2 by a single observer. The parameters measured were PI, pelvic tilt PT, sacral slope SS, thoracic kyphosis TK, lumbar lordosis LL. Pearson correlation was used to find the correlation between the parameters. **Results:** In the asymptomatic group a significant correlation was found between SS-LL (r-0.817), PI-SS(R-0.813), PI-LL(r-0.692), PI-PT(r-0.589), LL-TK (r-0.505). The correlation among different spinopelvic parameters in patients with

chronic low back pain is SS-LL(r-0.661), LL-TK(r-0.609), PI-SS(r-0.580), PI-LL(r-0.533), PI-PT(r-0.527). High correlation was found between, SS-LL(r-0.781), PI-SS(r-0.769), PI-LL(r-0.56), LL-TK(r-0.428), PI-PT(r-0.426), PT-LL(r-0.25) in spondylolisthesis group. **Conclusion:** Based on the results of our study we conclude that -The highest correlation was between sacral slope and lumbar lordosis among all the three groups. The relative extent of correlation between radiographically measured spinopelvic parameters differs in patients with chronic low back pain when compared to normal individuals. The relative extent of correlation between radiographically measured spinopelvic parameters in patients of spondylolisthesis matches that, observed in the normal population.

A104: Intraoperative Stress in Spine Surgery: Attending versus Resident

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Introduction: Mental and bodily requirements for Orthopaedic Spine Surgeons include occupational skills and concentrativeness, along with a certain level of physical fitness and psychological stress resistance in case of complications during spine surgery. So far, no study has looked at the Spine Surgeons' cardiovascular response and influence of physical and mental (psychological) stress during spine surgery in either the attending's or resident's position. Material and Methods: This study measured and evaluated stress-relevant cardiovascular parameters during 101 spine surgical procedures of a healthy 40-years old fellowship-trained Spine Surgeon with 12 years of work experience (BMI 25). A digital training computer (Polar Model RS300X), personal body weight scale, and room thermometer were used to record heart rate, calculate weight loss, calorie burn, and environmental temperature during surgery with special regard to the type of surgery, duration and subjective stress level (coded as: "easy", "moderate", or "difficult") along with an analysis of intraoperative complications during procedures. Results: The average maximum heart rate as an attending surgeon (124 bpm) was significantly higher when compared the resident's heart rate (99 bmp) during surgery ($P < .05$). The mean loss of body fluids (kilogram body weight) at an average room temperature of 20.4°C after surgery was -0.82 kg (0 to -2.3 kg). The mean loss of body weight (%) per hours was calculated with -1.12% at the attending versus -0.59% at the resident ($P < .05$). Higher metal workload and stress levels resulted in a higher physiological cardiovascular response, e.g. increased average maximum heart rate and duration of surgery "easy" (103 bpm, 1 h:51 min), "moderate" (125 bpm, 2 h:57 min), and "difficult" (131spm, 3 h:56 min)). There were six intraoperative complications (dural tears [n = 3], pedicel fracture [n = 1], excessive bleeding [n = 1], and unknown lumbar spinal nerve anomaly [n = 1]). Conclusion: For the first time this study evaluated the attending surgeon's cardiovascular response during spine surgery in comparison to the surgical assistant's (resident's). Technically more demanding, complex procedures and longer operating hours resulted in a higher cardiovascular response of the attending surgeon than resident. The observed cardiovascular parameters during spine surgery are similar to those of an intense workout such as fast bicycling or intense circuit training. Long lasting surgeries can cause weight loss and mild dehydration (-2 to -5% of body fluids). In these situations and according to the literature, lack of fluid ingestion and mild dehydration is substantially worsening someone's cognitive-, visual-, and motor skills. Thus adequate rehydration during surgery is helpful and might prevent intraoperative risks and complications related to possible physical exhaustion during prolonged, complex spine surgeries or in mentally stressful situations.

A105: Factors that Impact Pedicle Screws Stability in Patients with Degenerative Diseases of Lumbar Spine

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Introduction: Implant instability have a relatively high incidence in aged patients with degenerative diseases of lumbar spine. This problem is not resolved yet and it is essential to assess risk factors that may lead to implant instability while planning intervention. The objective of this study is to determine risk factors that may impact implant stability in patients with degenerative diseases of lumbar spine. **Materials and Methods:** This is a retrospective evaluation of 160 spinal instrumentations performed in case of spinal degenerative diseases of lumbar spine. Preoperatively patients underwent CT examination and bone density was measured in Hounsfield units (HU). CT scans utilized slice thickness 0.5 mm. Tube voltage was 120 kV, current 300 mA, auto mAs range 180-400; 1.0 sec/3.0mm/0.5x32, helical-pitch 21.0. Transpedicular fixation was used to treat patients either as a stand-alone technique or in combination with transforaminal interbody fusion. Also, if indicated, decompression of nerve roots and spinal cord was performed. Patients with suboptimal placement of pedicle screws and interbody implants were excluded from this study. Patients who underwent degenerative deformity correction and additional pelviosacral fixation were not included in this study. The duration of follow up was 18 months; patients underwent CT examinations at the period of 6, 12, 18 months after interventions. Cases with implant instability were registered and divided into partial and total implant instability. Logistic regression analysis was utilized to assess the relationship between implant instability rate and potential risk factors. **Results:** The following factors were taken into account

assessing risk for implant instability formation: bone density measured in HU, number of fixed levels (the extension of fixation), presence of segments without fusion within fixed zone; bilateral facet joints removal and laminectomy to achieve decompression. The rate of implant instability was growing with bone density in HU getting decreased and a positive relation of implant instability frequency with the number of fixed segments was estimated. Additional significant factor for implant instability development was destabilizing decompression with bilateral facet joints removal. The influence of other factors was found to be negligible. The parameters of general logistic regression for implant instability rate were: B0 = 0.1483, $P = .8568$ (insignificant); B1 for bone density = −0.0226, $P = .0001$; B2 for bilateral facet removal = 1.0188, $P = .0232$; B3 for number of fixed levels = 1.5208, $P < .0001$. Goodness of fit of general model - Chi-square = 62.40129, $P < .0001$. Classification of cases – 78.75% correctly predicted, specificity and specificity of estimated model achieve 85.5% and 70% respectively. Regression residuals do not have significant difference from normal distribution (Chi-square, Anderson-Darling and Kolmogorov-Smirnov tests were applied). **Conclusion:** Apparently, surgical intervention should be planned thoroughly avoiding destabilizing overdecompression because this could be a significant contributing factor for the implant instability formation in future. Bone quality is the most significant contributing factor for implant stability that must be taken into account planning spinal instrumentation. If necessary, augmentation with bone cement must be performed in order to prevent implant instability formation. The extensiveness of fixation should be clearly justified as far as this is also significant factor that may influence implant stability.

A106: Unilateral Spinous Process Non-Covering Hook Type Patient-Specific Drill Template for Thoracic Pedicle Screw Fixation: A Pilot Clinical Trial and Template Classification

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Introduction: The pedicle screw system for posterior instrumentation to the thoracic and lumbar spine is the general method nowadays. But complications due to screw malpositioning is still reported, and exact screw positioning needs radiologic confirmation which hazard The purpose of this study is to confirm that accurate thoracic pedicle screw position placed by the patient-specific drill template (PSDT) made by rapid prototyping (RP) and analyze of previously reported PSDT designs and its characteristics. **Material and Methods:** The preoperative spiral three-dimensional (3-D) CT scan (LightSpeed VCT, GE, USA) was performed on the thoracic spine with 0.625 mm slice thickness and 0.35 mm in-plane resolution. The images were stored in DICOM format and transferred to a workstation running MIMICS 17.0 software, 3-Matic 9.0 (Materialise company, Belgium) to generate a 3-D reconstruction template for the desired thoracic vertebra. The accurate trajectory and screw diameter and length were calculated with UG Imageware 12.1 (EDS Co., USA). The guide template was sterilized and used intra-operatively to assist with the placement of thoracic pedicle screws. After all of the pedicle screws was inserted. We performed the CT scan postoperatively to evaluate the position of thoracic pedicle screws. Using Imageware postoperative CT scan was compared with preplanned trajectory safety and accuracy. After all CBT screws were inserted, we performed a CT scan to evaluate the position of the screws. By using the Imageware program, the postoperative CT scan data were compared with the preplanned trajectory for the assessment of safety and accuracy. We stacked pre-CT and post-CT slices of axial and sagittal planes and measured the distance between the preplanned trajectory and the fixed screws. (Figure 3.) We reviewed 12 previous reports and classified by the shape and system of PSDT which met the inclusion criteria of the review. **Results:** In total, ten screws were placed using patient-specific drill guide template without violation of single laminar cortex. The drill guide template was fit to the lamina of the vertebra. There was no violation of the spinal canal or the cortex of pedicle by postoperative CT scans. The results of 13 PTSD type which included current study suggest that there is no significant difference in accuracy between the PSTDs. **Conclusion:** Using the unilateral Spinous Process Non-Covering Hook Type Patient-Specific Drill Template made by the RP provide us the accurate trajectory for thoracic vertebra and classification of PSDT in this study would be helpful for further study.

Basic Science Disc Regeneration

A107: Diffusion Characteristics of Human Annulus Fibrosus: A Study Documenting the Dependence of Annulus Fibrosus on Endplate for Diffusion

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Introduction: Intervertebral disc being avascular depends on nutrition either from endplate or annulus fibrosus (AF). Role of endplate on disc diffusion had been extensively studied. However diffusion of human AF remains poorly understood due to lack of reliable techniques to study AF in-vivo & non-invasively. Present study for the first time evaluates the 24-hr diffusion characteristics of AF in radial, axial & circumferential directions. **Material and Methods:** 25 discs from 5 healthy volunteers (age < 20 yrs) were studied. Diffusion over 24-hours following I.V gadodiamide injection (0.3mmol/kg) was studied

at 10 min, 2, 4, 6, 12 and 24 hrs. Axial images at cranial, middle and caudal zones of the disc were obtained. Vertebral body and endplate signal intensities were measured in sagittal sections. 39 ROIs (24 in AF, 15 in Nucleus-pulposus) at each disc were analyzed. Peak enhancement percentage (EP max) and time to attain EP max (T max) were calculated. Radial (outer Vs inner AF), axial (cranial Vs caudal Vs middle zone) and circumferential diffusion were analyzed. **Results:** AF showed a biphasic pattern of diffusion with a characteristic "double peak". Early peak was seen at 10mins (coinciding with T max of VB) and delayed peak at 6 hrs (coinciding with T max of nucleus pulposus) and characteristically noted after T max of endplate (2 hrs). Inner AF showed significant regional differences both at the early and delayed peaks but outer AF had no regional differences in the early peak. In axial direction, both outer and inner AF showed maximum EP at middle zone followed by caudal and least at cranial zone. **Conclusion:** Annulus fibrosus characteristically showed a "double peak" pattern of diffusion. Both the peaks had different characteristics confirming two different sources of nutrition. An initial peak was contributed by peri-annular vascularity and delayed one via endplate from vertebral body. The fact that even AF depends on endplate for nutrition, help us to better understand the complex nutritional pathways of inter-vertebral discs.

A108: Comparison of the Stemness Potential and Response to Inflammation of Human Intervertebral Disc Cells, Adipose- and Bone Marrow-Derived Stem Cells

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Introduction: The intervertebral disc (IVD) has a poor ability of healing. Nevertheless, the presence of resident progenitors having stemness features in the three main anatomical sites of the IVD, the nucleus pulposus (NP), the annulus fibrosus (AF) and the cartilaginous endplate (EP) was reported in few studies. These progenitors represent an alternative potential reservoir of specialized cells for tissue repair and homeostasis. In general, the role of mesenchymal stem cells (MSCs) in the maintenance of tissue homeostasis resides in their ability to secrete bioactive molecules in inflammatory condition, but the trophic and immunomodulatory role of NP, AF and EP cells and progenitors, to our knowledge, was not assessed anymore. Aims of this study are to characterize human cells from NP, AF and EP for their stemness features and to investigate their response to an inflammatory environment in term of ability to produce trophic factors and modulate the inflammation in comparison with MSCs harvested from bone marrow (BMSCs) and subcutaneous adipose tissue (ASCs). **Material and Methods:** NP, AF and EP cells from lumbar IVD were characterized for their CFU-F ability, immunophenotype, adipo-osteo-chondro-differentiative potential and stemness marker (NANOG, POU5F1) expression. After stimulation with IL-1β, the release of pro/anti-inflammatory mediators (IL-10, IL-6, IL-1Ra, TNFα) and the expression of growth factors (VEGFA, TGFB1), MMPs (1-3-13) and TIMPs (1-3) were evaluated, using ASCs and BMSCs as positive controls. **Results:** The three kinds of disc cells were able to form colonies, were negative for the expression of the surface markers CD14, CD34, CD45, CD71 and positive for CD44, CD73, CD105, CD151, expressed the stemness markers NANOG and POU5F1 and were able to differentiate toward osteogenic lineage as well as the MSCs. Differently from the MSCs, the disc cells showed no appreciable signs of differentiation towards adipogenic lineage. As expected, a better chondro-differentiation was observed in disc cells in comparison with MSCs in micromass culture. MMP1-3-13, VEGFA upregulation and TGFB down-regulation were observed in disc cells and MSCs after IL-1β treatment. A slightly higher basal expression of TIMP1 and an higher basal expression of TIMP3 in MSCs in comparison with disc cells was observed. IL-6 was up-regulated by the pro-inflammatory treatment in all the cells. Basal levels of this cytokine were higher in MSCs in comparison with disc cells. There was a higher release of IL-1Ra in disc cells after IL-1β treatment, but the basal levels of this antagonist were significantly higher in ASCs in comparison with disc cells. Disc cells presented a behavior similar to MSCs in term of TNFα release. A low concentration of the anti-inflammatory IL-10 was detected in disc cells culture supernatant, whereas was undetected in MSCs before and after pro-inflammatory stimulus. **Conclusion:** The progenitors resident in the IVD showed very similar features to MSCs in term of clonogenic ability, immunophenotype, osteo-differentiation, stemness marker expression, trophic potential and response to a pro-inflammatory stimulus. Due to their preferential commitment towards the chondrogenic lineage, the in situ stimulation of these highly specialized progenitors could enhance a more physiological tissue repair and homeostasis maintenance.

A109: Radiological, Histological, Morphological and Biochemical Comparison of Two Ovine Lumbar Intervertebral Disc Injury Models

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Introduction: The ovine annular injury model of disc degeneration has been extensively used to evaluate potential therapeutic modalities for disc repair. However, there are limited studies describing the similar use of this species as a model for evaluating disc reconstitution following microdiscectomy. The goal of the present study was to compare the reproducibility and experimental outcomes of two microdiscectomy models induced in the lumbar spines of sheep using a standard drill bit or limited surgical excision of the annulus fibrosis (annulotomy). **Material and Methods:** Twelve adult ewes were subjected to pre-operative 3 T MRI followed by either lumbar intervertebral disc injury at two levels induced by a drill bit ($n = 6$) or by annulotomy ($n = 6$). Both surgical procedures were induced using a lateral retroperitoneal approach. The annulotomy method consisted of surgical removal of a 3 x 5 mm (approximately 200 mg) tissue from the outer annulus fibrosus (AF) to the nucleus pulposus (NP). The drill bit injury consisted of the lateral insertion of a rotating 3.5 mm diameter drill bit to a depth of 12 mm through the outer annulus fibrosus (AF) to the nucleus pulposus (NP) and parallel to the cartilage end plates. Necropsies were performed six months following microdiscectomies. Complete lumbar spines were removed and subjected to 9.4 T and 3 T MRI, radiographic imaging followed by sectioning through their vertebral bodies using a band saw. Individual lumbar discs were then processed for histological, gross morphological and biochemical analysis which included topographical assessment of proteoglycan content as sulphated glycosaminoglycans (SGAGs), collagen and DNA contents using standard procedures. **Results:** There was no evidence of disc degeneration on pre-operative MRI. Drill bit injured and annulotomy injured discs demonstrated significantly increased Pfirrmann degenerative scores relative to controls and pre-operative scores. There was no significant difference in Pfirrmann scores between the drill bit injured and the annulotomy induced microdiscectomies. Gross morphology injury scoring was significantly increased in annulotomy injured discs relative to drill bit injured discs. Annulotomy injured discs demonstrated significantly greater disc height loss than drill bit injured discs. Biochemical analysis of the site of disc injury from both microdiscectomy procedures revealed significantly reduced proteoglycan (as S-GAGs) content of the NP and AF relative to the corresponding uninjured controls. However, the annulotomy injured NP region had lower proteoglycan content than the corresponding drill bit injured region. Moreover, the collagen and DNA content of the drill-bit induced microdiscectomy AF region were also higher than for the annulotomy procedure. DNA levels represent a surrogate marker of capillary and blood cell infiltrations. **Conclusion:** These finding have demonstrated that both the 3.5 mm drill bit and annulotomy procedures are suitable ovine microdiscectomy models that could be used to evaluate novel modalities for disc repair. However, the annulotomy procedure results in a more substantial injury which is probably a more relevant model to the human clinical situation but will also demand more effective therapeutic agents to achieve repair than would be required for the drill bit microdiscectomy model.

A110: Parvovirus B19 Infection in Intervertebral Disc

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Objective: Virus are known as origin for various diseases. Vaccination against human papilloma virus is established for avoiding cervix carcinoma. Furthermore, Parvovirus B19 seems to play a role in appearance of cardiomyopathy and rheumatoid arthritis. Disc herniation is generally considered as a degenerative disease. But can we explain a disc herniation in youth and young adults to be degenerative? For evaluation the pathogenicity of parvovirus B19 related to the onset of disc herniation the present study was designed. **Methods:** Out of 47 patients with lumbar or cervical disc herniation that underwent spinal surgery, the disc herniation was tested for Parvovirus by PCR (cervical prolapse $n = 16$; lumbar prolapse $n = 31$). After surgical excision of the herniated disc the sample tissue was placed in RNA-later and stored at $-20°C$ until the virological analysis was made. Initially samples of the patients' blood serum were screened with ELISA for IgG antibodies. After the mechanical comminution of the disc material the nucleic acid was automatically extracted. Subsequently the viral nucleic acid was detected with quantitative polymerase chain reaction. Prion Protein DNA was added to the lysis buffer before the extraction as a combined extraction and inhibitioncontrol. The validity of the PCR tests was assured through positive controls and standards, which need to be in a certain target range. **Results:** In 21 samples we could detect positive PCR-results for Parvovirus, while the internal control is in the expected normal range. The serological testing of our patient collective showed a 76.6% IgG-positive result ($n = 36$), corresponding to the available data in literature for the spread of infection in the

average population. Consequently 58.3% of serological positive patients and 44.9% of all patients showed an infection with Parvovirus B19 in herniated disc. **Conclusion:** The results of Parvovirus in herniated disc are surprising. This evidence suggests a possible correlation between the Parvovirus and the appearance of a disc herniation.

A111: Characterisation of the Annulus Fibrosus Mechanical Behaviour Requires a Specimen-Specific Approach

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Introduction: Intervertebral disc degeneration treatments include nucleus augmentation. However failures during clinical trials have stopped widespread uptake. Development of standardized in-vitro testing methodologies to examine the biomechanical performance of nucleus replacement materials have shown high variability in the mechanical performance of specimens [1]. The aim of this study was to understand the causes of this variability with a computational approach. **Material and Methods:** Bovine tail specimens (N = 6) were used to develop a standardized in-vitro testing methodology. Specimen were sectioned to isolate the disc with 15 mm of bone each side and imaged with microCT; embedded in PMMA cement; and tested under static compression. Specimen-specific in-silico models of bovine tails specimens were produced: image-based models (ScanIP, Simpleware Ltd.) were developed with a standard protocol to create annulus and nucleus regions of the disc based on standard ratio of cross-sectional area. Material properties were assigned using linear elastic bone [2] and cement, fibre-reinforced annulus, and incompressible nucleus [3]. Computational specimens were loaded in compression replicating the experimental setup (Abaqus, Simulia). For both experimental and computational data, stiffness values and transition displacement were extracted using a tri-linear interpolation of load-displacement data. Three cases of fibre parameters in the annulus were compared: parameters derived from bovine-specific literature data [3], parameters calibrated [4] independently for each specimen, and parameters calibrated using a least square fit over the six specimens. Sensitivity studies were performed on the choice of standard values for the anatomy segmentation. Concordance correlations (R.3.1.1, R foundation for statistical computing) were performed to compare stiffness values and transition displacements for each specimen between each group of computational models. **Results:** Independent calibration of the fibre parameters led to mean relative errors on the predicted force below 15% for each specimen. Transition displacement values from the tri-linear fit exhibited high concordance between the three type of models (CCC > 0.99). Concordance between stiffness values computed using literature data and those independently calibrated was lower than between those calibrated as a group and values independently calibrated (respectively CCC of 0.85 and 0.95). A 50% variation of the cross sectional area ratio between nucleus and annulus led to a variation in the transition displacement or stiffness values of less than 8%. **Conclusion:** Using material properties derived in the literature from mechanical testing and average geometry measurements does not permit the reproduction of whole disc mechanical behaviour in static loading in other laboratory conditions. This reflects the wide variation in tissue preparation, specifically hydration levels, which translates into variation in tissue stiffness. Developing a specimen-specific image-based computational approach to reverse-engineer the mechanical behaviour of the fibres in the annulus fibrosis leads to material parameters that account for this tissue variation. This is necessary to be able to model pre-clinical testing conditions, a first step into enabling optimisation of this testing.

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A112: The Utilization of Pressure Mapping Sensors to Measure Intradiscal Pressure Distribution and Implant Footprints: Abilities and Pitfalls

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Introduction: The pressure distribution inside the intervertebral disc as well as the footprints of fusion implants remain in the focus of current research. To our knowledge pressure mapping sensors have not been used to provide information about the pressure distribution inside the intervertebral disc. We like to present some of the major abilities and pitfalls utilizing these tools. **Materials and Methods:** We present a method using a pressure mapping sensor (Model 5033 I-Scan; Tekscan, Boston, MA, USA) in a robot-based in-vitro testing setup with a follower load of 350 N.We used six human specimens (L2–L5).

Five groups were tested: 1st intact; 2nd intact & 350 N; 3 rd pressure sensor & 350 N; 4th conventional fusion implant & 350 N; 5th expandable, prototype fusion implant & 350 N. The first and second group were used to define the "intact" status. For the third group a lateral, horizontal incision of the L3-L4 intervertebral disc close to the endplate of L3 was made and the pressure sensor pulled through the disc from one side to the other. The fourth and the fifth group consisted of an LLIF procedure with a conventional and a prototype implant with the pressure sensor between implant and endplate of L3. Both implants were covered with a 0.5 mm thick rubber pad to protect the pressure sensor from the spikes of the implants. The calibration of the pressure sensor was performed with a two-point calibration (100N/400 N) according to the manufacturer's recommendation. The range was based on intradiscal pressure values from the literature. **Results:** If ROM of the second group is set to 100%, the horizontal incision through the disc resulted in a median ROM of 98% for EF, 146% for AR and 139% for LB. Although the intervertebral disc was completely cut, it showed excellent equalization of the pressure conducted by the movement of the spine. Only at the end points of each movement high pressure peaks could be observed. For EF these were at the ventral respectively dorsal edge of the intervertebral disc. AR and LB exhibited pressure peaks at the dorsolateral edge of the intervertebral disc. Unfortunately the pressure applied by the implants of the 4th and 5th group exceeded the upper calibration limit. Therefore only contact areas could be observed reliably but the detection of the different footprints succeeded well. Due to high sheer forces during insertion of the implants only 3 sensors of the 4th and 2 sensors of the 5th group remained reasonably intact. **Conclusion:** The insertion of the pressure sensor with a transdiscal incision destabilized the motion segment in AR and LB. In EF it remained stable. The pressure peaks in the intact scenario were located at the dorsolateral edge of the intervertebral disc. This location matched the clinical experience of dorsolateral disc protrusion and prolaps. We recommend two different sensor calibrations for intact and implant scenario, as the loads vary highly. The pressure mapping sensor allows excellent detection of footprint and contact area dynamically throughout biomechanical testing.

Spine Infections 1

A113: Improvement in Frankel Scale in Caries Spine Patients with Frankel Scale "A" Undergone Anterior Decompression and Cage with Autologous Bone Graft after a 5 Years Follow up

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Introduction: Spinal tuberculous infection is the most common and dangerous form of skeletal tuberculosis. It constitutes 1/3 to 1/2 of all bone and joint tuberculosis. It is a result of hematogenous dissemination from primary focus in the lungs, lymph nodes, etc . According to the current estimates of the WHO, tuberculosis now kills 3 million people a year worldwide. Therefore, early diagnosis and management of spinal TB has special importance in preventing serious complications. **Materials and Methods**: It is a prospective case series study. 419 patients either through OPD or Emergency Department with Frankel Scale "A" from 2003 to 2011 were included. After taking proper history, examination, investigations and proper consent, all the patients underwent anterior decompression and locally made cage with autologous bone graft. Data was initially entered on pre formed Proforma and then using SPSS 17.0. After surgery, patients were given brace for 6 months and were followed at 6 weeks, 6 months, and then yearly upto 5 years to assess improvement in Frankel scale. The objective of the study was to determine improvement in Frankel Scale after anterior decompression and stabilization with locally made stand alone cage and bone graft in caries spine. **Result:** 419 patients presented with Frankel Scale "A" between 2003 to 2011. 21(5.01%) patients were lost to follow up. Out of remaining 398, 213(53.52%) were male and 185(46.48%) were females. 123(30.90%) were below 15 years, 167(41.96%) were between 16-40 years and 108 (27.14%) were above 40 years. All patients having Frankel Scale "A". After 1 year only 19 (4.77%) patients showed Frankel Scale "E" While after 3 and 5 years 167(41.96%) and 189(47.49%) patients show Frankel scale "E".90(22.61%) patients showed Frankel Scale "D",67(16.83%) showed "C", 24 (6.03%) showed "B" while 28(7.04%) patients showed no improvement after 5 years follow up. **Conclusion:** Early diagnosis and early intervention gives excellent results. However the patients with Frankel Scale "A" with delayed presentation after anterior decompression, stabilization with cage and bone graft results in significant improvement of Frankel Scale. Moreover there is no need for added instrumentation.

A114: The In Vitro and In Vivo Effects of Vancomycin on Osteogenesis in Lumbar Spine Surgery

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Introduction: Surgical site infections (SSI) represent a major complication in lumbar spine surgery. While a number of studies have been conducted to review the effect of vancomycin on surgical site infections, a minimal amount have examined its impact on local bone cells at the cellular level. Recent *in vitro* studies have suggested that vancomycin has an inhibitory effect on osteoblast proliferation and differentiation which may effect fusion rates. The primary purpose of this study was to

retrospectively examine our institution's overall revision rate for pseudarthrosis and infection before and after the routine use of vancomycin powder for lumbar fusions and correlate *in vitro* data of the effects of vancomycin on osteoblasts at a concentration based on surgical drain samples. **Material and Methods:** Drain samples were collected and vancomycin levels were analyzed from 37 patients following spinal fusion procedures where powdered vancomycin was placed inside the surgical site for postoperative day 0, 1, 2, and 3. A human osteoblast (HOB) cell line was used to model osteoblasts in vitro. Cell medium was changed to include vancomycin at a concentration based on drain level results. After exposure of the human osteoblasts to vancomycin, cellular metabolic (alamar blue) and osteogenic activity (alkaline phosphatase) was subsequently evaluated. A retrospective chart review of 453 patients including all patients undergoing lumbar fusions with at least 2 years of clinical follow up from 1/1/2007 - 12/31/2009 (pre-vancomycin group) and comparing them to all patients between 1/1/2012 - 12/31/2013 (vancomycin group). I&D codes of CPT: 22010, 22015, 10180 were used to determine which patients had SSI. Data reviewed included number of levels fused, use of bone morphogenetic protein (BMP), and use of inter-body grafts. **Results:** HOBs exposed to vancomycin concentrations of 1250 ng/ul (POD 0) showed significantly lower alkaline phosphatase activity compared to those exposed to 0, 245(POD 3), 285(POD2), and 500(POD1) ng/ul ($P = .017$, $P = .004$, $P < .001$, and $P < .001$ respectively). Interestingly, there was a significant increase in ALP activity comparing HOBs exposed to vancomycin concentrations of 285 ng/ul compared to 0 ng/ul ($P = .035$), whereas there was no significant difference in metabolic activity measured between the cells exposed to 0, 245, 285, 500, and 1250 ng/ul of vancomycin (oneway ANOVA, $P = .19$). Overall revision for psedarthrosis and infection respectively were: 8/221 (3.6%) and 4/221 (1.8%) in the Vancomycin group and 11/232 (4.7%) and 9/232 (3.9%) in the pre-vancomycin group, with a trend towards significance. There was a significant difference in the use of interbody grafts ($P = .016$) and BMP use in the pre-vancomycin group ($P = .001$); however, no significant difference was noted in the number of levels fused. **Conclusion:** The results of the *in vitro* data suggest a threshold value of vancomycin that favors osteogenesis, corroborating the *in vivo* data that vancomycin did not significantly alter our fusion rates despite significantly less use of interbody grafts and BMP use. Further in vivo and in vitro studies are necessary to fully elucidate the optimal dose of vancomycin and its role in the maturation of a fusion.

A115: Hematogenous Spondylitis caused by Methicillin-resistant Staphylococcus Aureus Incidence, Risk Factors, Management and Outcomes

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Introduction: The incidence of hematogenous spondylodiscitis is increasing. This may due to a combined effect between an increase in susceptible populations and an improved accuracy in diagnosis. Staph. aureus is the organism accounting for up to 80% of spondylodiscitis cases. MRSA- spondylodiscitis is similarly increasing and represents 10-30% of all Staph. aureus isolates. **Patients and Methods:** Retrospective analysis of the prospectively collected data of all patients with spinal infection between Jan. 2005 and Dec. 2015. The study revealed 600 patients with hematogenous spinal infections after exclusion of the cases with postoperative, wound infections and the cases treated for infection before this period. A causative organism could be identified from the site of infection in 405 patients (67.5%). Staph aureus was isolated in 171 patients of them. In this substudy we collected all cases of MRSA-spondylodiscitis and analysed the demographic, clinical, radiological and laboratory data as well as the outcomes of management in those patients. **Results:** This study identified 30 MRSA-patients of a total of 171 hematogenous Staph. aureus-infections (17.5%). There were 8 females and 22 males with mean age of 65 $\pm$ 10.9 years (37-81) and 28 (93.3%) were older than 50 years. In that age group, 70.3% of the patients had ASA- Score class III and IV and 33 patients (63.3%) were obese or overweight. The most common comorbidities were cardiac (22 patients), DM (18), renal insuffiecncy (17), peripheral vascular insuffiecncy (16). In 26 cases another site of infection outside the spine was diagnosed at admission. At the time of presentation, 19 patients (63.3%) had received antibiotic treatment for 24.36 days on average ($\pm$17.75, range 2-60 days). The pre-surgical interval ranged between 5-90 days (mean 33.14 $\pm$ 23.61). At admission neurological deficit was present in 22 patients (73.3%), fever in 20 (an organism could be isolated from blood culture in 17 of them) and sepsis in 10 patients. The lumbar spine was affected in 17 patients (56.7%). In most cases (26 = 80%) one segment was affected. Multifocal (non-contiguous) infection was found in 5 individuals. In 27 patients, epidural abscess was found and in 5 psoas abscess was present. The preoperative inflammatory parameters revealed mean CRP of 161.3 $\pm$ 105.84, WBC of 12.11 $\pm$ 6.15, ESR of 104.8 $\pm$ 23.37. In 3 patients (10%), more than one organism could be isolated (mixed infection). Surgical management was proceeded in 29 patients; combined ventro-dorsal approach was necessary in 26 of them. In three patients, recurrence of infection has been detected and treated surgically (10%). Four patients died with septic shock (one preoperatively), 2 patients with cardiac infarction, one with renal failure and one with respiratory failure (in-hospital mortality of 26.7%). The neurological improvement rate of at least one ASIA-grade reached 78%. Postoperative antibiotic therapy for more than 12 weeks was given in 17 patients (mean period of 70.6 $\pm$ 36.36 days). The most commonly used antibiotic was Vancomycin in 19 patients and in 11 patients a combination of antibiotics was necessary. **Conclusion:** In spite ofadvances in diagnosis and management strategies of spinal infections, the haematogenous spondylodiscitis by MRSA is

still a devastating condition. It is associated with significant morbidity and mortality. The type and duration of antibiotic therapy should be organism based, but all patients with previoushospital admission who have been diagnosed with spondylodiscitis without a positive culture should receive an antimicrobial regimen that provides cover for MRSA.

A116: Perioperative Invasive Vascular Catheterization Associated with Increased Risk of Postoperative Infection in Lumbar Spine Surgery: An Analysis of 65,158 Patient Records

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Introduction: Infection is a risk inherent to lumbar spine surgery, with overall postoperative infection rates of 1.9-2.1% despite advancements in aseptic technique, prophylaxis, and careful patient selection. Patients with postoperative infection are more likely to die, require revision surgeries, experience pseudarthrosis, osteomyelitis, failure of the primary intervention, and worsening pain and disability. Placement of arterial and central venous catheters (CVCs) in the perioperative setting is routine practice, particularly when caring for patients at risk for hemodynamic instability. Although central line associated infections have been studied extensively, no studies have assessed the risk of postoperative infection with perioperative invasive vascular catheter placement in lumbar spine surgery. **Materials and Methods:** In this retrospective cohort study, data was collected for patients undergoing lumbar spine surgery between January 2007 and December 2015 with records in the nationwide Humana private insurance database. Patients receiving single- and multi-level fusion, laminectomy, and discectomy were followed retrospectively for two months for perioperative infection complications, including wound infection, osteomyelitis, and subsequent incision and drainage. We then determined how a variety of risk factors, including central venous catheterization and arterial-line placement, modified the risk of postoperative infection. **Results:** Analysis of 65,158 patient records demonstrated an overall infection rate of 4.7% (2,925/65,158) within 2 months. Only 2.4% (1,526) of patients received a new central venous catheter on the day of their spine surgery, while 15.8% (8,896) received an arterial catheter. Patients receiving a new central venous catheter on the day of their spine surgery were more likely to experience infection (RR 3.0, 95% CI: 2.4-3.7), osteomyelitis (RR 6.6, 95% CI: 3.8-11.3), and undergo an incision and drainage (RR 3.0, 95% CI: 2.0-4.5) within 2 weeks post-op. Likewise, patients receiving a new arterial line on the day of their spine surgery were more likely to experience infection (RR 2.3, 95% CI: 2.0-2.6), osteomyelitis (RR 3.2, 95% CI: 2.2-4.8), and undergo an incision and drainage (RR 2.0, 95% CI: 1.6-2.6) within 2 weeks post-op. These trends were consistent through the 2-month follow-up period, with risk of all outcome measures increasing over that time period. **Conclusions:** In our study both perioperative CVCs and arterial lines significantly increased the risk of post-operative infections. Because the overall infection rate in lumbar spine surgery is relatively high (4.7% in our study), only 13 patients need to be given a new CVC with lumbar spine surgery in order for one to experience infection (NNH = 13). A causal pathophysiologic explanation for the observed risks is that bacteremia induced by placement of invasive vascular catheters leads to hematogenous seeding of surgical sites. Additionally, patients in need of invasive vascular catheterization may be inherently more ill, and therefore less likely to mount a robust systemic immune response to combat infection. Our data suggest that in patients requiring invasive catheterization, surgeons should consider the marginal risks and benefits of lumbar spine surgery more carefully.

A117: One Stage Surgical Treatment of Infected Lumbar Total Disc Arthroplasty with Cutaneous Abdominal Fistulas: Report of 3 Cases

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Introduction: Infection following lumbar total disc arthroplasty (TDA) is a rare, albeit serious event. Treatment of this condition is challenging due to a) possible involvement of major retroperitoneal vessels, b) tendency for an infection with low pathogenic microbes that are difficult to verify, c) accompanying prevertebral abscesses, and d) little experience of surgeons in handling this rare complication. Although mentioned in each review, today only two case reports about this serious complication after lumbar TDA are available in the literature. Hence, to the best of our knowledge this is the largest case series about infected lumbar TDA published so far. **Material and Methods:** Three patients (2 male, 1 female, average age: 41 years) with 5 infected lumbar disc prostheses (3 x L4/5, 2x L5/S1). All cases were late infections occurring between 9 months and 6 years following index surgery. Presenting symptoms included abdominal and lumbar back pain (VAS back pain: 8.3, VAS leg pain: 4.3) and cutaneous abdominal fistula. Leukocyte counts and CRP were elevated significantly. Psoatic abscesses were seen on CT- and MRI scans in all 3 cases. Two patients had unsuccessful repeated local abdominal revisions (6 and 8 times). **Results:** Treatment involved a one stage, two-step revision surgery with posterior stabilization and fusion using pedicle screws. Additionally, an anterior (2x) or a lateral transpsoas approach (1x) with TDA removal and fistula excision followed by stabilisation using titanium cages packed with autologous bone graft was performed. Surgical treatment was accompanied by iv. antibiotic therapy for 3 months.

Average OR time was 5 hours (296 Min). Although in average 3 lesions of either the vena cava, the left iliac vein or the ascending iliolumbar vein occurred during anterior surgery average blood loss was only 1.6 l. No postoperative complications occurred and all 3 patients made an uneventful recovery. Serum parameters subsequently returned to normal values. After 12 months follow-up all patients were clinically satisfied (VAS back pain: 0.6, VAS leg pain: 0). Fusion was accomplished in all cases as documented by serial X-rays and CT scans. **Conclusion:** One stage implant removal and instrumented fusion is an effective and safe surgical treatment for patients with infected lumbar TDA. TDA removal is possible using either anterior or lateral transpsoas approaches. Individual case planning is mandatory to achieve satisfactory results. However, vascular lesions are common and have to be anticipated during the planning and preparation to make this complex revision surgery safe.

A118: Wound Infection after a Spinal Surgery Has Got a Negative Influence on the Patients' Subjective Long Term Treatment Outcome

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Introduction: Limited data has been published about the long term effect of a surgical complication. One of the major complications after a spine surgery is the wound infection (surgical site infection, SSI), but the effect of this compliaction on the long term treatment outcome of the index surgery is not known. The aim of the study was to explore the effect of SSIs on the objective and subjective long term outcome in a prospective cohort of lumbar degenerative surgeries. **Materials and Methods:** One thousand thirty (N = 1030) patients were recruited into the study. Patients underwent single- or two-level microdiscectomy, decompression or instrumented fusion from open posterior approach. Revision surgeries were excluded. A questionnare booklet was filled out before and two years after the index surgery by the subjects. SSIs were diagnosed and treated according to the CDC guidelines. Treatment outcome was determined in terms of the change in Oswestry Disability Index (ODI), Core Outcome Measurement Index (COMI) and pain (VAS). Subjective global treatment outcome (GTO) was also reported by the patients. Comparisons were made applying Chi2-test and t-tests, where $P < .05$ was considered significant. **Results:** Prevalence of SSI was 3.9%. A significant difference in score-change of pain and disability between patients with "good" and "poor" GTO ($p(ODI) < 0.001$, $p(COMI) < 0.001$, $p(VAS) < 0.001$) was observed. There was no significant difference in the results of the patient reported outcome measures (ODI, COMI, VAS) in case of an SSI ($P > .05$) two years after the surgery. On the other hand, patients suffered the complication reported a signifcantly worse GTO two years after the surgery compared to the patients who did not have any wound infection ("poor" outcome in the SSI group was 24% compared to 12% in the non-SSI group, $P = .017$). **Conclusions:** Guideline-based diagnosis and management of an SSI after a spine surgery can help to achieve an optimal physical status long term. On the other hand, even in case of a careful treatement process, the appearance of a major complication can signficiantly influence the sunjective patient reported treatment outcome which means an increased risk for patient's dissatisfection and its psychosoical consequences. Based on our findings, the deeper analysis of the psychological consequences of surgical complications as well as the development of possible mitigation startegies are advised.

Minimally Invasive Spine Surgery 1

A119: Minimally Invasive Resection of Ventral and Ventrolateral Intradural Extramedullary Spinal Lesions: Clinical Outcomes and the Addition of Image Merge Technique

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Introduction: Posterior translaminar approaches for resection of ventral and ventrolaterally placed intradural extramedullary lesions is challenging. Reports using these approaches for ventral lesions show a high neurological complication rate, likely due to spinal cord manipulation. Minimally access surgery (MAS) with image guidance minimizes soft tissue morbidity, and may potentially facilitate tumor resection and lower complication rates for tumors ventral to the spinal cord. We present our results of MAS image guided surgery for intradural ventral and ventrolateral lesions resected through a paramedian oblique tubular MAS approach. **Methods:** Retrospective review of clinical, radiological and surgical records of patients operated for intradural mass lesions with MAS technique from 2004 to 2016. Preoperative status, lesion location, surgical technique (MAS vs IMTAR) and follow-up surgical results and complications were documented according to the type of MAS technique (image merged vs classic image guided). **Results:** 54 patients operated using tubular techniques for intradural lesions, there were 12 ventrally located lesions. Mean age was 57 years (range 23-92), 6 males and 6 females. There were 7 meningiomas, 4 schwannomas, and 1 arachnoid cyst. 6 patients presented with myelopathy, 4 with radiculopathy, 2 dorsal pain. Surgery was performed with fluoroscopic guided tubular MAS technique in 7 cases while 5 patients were treated using the IMTAR technique (Maduri et al 2016), both using a posterolateral oblique transmuscular trajectory. Bone removal was tailored to resection needs. Mean blood loss was 253 mL. Miniextracavitary costotrasversectomy was necessary in 3 patients, complete facetectomy in 3 patients and complete

pediculectomy in 1 patient. Mean hospital stay was 7.8 days (3-26). Postoperatively, there were no neurological complication and no CSF fistula. 1 patient had superficial wound infection treated with antibiotics. 2 patients with Schwannoma underwent deliberate nerve root sacrifice with expected postoperative radicular sensory loss. GRT was achieved in 13 patients. Mean FU was 24.8 months (1-60), only 1 patient presents myelopathy, 3 patients with dysesthesia controlled with medical treatment. Axial pain is present in 1 patient operated for a C2-C3 meningioma with no radiological signs of instability. **Conclusions:** Translaminar approach for ventral intradural spinal tumors has been reported to have a 41.6% overall complication rate (25% of postoperative neurological deficit) and 1.5% of mortality (Mehta et al, 2013). MAS facilitates surgical access to ventral and ventrolateral tumors with almost a 180° range of access. Furthermore, implementation of intraoperative image guidance allows customization of surgical trajectory, bone resection and tumor removal thus reducing the risk of neurological complication. In the present series the rate of overall complication and neurological aggravation is low despite the ventral location of the lesions. Although our experience with these techniques is small, we believe that for ventral and ventrally located spinal tumor, the use of MAS image guided tubular techniques optimizes tumor access and may facilitate a reduction in neurological morbidity. Further experience is needed to confirm this.

A120: Old Dogs, New Tricks: What Motivates Experienced Spine Surgeons to Try Minimally Invasive Surgery?

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Introduction: The aim of this study was to explore the motivations of spine surgeons who have sought to learn new technical skills through a qualitative analysis of the self-identified motivational factors that purportedly shaped their decision to learn a new technique. Embarking on a learning pathway to gain competence in a new procedural skill is a major undertaking for experienced surgeons. Their expertise in the surgical procedures they routinely use has been obtained through years of practice. To step outside their comfort zone and risk harming their patients while they gain expertise in a new procedure requires strong motivation. To my knowledge, a qualitative analysis of this process has not been done with specific reference to spinal surgery. If we are able to identify salient mediating factors related to changing surgical techniques amongst experienced surgeons, then we may be able to enhance the design of future educational interventions in spinal surgical training. **Materials and Methods:** The research method was in-depth interviews with spine surgeons who have more than ten years of experience and had made a deliberate choice to adopt a new surgical technique in their practice in the last five years. They were recruited by direct invitation to view an information and consent document in a Dropbox file. Seven surgeons agreed to participate in the study. **Results:** The surgeons interviewed were all male, four orthopaedic surgeons and three neurosurgeons. Their age range was 44 to 63 years and they had been in specialist practice for between 12 and 30 years. All of them were self-employed, some were in private practice alone but most were working in the public and private health system. The interview transcripts were analysed using direct content analysis with codes derived from existing literature on change of practice motivation.All seven of the surgeons interviewed identified the desire to improve patient outcomes and avoid complications as being the two major motivators for adopting a new technique. Other common factors included having more treatment options, staying up to date and trying something new. Some of them mentioned financial gain and competing with colleagues. They were all asked about techniques they had adopted and techniques they had tried but not taken up. Minimally invasive spinal surgery was identified by all as likely to improve patient outcomes but only two continued with the technique and five decided not to adopt. The other common technique was corrective surgery for degenerative deformity. This apparent dichotomy between seeking a new technique to improve patient outcomes or avoiding having to learn a new technique due to concern over possible complications was a recurring theme during the interviews. **Conclusions:** The experienced spine surgeons in this study were motivated to adopt a new technique after identifying areas in their practice where patient outcomes could clearly be improved or complications avoided. The process of learning the new technique involved embarking on a learning curve with its potential difficulties, which for some was accepted but for others was a deterrent.

A121: A Single-Incision, Oblique Retroperitoneal Approach for Lumbar Interbody Fusion from L1 to S1 in Adult Spinal Deformity

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Introduction: Retroperitoneal lumbar oblique corridor was defined as the left lateral border of the aorta (or iliac artery) and the anterior medial border of the psoas. The L5/S1 corridor of access was defined transversely from the midsagittal line of the inferior end plate of L5 to the medial border of the left common iliac vessel and vertically to the first vascular structure crossing the midline. This provides a slightly oblique trajectory to the intervertebral disc spaces of L1 to L5, with a separate Pfannenstiel approach required for access to the L5/S1 intervertebral disc space. Consequently, separate incision and position change is needed to perform L5/S1 oblique interbody fusion. To perform oblique lateral interbody fusion

from L1 to S1 without separate incision and position change, the authors placed the patient in a 45° right oblique decubitus position. This modified oblique retroperitoneal approach allows extending access to the L5/S1 intervertebral disc without separate incision and position change. In this study, we illustrated a single-incision oblique retroperitoneal approach for lumbar interbody fusion from L1 to S1 in adult spinal deformity and evaluate the radiographical findings and clinical outcomes of patients treated using this technique. **Material and Methods:** This study included 15 patients scheduled to undergo anterior and posterior long level fusion for lumbar degenerative kyphosis or degenerative lumbar scoliosis. Data collected included blood loss, operative time, incision size, perioperative complications. Pre- and postoperative radiographic parameters and clinical outcome measures were assessed. Mean follow-up time was 22.1 months. **Results:** The mean Blood loss was 107.4 ml,12.4 ml and 87.6 ml with in 5 levels(8 cases), 4 levels(6 cases) and 3 levels(1case), The mean operative time was 116 minutes, 97minutes and 82 minute the patients with in 5 levels(8 cases), 4 levels(6 cases) and 3 levels(1case). The mean incision sizes were 14.63 cm, 13.82 cm and 12.5 cm in the patients with 5 levels, 4 levels and 3 levels. The mean preoperative sagittal vertical axis was +17.12 cm and postoperative sagittal vertical axis was +2.11 cm. The preoperative lumbar lordosis was 3.28°and the postoperative lumbar lordosis was 48.08°. The mean pelvic incidence was 51.64°. The mean correction angle was 59°. There was no injury to the iliac artery or vein, but there were complaints of groin and medial thigh pain in 3 cases, however the pain disappeared at 3 months postoperatively. There was no retroperitoneal hematoma or herniation. In 2 cases, the peritoneum was torn during the surgery and was sutured immediately with no complication. **Conclusion:** The outcomes from our study demonstrate that this oblique retroperitoneal approach is a very safe, allowing reproducible access from L1 to S1 for lumbar interbody fusion in adult spinal deformity. It is associated with a short operative time, minimal blood loss. Furthermore, this approach may have a number of theoretical advantages to traditional techniques. It may facilitate greater sagittal deformity correction with placement of lordotic anterior interbody cages, and the need for a three-column osteotomy in the setting of significant deformity may be avoided.

A122: Treatment of the Fractional Curve of Adult Scoliosis with Circumferential Minimally Invasive Surgery (cMIS) versus Traditional, Open Surgery: An Analysis of Surgical Outcomes

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Introduction: The fractional curve of adult scoliosis can cause significant radiculopathy. We sought to evaluate the outcomes of patients whose fractional curves were treated with either cMIS or open techniques. **Material and Methods:** A multicenter retrospective review of an adult spinal deformity database of MIS and open surgically treated patients, with the following inclusion criteria: age >18 years with fractional curves >10°, ≥3 levels of instrumentation, and one of the following: coronal Cobb angle (CCA) > 20°, PI-LL > 10°, PT > 20°, SVA > 5 cm. **Results:** 420 patients met inclusion criteria for the database, of those, 165 had complete 2 year data. 118 patients had their fractional curves treated, 79 open and 39 cMIS. The fractional curves were similar pre-op (17 cMIS, 19.6 open) and post-op (7 cMIS, 8.1 open), but open had more levels treated (12.1 vs 5.7). cMIS had greater reduction in VAS leg (6.4 to 1.8) than open (4.3 to 2.5). When propensity matched for levels treated (6.6 cMIS and 7.3 open), 40 patients had their fractional curves treated with either cMIS (n = 20) or with open (n = 20) surgery. Both groups had similar fractional curve correction (18° in both groups before surgery, 6.9° in cMIS and 8.5° in open after). cMIS patients had a smaller postoperative coronal Cobb angle (12.5° vs 24.3°) and lower EBL (809 cc vs 2299 cc). Open patients had a higher SVA change (−19.6 vs +13.2), more pelvic fixation (55% vs 15%), and more direct posterior decompressions (80% vs 22.2%). Both groups had similar pre-op leg pain (VAS leg 6.1 cMIS and 5.4 open) and similar postop leg (VAS leg 1.6 cMIS and 3.1 open). All cMIS patients had interbody grafts whereas 35% of open did. The cMIS and open patients had similar reduction in leg pain (change VAS Leg −4.4 vs −2.2). There was no significant difference in change of Cobb angle, PI-LL, LL, ODI or VAS Back. **Conclusion:** In the treatment of the fractional curve of adult scoliosis with magnitude greater than 10 degrees, patients treated with cMIS achieved similar reduction in leg pain compared to those treated in an open fashion, even though significantly fewer cMIS patients underwent direct decompression of the fractional curve nerve roots.

A123: Learning Curve for MISS Aspirants: A Retrospective Review from Five Years of Minimal Invasive Spine Surgeries

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Introduction: There is an inherently difficult learning curve associated with minimal invasive surgical approaches to spinal decompression and fusion. Complication rates and learning curve are often associated with little information about their correlation. **Materials and Methods:** We did a retrospective review of 126 patients operated by the same surgeon during first five years of independently implementing MISS (Minimal Invasive Spine Surgeries). All surgeries were done by MED (Micro Endoscopic Discectomy) technique (later on also added with MISS fixations) between 2011 and 2016. All had disc herniation and/or lumbar stenosis at single or double level with or without instability and were followed up till date for clinical results, VAS (Visual Analogue Score) and complications. The indoor charts were also reviewed to compare intraoperative blood loss, operative time, hospital stay, and any other complications. **Results:** Average age was 44 $\pm$ 11 years and average operation time was 117 $\pm$ 54 minutes. The analysis of the operative time showed that the average surgical time decreased to less than 90 minutes after 30 surgeries. The operative time for MED was around one hour after 50 surgeries and MISS fixations were done in less than 3 hours. After 50 surgeries, the timing for single level discectomy and decompression was less than 60 minutes including bilateral decompression with unilateral approach. Hospital stay was around 3.06 $\pm$ 1.38 days which were uniformly same in all surgeries. Pre-operative VAS score was 8.6 $\pm$ 0.9 v/s 1.8 $\pm$ 1.3 ($P < .05$) in the post-operative period. Intra-operative and post-operative complications such as dural tear or root injury, post-operative hematoma, incomplete excision requiring revision and loosening of screw cap were found in initial 50 surgeries (11 versus 1 between first 50 and later cases respectively). **Conclusion:** MISS procedures for discectomies and spine fixations have shown early encouraging results. However, a spine surgeon needs to believe and stay persistent while implementing MISS surgeries inspite of excellent clinical hands on fellowships. As per our case series, first 30 surgeries should be restricted to MISS decompression and discectomy without getting stressed by difficulties. Next 20 cases can be combined with some MISS fixations and mastering the technique. After the first 50 cases, bilateral decompression with or without fixation and TLIF (Trans-Foraminal Lumbar Inter-body Fusion) can be considered.

A124: Efficiency of MISt (Minimally Invasive Spine Stabilization) for the Patient of Metastatic Spinal Tumor

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Introduction: Metastatic spinal tumor is a frequent complication in cancer patients. Traditional aggressive surgical strategies for metastatic spinal tumors are associated with high morbidity and complication rates, which can limit their indication in patients with a limited life expectancy. Even as minimally invasive spine stabilization (MISt) gains popularity in Japan, effectiveness for the treatment of metastatic spinal tumors has yet to be established. **Methods:** The subjects comprised 37 cases that underwent surgery using the MISt technique against metastatic spinal tumors. The cases included 21 men and 16 women, with a mean age at surgery of 66 years old. The primary tumor was: breast cancer in10 cases, prostate cancer in 8 cases, lung cancer in 7 case, and another cancer in 12 cases. We checked operation time, blood loss, length of time taken until recovery, complications, and prediction of the prognosis using the Tokuhashi score, Tomita score and Katagiri score. The Frankel classification was used for paralysis. And we have evaluated instability of the spine using Spine Instability Neoplastic Score (SINS). **Results:** The mean operation time was 173 minutes (50-410 minutes). The mean blood loss was 123 g (10-810 g). The number of fusion areas was 5.8 vertebrae (3-24 vertebrae).The mean time taken until recovery was 3.7 days (1-14 days). The averageTokuhashi score was 8.9points, Tomita score was 5.3 points, Katagiri score was 3.6 points. SINS score was 9.9 points (indeterminate instability). No complications were reported during the procedure. PS was improved after surgery, and the number of Frankel E cases was 63%. Regarding paralysis, no improvement was observed.In addition, even the survival probability for the group with no paralysis was significantly longer. **Conclusions:** The benefits of the MISt technique against metastatic spinal tumor is 1) Few infections. 2) Less bleeding. 3) Early recovery. 4) No need to open the wound. 5) A more rapid initiation of postoperative adjuvant therapies. The results of this study revealed that the MISt for patients with metastatic spinal tumor, especially of thoracolumbar spine was safer and less invasive surgical management. It should be considered as palliative surgical strategy in patients with limited life expectancy, to limit morbidity and preserve quality of life.

Novel Technologies 1

A125: Detethering of the C2 Nerve Root and Avoidance of Transection and Injury during C1 Screw Placement: A Cadaveric Feasibility Study

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Introduction: Regional neurovascular structures must be avoided during invasive spine hardware placement. During C1 lateral mass screw placement, the C2 nerve root is put in harm's way. Therefore, the current anatomical study was performed to identify techniques that might avoid such neural injury. **Materials and Methods:** On 10 cadaveric sides, dissection was carried down to the craniocervical junction. The C2 nerve root was identified and its distal branches traced out into the surrounding posterior cervical musculature. Once dissected, the nerve was displaced inferiorly away from the lateral mass of C1. **Results:** On all sides, the C2 nerve root could be easily detethered from surrounding tissues. On all sides, this allowed lateral mass screw placement without compression of the nerve. **Conclusions:** Based on our cadaveric study, the C2 nerve root can be detethered enough at the level of the posterior lateral mass of C1 to avoid its injury during screw placement into this area.

A126: Development of a New Assessment Tool for Cervical Myelopathy using a Virtual Reality Hand Tracking Sensor

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Introduction: Myelopathy hand is a characteristic feature of cervical myelopathy. Since there are only a few scales to quantify the severity of cervical compressive myelopathy, there is a need to introduce a universal objective platform in outpatient settings. Virtual-Reality offers promise as a means of producing quantitative data regarding the function of the neural system in the hand. The Leap Motion Controller (LMC) is a small, USB Virtual-Reality motion tracking device that could be used for this purpose. The aim of this study was to assess the reliability and validity of the LMC in the 15-second hand grip-and-release (G-R) test, as compared against human inspection of an external digital camera recording. Moreover, to set a baseline measurement of the number of hand flexion-extension cycles and analyse the degree of motion in young healthy individuals, besides examining gender and dominant hand differences. **Materials and Methods:** Fifty healthy participants were asked to fully grip-and-release their dominant hand as rapidly as possible for three tests, each separated by a 10-minute rest, while wearing a non-metal wrist splint. The first two tests lasted for 15 seconds, and a digital camera was used to film the anterolateral side of the hand on the first test. The third test lasted for a maximum of three minutes or until subjects fatigued. Three assessors counted the frequency of G-R cycles, of the recorded videos, independently and in a blinded fashion. One assessor counted the frequency of grip-and-release cycles as well as the number of motions (*magnitude of motion*) from the data output of the LMC. The average mean frequency of the three video observers was compared with that measured by LMC using the Bland-Altman method. Test-retest reliability was examined by comparing the two 15-second tests. **Results:** The mean number of G-R cycles recorded in each 15-second test was: 47.8 ± 6.4 (test 1, video observer); 47.7 ± 6.5 (test 1, LMC); and 50.2 ± 6.5 (test 2, LMC). Bland Altman indicated a bias of 0.15 cycles (95%CI = 0.10-0.20), with upper and lower limits of agreement -1.16 and 1.46 cycles, respectively. The ICC showed high inter-rater agreement (ICC = 0.998, 95%CI = 0.997-0.999, $P < .01$). The coefficient of repeatability for the number of cycles was ± 5.393, with a mean bias of 3.63. Over 3 minutes, the frequency of cycles (per 10-second interval) decreased, as did the magnitude of motion. However, the decline in frequency preceded that of motion's magnitude. Participants reached fatigue from 59.38 seconds; 43 participants were able to complete the 3-minute test. There were no statistically significant differences according to gender or dominant hand at most time intervals ($P > .05$). **Conclusions:** LMC appears to be valid and reliable in the 15-second grip-and-release test. This serves as a first step toward the development of a universal objective platform for the assessment of cervical myelopathy. Further assessment is warranted to gauge benchmark values in a wider range of healthy individuals and in cervical myelopathy patients. Assessing the LMC as a diagnostic tool in the clinical setting is also necessary.

Keywords

Cervical Myelopathy, Virtual Reality, Grip and release test, Reliability, Validity

A127: A Proinflammatory and Degenerative Intervertebral Disc Organ Culture Model to Investigate Novel Anti-inflammatory Treatment Approaches for Degenerative Disc Disease

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Introduction: Degeneration of the intervertebral disc (IVD) is considered to be a major reason for low back pain. Proinflammatory cytokines, such as tumor necrosis factor α (TNF-α), were shown to be highly expressed in human degenerated IVD, causing a breakdown of extracellular matrix components by stimulation of matrix degrading enzymes. Therefore, therapies that inhibit the expression of proinflammatory cytokines may be a promising therapeutic approach to consider, aiming to reduce inflammation and maintain the IVDs extracellular matrix. However, no clinically relevant in vitro systems to test new anti-inflammatory therapeutics are available to date. The aim of the study was to design and evaluate a proinflammatory and degenerative organ culture model to simulate the early onset of degenerative disc disease (DDD). **Material and Methods:** Bovine IVDs with endplates were harvested and cultured with or without an intradiscal injection of TNF-α (100 ng TNF-α / IVD) for 4 days. IVDs were cultured within a bioreactor system under 2 different loading and medium conditions: (1) physiological loading (0.02-0.2 MPa; 0.2 Hz; 2h/day, 3 days) and high glucose (4.5 g/L) medium (Phy), or (2) degenerative loading (0.32-0.5 MPa; 5 Hz; 2h/day, 3 days) and low glucose (2 g/L) medium (Deg). IVDs were cultured free swelling between dynamic loading cycles. After the first dynamic loading cycle on day 1, TNF-α was injected into the disc nucleus pulposus (NP) tissue. Disc height was recorded daily after load and free swelling (FS) recovery. Conditioned medium was collected for nitric oxide (NO) and Glycosaminoglycan (GAG) analysis. After 4 days, NP and annulus fibrosus (AF) tissue were harvested and gene expression was analyzed using real-time PCR. GAG/DNA and Hydroxy-proline (OHP)/DNA content of the disc tissue were assessed. One-way ANOVA or Kruskal-Wallis tests were used to determine statistical significance. **Results:** Degenerative dynamic loading caused significantly higher disc height loss ($\sim 20\%$) compared to physiological dynamic loading ($\sim 10\%$). Intradiscal injection of TNF-α did not further induce disc height loss after loading. TNF-α combined with Deg condition up-regulated NO release from IVD ($P < .01$ Phy vs Deg+TNF-α). TNF-α injection also enhanced GAG release in Phy group ($P < .05$). Gene expression analysis demonstrated a decrease of type I collagen (COL1) in AF tissue, caused by Deg condition or TNF-α injection ($P < .05$). TNF-α injection combined with Deg condition induced an up-regulation of interleukin-6 (IL6) and matrix metalloproteinase 1 (MMP1) in NP tissue, as well as increased interleukin-1β (IL1B) gene expression in AF tissue ($P < .05$). **Conclusion:** This degenerative and inflammatory model is capable to induce catabolism on organ cultured IVDs indicated by a significant upregulation of catabolic and inflammatory gene expression markers in disc tissue, together with enhanced NO release. The early onset of DDD can be simulated and novel anti-inflammatory treatment approaches can be investigated under relevant conditions by utilizing this model. Further research will aim to analyze the biologic and biomechanical response of selective cytokine inhibitors on organ cultured IVDs as alternative therapies for DDD.

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A128: Comparative Analysis of Inflammatory Processes during Cervical and Lumbar Degenerative Disc Disease

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Purpose: To investigate the occurrence of inflammatory processes in the sites of disc degeneration in the lumbar and cervical spine by a cytokine gene array and subsequent qPCR. **Materials and Methods:** Disc samples were obtained from 31 patients undergoing discectomy, 11 men and 20 women, with a mean age of 56 years. RNA was extracted by Trizol/Chloroform method and examined for 28 cytokines by a gene array ($n = 6$) and then followed up by standard qPCR for eight selected cytokines on all samples Samples had the following characteristics: site = 24x cervical and 7x lumbar; pathology = 11x disc herniation and 20x degenerative disease (all $\geq$ grade 3); level = 13x one level discectomy and 18x multilevel discectomy. For the patients that underwent multilevel discectomy, one sample was gathered. The nucleus pulposus (NP) and annulus fibrosus (AF) of the lumbar samples were seperately examined. Results were statistically analyzed by the two-sample Kolmogorov–Smirnov test with a significance level of $P \leq .05$. **Results:** In both, cervical and lumbar discs, the interleukines IL-6 and IL-8 were found to be the overall highest expressed genes, whereas the expression of IL-1β, TNF-α and IL-15 (a disc cytokine that has been sparsely investigated up to now) was comparatively low. Interestingly, three previously unreported cytokines could be detected in cervical and lumbar disc tissue: the interferones INA1, IFNA8 and IFNB1. No statistically significant difference was found between cervical and lumbar samples, or between AF and NP samples for any of the investigated genes. Also, no correlation was found between gene expression and gender, age or the extent of the operation (single/multilevel). **Conclusions:** Our results show that no major differences exist in the inflammatory profile of cervical and lumbar degenerated discs, indicating that novel anti-inflammatory treatments currently under investigation may be applicable independent of the degeneration site. The high expression of IL-6 and IL-8 supports their described relevance in nociception and matrix degradation. Although IL-1β and TNF-α are well described to play a role in the pathogenesis of disc disease, their expression was comparatively low.

Importantly, this study is the first to describe the expression of type I interferons (interferons alpha and beta) during disc degeneration, which can have both, proinflammatory and anti-inflammatory properties. Although their role in degenerative disc disease is currently unclear, they are often described to have immunomodulatory effects (e.g. in osteoarthritis) and may hence be a reactive attempt to inhibit inflammation in the disc. Further studies will be required to identify their disc-specific function as well as the role of IL-15, which has also been sparsely investigated thus far.

A129: Dysphagia in Standalone versus Conventional Anterior Cervical Discectomy

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Introduction: Dysphagia is an extensively described complication of anterior cervical discectomy and fusion. It has been proposed that mechanical irritation, additional dissection or displacement of the esophagus by plate placement may contribute to a greater incidence of post-operative dysphagia. The aim of this study was to compare dysphagia symptoms and pain severity of standalone cage systems versus interbody devices in combination with an anterior plate. **Material and Methods:** A retrospective cohort study identified 377 consecutive patients (stand alone, n = 211; plate and cage, n = 166) meeting the study criteria between the years 2014 to 2015. Patient-specific characteristics and surgical characteristics and Numeric Pain Rating Scale (NRS) scores were collected preoperatively. Complication and readmission rates, the Dysphagia Disability Index (DDI), and NRS scores were collected at one year and two years post-operatively. **Results:** Both groups were similar with respect to age, gender, body mass index, smoking status, several comorbidities including the Charlson score, and preoperative NRS scores (5.3 $\pm$ 2.1 versus 5.4 $\pm$ 1.9 in the stand alone and plate and cage groups, respectively). Patients in the stand along group were more likely to have a primary diagnosis of radiculopathy and less likely to have the diagnosis of myelopathy. They were more likely to have had prior cervical surgery (22.8% vs 13.3%; $P = .02$). Patients in the plate and cage group were more likely to have multiple levels of surgery (57.8% versus 34.6%; $P < .01$) and experienced a longer length of surgery (143 $\pm$ 51 minutes versus 108 $\pm$ 43 minutes; $P < .01$). Both groups experienced similar complication and readmission rates. The stand along group experienced a higher rate of symptomatic non-union with reoperation but this did not achieve statistical significance (9% versus 4%; $P = .07$). There was a significantly greater improvement in neck pain scores in the plate and cage group after one and two years post-surgery compared to the stand alone group (2.3 and 3.1 versus 1.6 and 1.5, respectively; $P < .01$). Post operative DDI scores were similar at 2 years post-surgery (9.4 $\pm$ 11.9 versus 9.5 $\pm$ 11.7). **Conclusion:** Chronic dysphagia scores are comparable between standalone cage systems and interbody grafts with plating. We observed a greater improvement in neck pain and a lower incidence of nonunion in the group that underwent interbody graft and plate placement at followup. Further research is needed in order to determine factors that may lead to a higher rate of non union for patients undergoing stand alone cage placement.

A130: Driving Reaction Time after Spinal Surgery: A Systematic Review

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Introduction: The driving reaction time is defined as the amount of time, on the order of milliseconds or seconds, at which a driver can adequately react to a stimulus requiring them to brake emergently. Although, DRTs can vary depending on variables such as mental processing time, movement time, and device response time there are standard or safe ranges quoted in the literature. Thus, a standardized postoperative DRT might represent an objective indicator for when a patient can resume safe driving after spinal surgery. The objective of our study was to assess driving reaction times (DRTs) after spinal surgery, to establish a timeframe of when postoperative patient's can safely resume driving. **Methods:** The MEDLINE and Google Scholar databases were analyzed according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) statement for clinical studies investigating changes in DRTs following cervical and lumbar spinal surgery. Changes in DRTs and patients' clinical presentation, pathology, anatomical level affected, number of spinal levels involved, type of intervention, pain level, and driving skills were assessed. **Results:** The literature search identified 12 studies addressing DRTs in postoperative patients; of those studies, 6 studies met the inclusion criteria. Amongst these 6 studies, 5 studies assessed changes in DRT after lumbar spine surgery and 2 studies after cervical spinal surgery. The spinal procedures included were: selective nerve root block (SNRB), anterior cervical discectomy and fusion (ACDF), and lumbar fusion and/or decompression. Overall, DRTs exhibited variable responses to spinal surgery dictated by the patients' clinical presentation, spinal level involved, and the type of procedure performed. **Conclusions:** The evidence regarding patients' ability to resume safe drive after spinal surgery is scarce. Normalization of DRT or returning to pre spinal intervention values represents a widely accepted indicator for safe driving with mixed statistically significance due to multiple confounding factors. Considering the type of spinal intervention, the pain

level, opioid consumption, and cognitive function is unique to each case and will be more adequate reflection of when to safely resume driving

Osteoporotic Fractures

A131: Bone Quality of Lumbar Spine Assessment Using Dual Emission X-ray Absorptiometry: A Potentially Misleading Results

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Introduction: Diagnostic role of DEXA in bone quality assessment that is required to predict a low energy fracture and implant failure after spinal instrumentations is still questioned because of limited specificity. The aim of this study is to study the relationship between CT and DEXA to assess a potential bias in bone quality assessment. **Materials and Methods:** This is a cross-sectional study; twenty-five patients were selected for study who underwent a CT scan and DEXA of the lumbar spine. Using DEXA scan of a lumbar spine; BMD (g/cm^2) was calculated for each vertebra of lumbar spine (L1-L4 inclusive). The CT scans were performed from the T12-L5 levels. The scans utilized a slice thickness was 0.5 mm, covering a scan area of 50 cm. The scan parameters included: tube voltage 120 kV, tube current 300 mA, auto mAs range 180-400; 1.0 sec/3.0mm/0.5x32, helical-pitch 21.0. Integrated software was utilized for calculations of bone density (Vitrea Version 5.2.497.5523) incorporating a window width/window level ratio of 2000/500. Measurements of bone radiodensity were obtained in HU from each vertebral body in the sagittal, axial and coronal planes from level L1 to L4 inclusively. Radiodensity was measured in two ways: a total vertebra body radiodensity including cortical bone and radiodensity of only a cancellous bone were obtained. Finally a mean value in HU was calculated for cancellous bone and a total vertebra body radiodensity. To study the impact of other structures on bone quality assessment using DEXA, a mean square and radiodensity calculated of right and left vertebra pedicles in frontal plane and a mean square and mean radiodensity calculated of right and left facet joints in axial plain were measured for each vertebra. General factorial regression analysis was applied to study relationships between CT and DEXA data. **Results:** The required measurements were taken from 100 lumbar vertebrae. The logistic regression analysis demonstrated a strong correlation between BMD measured by DEXA (dependent variable) and CT data (predictors). The estimated multiple correlation coefficient of estimated model accounts for 0.8093, $r^2 = 0.6550$, $P < .0001$. The estimated parameters of regression model were: B0 = 0.4967149686, p,0,0001; B1 for cancellous bone = −0,0005116753, $P = .4633$, B2 for a product of facet joints radiodensity and mean square = 0,000003379, $P < .0001$; B3 for pedicle radiodensity on a frontal image = 0.0001253732, $P = .2610$; B4 for Pedicle mean square on frontal plane image = −0.0006727354, $P = .08682$; B5 for total vertebral body radiodensity = 0.0016395253, $P = .0201$. Beta coefficients for a product of facet joints radiodensity and total vertebral body radiodensity accounted for 0.6729 and 0.3037 respectively. Linear correlation analysis showed only a moderate correlation between a vertebra body and facet joints radiodensity r = 0.4854, $P < .0001$ (Pearson correlation). **Conclusion:** The results of bone quality assessment of spine column using DEXA can be strongly influenced by facet joints condition especially in case of degenerative changes. The provided by DEXA results of BMD are partly relevant to vertebral body bone quality assessment and irrelevant to the characteristics of bone in pedicles so that prognostic value of those results might be limited in relation to low energy vertebra fracture and implant stability forecasting.

A132: Vertebral Fracture Over the Metal Structure in Patients with Osteoporosis: Can We Prevent These Injuries?

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Introduction: Compression fractures of the vertebrae at the junction with PSF are a serious problem. Most often these fractures occur in patients with osteoporosis. The experimental studies (Kebaish K.M. et al., 2013, Basankin I.V. et al, 2015) show the effectiveness of the preventive using of vertebroplasty for preventing fracture of the overlying vertebra above the pedicle screw system. The purpose of our work is the evaluation of the effectiveness of preventive vertebroplasty of vertebra over the PSF in patients with osteoporosis. **Material and Methods:** The work consists of patients who were treated in our hospital over the vertebral osteoporotic fractures in the period 2012-2014. Osteoporosis was confirmed by performing CT densitometry. The study includes patients with a T-criterion from −2.5 to −4. PSF length was between 2 and 4 segments depending on the type of fracture. Between 4 and 8 screws were implanted to each patient. There were 51 people (34 women) aged 48-76 (mean 62 +/− 2) years. Screws with augmentation were implanted to all patients. Patients were divided into two groups: Group 1 - Control: 27 people - PSF with augmentation; Group 2 - Experienced: 24 people - PSF with augmentation plus prophylactic vertebroplasty of overlying vertebra. Preventive vertebroplasty was performed in the standard way. 7-9 ml

of bone cement of high viscosity were introduced in the body of the vertebra by 2 Jamshidi needles. Surgical technique was comparable and performed by 3 surgeons of one department. All patients were discharged from clinic in satisfactory condition. There were no complications of surgical and infectious nature. Control examination was carried out after 3, 6, 12 and 24 months or in some problem cases. **Results:** Group 1 - control. Using the PSF with augmentation for the treatment of osteoporotic fracture ensured the stability of damaged segments soon after surgery. However, at different periods of time (3 to 9 months.) 7 (25.9%) cases of fractures of overlying vertebra were diagnosed and required surgery. Patients in this group had a normal life and were not exposed high-energy trauma. Group 2 - experienced. Using the PSF with augmentation combined with prophylactic vertebroplasty of overlying vertebra had provided the following results. Adequate stabilization of the affected segments was achieved. Overlying vertebra fracture was detected in 1 (4.1%) case. The patient suffering from epilepsy fell from the height of its own growth as a result of the attack, after a fracture of the vertebra was diagnosed and was located above the prophylactic vertebroplasty. **Conclusion:** Using vertebroplasty of overlying vertebra (in the volume of 7-9 ml.) is an effective way to prevent vertebral fractures over PSF. The method significantly reduces the number of revision surgeries.

A133: Comparison of Unipedicular versus Bipedicular balloon Kyphoplasty for Osteoporotic Vertebral Compression Fractures

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Introduction: To evaluate the clinical results of a unipedicular balloon kyphoplasty for the treatment of osteoporotic vertebral compression fractures. **Material and Methods:** Between January 2011 and December 2014, 331 vertebrae of 297 patients, who underwent kyphoplasty for osteoporotic vertebral compression fractures, were analyzed. Group 1, with the bipedicular approach, consisted of 141 vertebrae of 143 patients with a mean age of 74.1 years. Group 2, with unipedicular approach, consisted of 190 vertebrae of 154 patients with mean age of 73.0 years. The plain radiographs, MRI and surgical records were reviewed. **Results:** In group 1, the mean VAS score changed from 7.29 to 2.73, the mean period of hospitalization was 3.10 days and the mean amount of cement infused was 7.32 cc. The degree of vertebral body collapse was 0.81, 0.73, 0.62 and 0.60 on follow-up, and 15 cases had fresh fracture. In group 2, the mean VAS score changed from 6.38 to 2.42, the mean period of hospitalization was 3.32 days and the mean amount of cement infused was 3.97 cc. The degree of collapse was 0.75, 0.67, 0.62 and 0.60 on follow up and 4 case had fresh fracture. The two groups showed no statistical significance for the change of the VAS score and the period of hospitalization, and the amount of cement was significantly less in group 2. The degree of collapse was not significantly different on the 4 times of follow-up. The frequency of fresh fracture was significantly less in group 2. **Conclusion:** There were no significant differences in clinical satisfaction and radiological results between the unipedicular and bipedicular kyphoplasty. The advantage of a unipedicular approach is the shorter procedure time than the bipedicular approach and less amount of cement. This is particularly useful in multi-level compression fractures.

A134: Percutaneous Vertebral Body Stenting and Bone Cement Augmentation Reduces Morbidity in Osteoporotic Spine Fractures

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Introduction: The morbidity of osteoporotic vertebral fractures increases with the ageing of populations globally. Treatment options have ranged from simple immobilization to vertebroplasty with acrylate to formal open surgical stabilization with instrumentation. We studied the results of our treatment in which the affected vertebral body is stented from within before augmentation with acrylate. **Material and Methods:** Fifty patients with symptomatically painful osteoporotic fractures were treated throughout 2012 till 2014. They were followed up for 24 months. All were female, postmenopausal and had suffered osteoporotic fractures in the lower thoracic or lumbar spines or a combination of both. All had bone density deficits as documented by density scans, and suffered light to moderate degrees of Genant-type vertebral fractures. All were single-level injuries. Excluded were fractures due to secondary malignant spread, multiple-level fractures, injuries with neurological deficit, unstable fractures that required open surgical decompression and fractures that fragmented into the spinal canal. All patients were treated by the same surgeon. The procedure was an image-guided, percutaneous bilateral transpedicular insertion of a trocar that delivered a catheter-mounted, collapsed cobalt-chromium mesh (VBS^{TM}, Synthes GmbH, Solothurn, Switzerland) into the corpus of the vertebra. The mesh is hydraulically expanded with an inner balloon to achieve vertebral height restoration before the balloon is deflated and withdrawn to accommodate polymethylmethacrylate injection. The patient is rested overnight and receives a chest radiograph in addition to a spine check radiograph before being discharged the next morning. We studied the efficacy of pain relief and the chronology of physical activity resumption in the short term and the incidence of adjacent fractures in the long term. The results were tabulated and statistical analysis applied to test for significance. **Results:** All patients experienced pain relief of varying degrees within 48 hours of the procedure. Forty six patients were able to resume

physical activity and mobilise within 24 hours after the treatment while 4 required a longer time which did not exceed 72 hours after the procedure. Eight patients suffered cement leaks anteriorly or laterally into the peri-vertebral region, but which were of no clinical consequence. No pulmonary extravasation was encountered. At 24 months of follow-up, there was no worsening of the fracture profile and no adjacent vertebral fracture was encountered. **Conclusion:** We propose that vertebral body stenting has effectively relieved the symptoms of pain and radiographically restored vertebral body dimensions in our patients. It has been executed reliably without major complications, and has fared well in our patients even at a minimum of 24 months of follow-up. It has consistently prevented otherwise-deterioration of the fracture profile.

Disclosure

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A135: Conservative Management of Osteoporotic Vertebral Fractures

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Introduction: To present updated information on the conservative treatment of osteoporotic Vertebral Fractures. **Material and Methods:** Forty four consecutive patients, diagnosed with osteoporotic vertebral fracture, underwent the predetermined protocol of conservative treatment (bed rest, titrated analgesia, antiosteoporosis pharmacotherapy, bracing, and supervised physical therapy) after assessment of basic demographic data and clinical examination. They were evaluated every three months for nine months, using visual analog scale (VAS) for backpain, Oswestry Disability Index (ODI), and radiological parameters. **Results:** At nine months after treatment, there was a significant decrease in the VAS score ($P < .0001$) and the ODI score ($P < .0001$), with the final VAS score improving by 52.49% and the ODI score improving by 49.78% from the baseline. There was progressive increase in vertebral collapse ($P = .032$) with no change in kyphotic or scoliotic angles. **Conclusion:** Conservative treatment is effective in relieving pain and improving the spine function in such cases without obvious complications and can be therefore an alternative treatment to vertebroplasty or balloon kyphoplasty.

A136: Cement Leakage after Vertebroplasty: Correlation with Patterns of Compression Fractures and Bone Mineral Density

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Introduction: To analyze the influence of fracture patterns and the result of bone mineral density on cement leakage after percutaneous vertebroplasty for osteoporotic vertebral compression fractures. **Material and Methods:** Between March 2014 and March 2015, 102 patients with single level osteoporotic compression fracture were treated by percutaneous vertebroplasty, and the clinical data were analyzed retrospectively. There were 15 males and 87 females, with a mean age of 79.1 years (range, 57-98 years). The patients were divided into cement leakage group and no cement leakage group by occurrence of cement leakage based on postoperative CT. **Results:** The incidence of leakage was 59.1%. Binary logistic analysis revealed that larger volume of bone cement ($P < .001$) and higher fracture severity grade ($P < .001$) were the strongest independent risk factors. Univariate analysis and multinomial logistic analysis showed that surgical approach ($P < .001$), gender ($P = .016$), and operated level ($P = .032$) were additional risk factors for leakage. **Conclusion:** High fracture severity grade and low viscosity of polymethylmethacrylate bone cement are general, strong, and independent risk factors for cement leakage. Using CT and MRI assessment, cortical disruption and the presence of an intravertrebral cleft were identified as additional strong risk factors regarding cortical (intradiscal) cement leakage, thereby potentiating anticipation.

Adolescent Scoliosis 2

A137: Direct Vertebral Rotation vs Single Concave Rod Rotation: Low-Dose Intraoperative Computed Tomography Evaluation of Spine Derotation in Adolescent Idiopathic Scoliosis Surgery

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Introduction: It remains unclear whether SCRR manoeuvre alone causes Apical Vertebral Derotation (AVD) and rib hump correction. Although the influence of DVR on AVD and rib hump change has been described, it has been evaluated mainly with indirect methods. This is the first study to evaluate separately the derotational effectiveness of these two manoeuvres during the low-dose Intraoperative Computed Tomography (ICT). The aim was to compare the effectiveness of two main corrective manoeuvres: Single Concave Rod Rotation (SCRR) and Direct Vertebral Rotation (DVR) in regard to Apical Vertebral Rotation (AVR) and rib hump correction in Adolescent Idiopathic Scoliosis (AIS) surgery. **Material and Methods:** A study group consisted of 38 AIS patients treated by Posterior

Scoliosis Surgery (PSS) with all pedicle screw constructs. The mean age when operated was 15.8 years (11.7 – 17.9 years). Written informed consent for the surgery and publication of this study and all images was obtained from each patient and the Medical University of Gdansk Ethics Committee approved the study. All examined patients had dow-dose ICT evaluation (before correction, after SCRR and after DVR) for the safe pedicle screws placement and for confirmation of screw position after corrective manoeuvres. During the first ICT, precorrectional AVR measure with Aaro&Dahlborn method was performed. AVD assessment was performed with our own method. In every case pre and post correctional rib hump angle was measured (Pleura –Pleura line and Spine – Sternum line ratio). All patients had pre and postcorrectional Cobb angle measurement on plain PA and lateral spinal radiographs. Lenke classification was used for the curve pattern evaluation. All patients had Intraoperative Spinal Neuromonitoring (ISN) performed. For statistical analysis SPSS 17v software (SPSS Inc.) was used. A paired Student T-test was used for the examination of statistical differences. R-Spearman test of correlation was used to evaluate the relationship between perioperative variables. **Results:** We found SCRR ineffective – mean postcorrectional AVR increased insignificantly 1.5° (16.1% worsening) $P = .170$. On the contrary, an average postcorrectional AVR after DVR decreased significantly mean 3.1° (33.3% improvement) $P = .049$. Precorrectional rib hump angle was 19.3°, after SCRR - 15° and after DVR - 12.3°. It was found that despite the lack of true derotation after SCRR there was a significant 22.3% decrease of the rib hump $P = .043$. Although the rib hump decreased significantly 36.3% after DVR as well $P = .023$. There was also significant difference between a rib hump angle after SCRR and DVR ($P = .049$). **Conclusion:** SCRR do not lead to AVD. The true spinal derotation is possible only when DVR systems are used. The decrease of rib hump is achieved both after SCRR and DVR, but the improvement is significantly better after DVR.

A138: Prognostic Factors of Uninstrumented Thoracic Curve Correction Above Selective Fusion for Lenke 5 Idiopathic Adolescent Scoliosis

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Introduction: Spontaneous correction of uninstrumented overlying thoracic curves above selective fusion for Lenke 5 adolescent idiopathic scoliosis (AIS) is usually between 29% and 46%. It is known to be influenced by Thoracic Cobb Angle (TCA), TCA on bending, ratio thoracolumbar Cabb angle/TCA, thoracic kyphosis, growth stage and correction of main curve. To our knowledge, preoperative rib hump has never been expressly evaluated as a prognostic factor. **Aim:** To test rib hump and well-known parameters as prognostic factors of TCA at follow-up above selective fusion for Lenke 5 AIS. **Material and Methods:** Retrospective monocentric series of 48 Lenke 5 AIS, operated on by posterior selective construct with minimum 2 y follow-up. Demographic data, preoperative thoracic rib hump (measured in mm in trunk anteflexion as the distance between the horizontal tangent line to the apex of rib hump and the hollow of the contralateral ribs at the same distance from midline), frontal, sagittal and bending spinal parameters preoperatively and at last follow-up were recorded. Statistics were performed by STATA 9.2: T-Test to compare mean values, Pearson coefficient to assess correlations, Linear multiregression to assess predictability of final thoracic cobb angle. **Results:** Main thoracolumbar curve averaged preoperatively 47° (36° - 72°), at follow-up 12° (1° - 28°). Overlying TCA averaged preoperatively 26° (2° à 40°), at follow-up 16° (2° à 41°), that is correction = 37%. TCA difference between preoperative and follow-up was significant ($P = .001$). Final TCA was correlated to bending TCA (0,63), preoperative TCA(0,62) and rib hump (0,55). Multiregressions confirmed significance of bending TCA exceeding 20° ($P = .001$), preoperative TCA ($P = .011$) and rib hump ($P = .012$). **Conclusion:** Rim hump was proved to influence final TCA. In case of lenke 5 AIS and overlying curve with rib hump and /or TCA bending exceeding 20°, an extensive construct including both thoracolumbar/lumbar and thoracic curve should be discussed.

A139: Optimal Selection of the Lowest Instrumented Vertebra for Lenke Type 5 & 6 Thoracolumbar/Lumbar Major AIS Curves at Minimum 5 Year Followup

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Introduction: Controversy still exists when selecting the lowest instrumented vertebra (LIV) in major TL/L AIS curves. The

decision is typically to stop at L3 vs L4 but is more difficult when the preop L3-4 disc is parallel. We reviewed a large series of Lenke Type 5 & 6 TL/L curves assessing results of LIV selection relative to the lower end vertebra (LEV) and touched vertebra (TV) at 5 yr f/u. We hypothesized that fusing to the LEV in major Thoracolumbar/Lumbar Type 5 & 6 AIS curves will produce acceptable long term results except when the disc below the LEV is parallel (ie, L3/4). In those cases, fusing to the TV, (ie, L4) will lead to better balance & decreased disc angles postop. **Material and Methods:** 106 Lenke Type 5 & 6 AIS curves were retrospectively reviewed from a large AIS database by 2 examiners who selected the TV from the center sacral vertical line (CSVL), and confirmed the LEV of the curve. The LIV distance from the CSVL (cm), LIV disc angle & overall balance at 5 yr f/u were evaluated. Patients were separated into 3 groups based on the L3-4 disc: open on the convex side of the TL/L curve (Open), closed on the convex side (Closed), or Parallel. **Results:** 17/106 pts. were in the Open, 61 in the Closed & 28 in the Parallel group. There was a statistically inferior result of stopping at L3 vs L4 in the Open grp with increased LIV-CSVL distance (2 vs 0.7 cm, $P = .005$) & an increased postop Disc Angle (4 vs 0.2°, $P = .003$). The Parallel grp also had a statistically greater risk of increased LIV-CSVL translation for those fused to L3 vs L4 ($P = .007$, Figure 1). There was no difference in postop LIV distance or angle parameters for the Closed pts. with a L3 vs L4 LIV. **Conclusion:** For Type 5 and 6 TL/L AIS curves, one can reliably stop at L3 & expect a well-centered LIV with minimal disc angulation when the preop L3-4 disc is closed on the convexity of the TL/L curve, but should fuse to L4 when that disc is open on the convexity. When the L3-4 disc is parallel, patients with a L3 LIV will have a greater risk of increased LIV-CSVL translation vs a L4 LIV at minimum 5 yrs f/u.

A140: ISYQOL Discriminates Better than the SRS-22 Subgroups of Adolescents with Spinal Deformities

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Introduction: Quality of life (QoL) is evaluated in spinal deformities by several questionnaires. Rasch analysis is a statistical methodology to develop good QoL questionnaires, and make them interval instead of ordinal measures. ISYQOL (Italian Spine Youth Quality of Life questionnaire) is the first questionnaire developed through Rasch analysis. The aim of the study was to compare the discriminative validity of ISYQOL versus the actual gold standard questionnaire (SRS-22). **Materials and Methods:** We performed a cross sectional study. We included in the study 1677 participants (1251 females), median age 14 years (1-3 quartile: 11-14) affected by scoliosis or hyperkyphosis. Consecutive patients of a tertiary outpatients clinic specialized in conservative treatment of spinal deformities completeted the SRS-22 (22 items, 5 categories per item) and ISYQOL (20 items, 3 categories per item) questionnaires before consultation. Multiple linear regressions were computed to predict ISYQOL measure or SRS-22 score (independent variables: age, gender, diagnosis, and bracing). A subgroup analysis was performed through linear regression modelling (variables: age, gender, Cobb degrees, brace dosage and type) to check if each questionnaire was able to discriminate QoL changes according to specific influencing factors. **Results:** SRS-22 and ISYQOL scores correlate (Spearman -0.68, R2 0.43, $P < .001$) but the best fit is a parabole (R2 0.51). With ISYQOL above 80% SRS-22 does not change (higher ceiling effect). SRS-22 and ISYQoL detect the effect of age, gender, diagnosis (scoliosis vs hyperkyphosis) and bracing (brace vs no brace) on QoL: $F = 92.42$ ($P < .001$) for ISYQOL and $F = 85.59$ ($P < .001$) for SRS-22. The variables explained 19% and 14% of the variability for ISYQOL and SRS-22 respectively. The QoL measured by ISYQOL is explained by: age (years), gender, Cobb degrees, brace hours per day and brace type (soft vs hard) ($F = 10.69$; $P < .001$; $R^2 = 0.11$); SRS-22 by age and Cobb degrees only ($F = 13.66$; $P < .001$; $R^2 = 0.05$). **Conclusions:** ISYQOL is correlated to SRS-22 but showed a reduced ceiling effect. Despite having considerably less items and categories, ISYQOL appears to be a better measure of QoL during growth in spine deformity individuals in a conservative setting.

A141: Use of Intraoperative Traction in Adolescent Idiopathic Scoliosis: Impact on Concave Apical Screws Density, Curve Correction and Functional Outcomes

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Introduction: The use of intraoperative traction to facilitate pre-instrumentation curve correction and subsequent screw insertion is not widely practice. We analysed the impact of intraoperative traction as a strategy to optimize implant placement and improve the curve correction in adolescent idiopathic scoliosis. **Materials and Methods**: We reviewed retrospectively collected data of patients were consecutively operated at our centre by a single surgeon. Group A includes patients were operated during 2008-2011 without intraoperative traction and Group B between 2011-2013 with Skull tong and bilateral skin traction (Traction with 15% of body weight at skull tongs and 10-15% on each leg). Radiological parameters like apical rotation, concave apical screws density and correction of cobb angle and functional outcomes with SRS 22

questioners were measured. **Results**: Group A (no traction) had 72 patients (86% female) with a mean age of 15.5 years. Group B (traction) had 84 patients (88% female) with a mean age of 14.2 yrs. In group A pre-op mean major Cobb's angle was 62.8 degree and final correction to 19.5 degree (71% correction). Group B - Pre-op mean major Cobb's angle was 78.3 degree which reduced to 48.5 degree (40% correction) on traction film and final correction to 13.5 degree(83% correction, $P < .001$). Apical vertebral rotation changed from mean Nash-Moe grade of 2.6 to 2.2 with traction ($P = .011$). Concave apical implant density (CAID) was calculated by apical concave sided implant ratio in apical and adjacent vertebra, measured as 87% under traction compared to 26% without ($P < .0001$). SRS-22 post-operative outcomes showed mean final score of 4.3 in group A and 4.38 in group B with no statistical difference between the groups ($P = .66$). No complication in relation to traction was observed in group B. **Conclusions**: Intraoperative traction decreased apical vertebral rotation, allowed for easier placement of apical screws improving the implant density and final curve correction. This technique obviates the need for complex osteotomy techniques and excessive correction manoeuvres to correct larger curves.

A142: The Development of an Adolescent Spine Deformity Surgery Core Outcome Set for the Nordic Spine Registries: A Project Supported by the AOSpine Knowledge Forum Deformity

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Introduction: Routine patient-related outcome monitoring is gaining importance in medical care. Healthcare providers are putting more emphasis into assessing the value (health gain per unit cost) of treatment provided.[1] However, outcome registries are most valuable if they are comparable between countries and include outcomes that are relevant to the patient population of interest.[2,3] The COSSCO (Core Outcome Set for SCOliosis) project aims to reach consensus, across the Nordic Spinal Deformities Societies (Sweden, Denmark, Finland, Norway, The Netherlands), about which patient-relevant outcome domains (e.g. appearance) and subsequent measurement instruments (e.g. SRS-22) are to be included in the 5 national spine outcome registries for adolescents and young adults (10-25years) with a spinal deformity undergoing surgery. **Material and Methods:** A systematic literature review and quality assesment of existing patient-reported outcomes (PROs) used in adolescent spine deformity studies were conducted. To identify reported outcome domains, PROs were linked to the WHO's International Classification of Functioning, Disability and Health (ICF) framework. Spinal deformity surgeon representatives from each of the NSDS countries were invited to participate in a modified Delphi study. They were asked to vote which of these outcome domains were considered essential to measure in every patient. The first consensus round was held face-to-face. The second and third round consisted of web-based surveys. **Results**: A total of 26 PROs were identified in 191 papers that met the inclusion criteria. This provided a list of 39 potential core domains. Through three Delphi rounds, consensus was reached on 14 "core outcome domains". Existing PROs were studied to identify which core outcome domains they measure, how much time is required to complete them, the availability of validated translations in the Nordic languages and quality metrics. **Conclusions:** Based on this analysis, the study group advises the implementation of a combination of SRS-22, EQ-5D and a yet to be defined respiratory questionnaire in the Nordic registries as the appriopriate instruments to cover all core outcome domains. A further consensus round will be held on the proposed combination of instruments. The results will be validated among patients (and their parents) and translated into an outcome standard that can be implemented in the Nordic spine registries. The development of this core outcome set will facilitate comparison across registries and will ultimately improve the quality of daily clinical practice by routinely measuring outcomes of care, enabling continuous evaluation and improvement.

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A143: Is There Still a Place for Convex Hemiepiphysiodesis in Congenital Scoliosis in Young Children? A Long Term Follow-up

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Introduction: Nowadays, hemivertebra(HV) resection followed by limited fusion and instrumentation is the most used procedure in the treatment of congenital scoliosis in children with HV. This procedure has its well-known risks (particularly

neurologic). The purpose of this study is to evaluate the long term results of anterior and posterior convex hemiepiphysiodesis used to treat congenital scoliosis with HV and to evaluate its effect on coronal deformity correction. **Material and Methods:** This is a retrospective descriptive study performed on 30 children with 33 congenital scoliotic curves operated on using a one staged double approach (anterior+posterior) hemiephysiodesis by bone grafting of the convex side of the curve without instrumentation. A post-operative cast is worn for 3 months. We defined a "Limited Fusion" as the one centered on the HV and including the 2 adjacent levels. An "Extensive Fusion" is the one that is carried on more than one adjacent vertebra to the HV, proximally or/and distally. Patient's mean age at surgery was 3 years (6 months to 12 years), with an equal distribution of genders and a mean frontal Cobb angle of 42.5°. The mean follow up is 15 years (8 to 25 years). There were 23 isolated HV and 10 HV associated to a congenital bar(CB). Limited Fusion was performed on 21 curves with a mean angle of 37° while Extensive Fusion was performed on 12 curves with a mean angle of 50°. **Results:** Overall results showed a frontal Cobb angle reduction from 42.5° (18° - 80°) to 29.5° (2° - 77°). Detailed analysis showed that 22 curves had a mean correction of 47% (41° to 21.6°), 8 curves were stabilized (mean Cobb = 38°) and 3 curves had a mean aggravation of 16% (53.7°→64.3°). Subgroup analysis took into account age at surgery, type of the malformation, and Cobb angle. It showed: 57% correction in patients aged <3 years and 32% in patients aged >3 years; 55% correction in curves with isolated HV compared to 26% correction in curves with HV and CB; 65% correction in curves <35° compared to a 40% correction in curves >35°. The best correction with Limited Fusion (71%) occurred in case of an isolated HV, with a curve less than 35° and a surgery performed before age of 3. Limited Fusion in patients aged >3 years, with a HV associated to a CB, and a Cobb angle >35° showed a deterioration in 50% of cases, while Extensive Fusion showed a stabilization in 50% and even a mild amelioration in 50% of these patients. **Conclusion:** A limited convex hemiepiphysiodesis still have a place in congenital scoliosis care, sparing the patient the risks of vertebral resection and instrumentation, fusing the same number of levels, when it is performed in case of isolated HV, in curves less than 35° and in children younger than 3 years old.

A144: ISYQOL: New Quality of Life Questionnaire for Adolescents with Spinal Deformities Developed through Rasch Analysis

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Introduction: Spinal deformities are usually associated with poor quality of life (HRQoL). Several questionnaires have been developed to evaluate HRQoL in idiopathic scoliosis (the SRS-24, SRS-22, the SQLI and the EOSQ for early onset scoliosis). Rasch analysis is able to turn ordinal scale measures into interval, with obvious clinical and research advantages. Only the SRS-22, the most widely used questionnaire, has been evaluated with Rasch analysis, but showed poor clinimetric properties after Rasch analysis application. The aim of this study was to develop a new questionnaire (ISYQOL: Italian Spine Youth Quality of Life questionnaire) able to satisfy the fundamental requirement for Rasch analysis, for HRQoL evaluation in adolescents with spinal deformities. **Materials and Methods:** A multistage classical methodology has been used: content analysis of the posted messages by adolescents with spinal deformities in an internet forum (developed in 2006, including 5758 posts and 1156 answers from expert clinicians), to guide the items selection; an opinion poll among 23 experts provided a first version of the questionnaire, with 50 possible items; test of the first draft of the questionnaire (50 questions) in 94 patients; Rasch analysis to generate the second version of the questionnaire (23 questions) that was tested again in 39 patients; finally, 402 participants filled out the last version of the ISYQOL in the waiting room, immediately before medical evaluation. To analyze the data Rasch analysis was performed by using Winsteps Rasch Measurement software (2009, version 3.69.1; partial credit model). **Results:** We found that 20 items fitted the model and constituted the final version of the ISYQOL questionnaire. Differential Item functioning was significant for brace (−0.87 vs −1.62 logit, respectively; $P = .0015$), thus allowing comparison among patients with and without brace. The principal component analysis on Rasch residual confirmed the unidimensionality of the ISYQOL. The finding of an addition variable hidden in the ISYQOL Rasch residuals (1st factor Eigenvalue = 2.2) explains 5.2% of the total data variance. Participant reliability of ISYQOL is 0.83 and thus ∼3 significantly different strata can be discerned in the sample. **Conclusion:** The present work presents the ISYQOL, the first questionnaire developed in the Rasch setting which measure HRQOL in adolescents with spinal deformity. Being Rasch consistent, ISYQOL offers an HRQOL measure which is additive, generalizable and unidimensional thus complying with requirement of a genuine continuous measure. ISYQOL can offer an insight on the impact of the brace prescription.

A145: Magnetically Controlled Growing Rods with Maximal Distraction: A New Mode of Failure

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Introduction: Early reports of magnetically controlled growing rods (MCGRs) have demonstrated promising results in the management of early onset scoliosis (EOS). However incidence of device failure has been reported in 0-50% of cases. The reasons for this variation, and the risk factors for device failure, are poorly understood. Similarly, consensus regarding optimum distraction technique, frequency and amount is lacking. **Materials and Methods:** A retrospective case series of all patients treated with MAGEC (MAGnetic Expansion Control, Ellipse Technologies Inc, Aliso Viejo, CA, USA) rods at a tertiary referral centre was performed. Patient notes and radiographic images were reviewed. Coronal Cobb angles, thoracic height (T1-T12), spinal height (T1-S1) and total rod distraction were measured independently by two authors. Rods were implanted as described by Cheung et al. Subsequent distraction took place at 3 monthly intervals. Each occasion the rods were distracted maximally until clunking was heard. Failed rods were explanted and analysed by an independent team of specialists. Rods were disassembled and the actuator casing was cut open to allow examination of the inner components. **Results:** 11 patients at our institute had MAGEC rods implanted with 8 meeting the minimum follow up (3 male, 5 female). Average age was 10.1 years. Two had syndromic EOS curves, six were idiopathic curves. Dual rod constructs were used in all cases. Patients underwent an average of 9.5 distractions over a period of 33.3 months. Mean pre-operative Cobb angle was 63.0° and improved to 41.4° following surgery ($P = .02$). This was maintained at 37.7° ($P = .56$) at most recent follow up. Thoracic T1-T12 and T1-S1 spinal heights were also significantly improved following surgery ($P = .003$ and 0.001) and subsequent distraction. 5 patients encountered complications: pain during distraction ($n = 1$), failure to distract on at least one occasion ($n = 4$), proximal screw pullout ($n = 1$) and device failure requiring explantation ($n = 3$). In two cases, separation of the lead screw from the radial bearing, as a result of drive pin fracture within the actuator portion of the device, was seen radiographically. A third patient's rods were explanted due to curve progression despite normal radiological images. In this case, pistoning of the rods was seen at the time of surgery. All explanted devices displayed evidence of impingement between the lengthening rod and internal actuator casing. Titanium oxide debris was seen between the magnet and the internal aspect of the outer casing. This debris is thought to bring about device failure by preventing the actuator magnet rotating. Fractured drive pins were found in five of six explanted MCGRs. **Conclusion:** Our results support the notion that MCGRs are an effective method of spinal growth guidance in patients with EOS. We report higher rates of implant failure than other series using dual rod constructs. We postulate that our higher incidence of mechanical failure is due to over stressing the rods during maximal distraction to the point of clunking.

Cervical Myelopathy

A146: Combinatorial Surgical and Neuroprotective Therapy for Cervical Spondylotic Myelopathy Results in Improved Neurological Function: From Preclinical Proof of Concept to a Phase III Randomized Controlled Trial

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Introduction: Surgical decompression is an effective treatment for cervical spondylotic myelopathy (CSM). However, a number of patients continue to experience substantial neurological impairment post surgery. Riluzole has neuroprotective effects in injuries of the central nervous system. To determine the efficacy of riluzole for promoting neurological improvement in CSM following decompression, we performed a preclinical proof of concept experiment and then we translated our work and established a Phase III multi-center randomized controlled clinical trial (CSM-Protect). **Material and Methods:** Surgical decompression was performed in a rat CSM model and riluzole, or control, was administered. Spinal cord blood flow (SCBF) was evaluated in all CSM rats, in vivo, before and after decompression using FAIR MRI. The long-term outcomes of decompression with or without riluzole treatment determined using neurobehavioural and neuroanatomical assessments. Our multi-center double-blind randomized CSM-Protect trial includes a total of 300 CSM patients undergoing decompression surgery and randomized 1:1 to receive riluzole (2x50 mg daily for 14 days before and 28 days post surgery) or placebo treatment. MJOA score will determine the effectiveness of the combinatorial treatment at 6 months following surgery. Statistical analysis will be performed as a sequential adaptive trial with interim analysis. **Results:** Rats receiving combinatorial treatment displayed long-term significant neurological improvements associated with preservation of motor neurons and corticospinal tracts compared to rats treated with decompression alone. Riluzole also dramatically reduced the extent of ischemia-reperfusion injury post surgical decompression in our animal model. At present, 274 subjects have been enrolled into the CSM-Protect trial. A planned interim analysis using this sample has commenced. **Conclusion:** The proposed combinatorial therapy promotes neurological recovery in CSM rats. Confirmation of this proof of concept has been translated from bench to the bedside and we are currently running the CSM-Protect trial to determine the efficacy of this combinatorial treatment option for use in CSM patients.

A147: Congenital Cervical Spine Stenosis in a Global Cohort of Patients with Degenerative Cervical Myelopathy: A Report Based on a MRI Diagnostic Criterion

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Introduction: Congenital Spinal Stenosis (CSS) is a known predisposing factor for Degenerative Cervical Myelopathy (DCM). Previous studies have suggested that an AP canal diameter less than 12-13 mm or a Torg-Pavlov ratio (TPR) of <0.82 are indicative of CSS. However, these studies are based on radiographs and cadaver studies, and do not take into account the variability in the spinal cord size between individuals. In a global cohort of patients with DCM, MRI-based criteria were developed to diagnose patients with pre-existing CSS. Furthermore, patient characteristics and surgical outcomes were compared between patients with and without CSS. **Material and Methods:** Patient and MRI data were derived from two international prospective and multicenter studies. A total of 349 MRIs were available for quantitative analysis. Spinal canal and spinal cord anteroposterior diameters were measured above and below the region of interest at non-compressed sites, and an average spinal cord occupation ratio (SCOR) was calculated. A SCOR of $\geq$70% was used to diagnose patients with CSS. Additionally, a TPR and spinal canal diameter at C3 and C5 were measured on lateral radiographs. Clinical and MRI factors were compared between patients with and those without CSS using t-tests. Multiple linear regression was used to assess the impact of CSS on surgical outcome. Sensitivity analysis was conducted to assess CSS at a lower SCOR threshold ($\geq$65%). **Results:** Calculation of SCOR was feasible in 311/349 patients (89%), as reference levels free of pathology were not present in the remainder of patients. Twenty-six patients with CSS were identified (8.4%). Patients with CSS were younger than patients without CSS (50.8 vs. 56.3, $P = .03$) and had worse baseline severity as measured by the mJOA ($P = .04$), Nurick ($P = .05$) and NDI ($P < .01$). CSS patients also presented more commonly with T2 cord hyperintensity changes ($P = .09$), and worse SF-36 Physical Component scores ($P = .06$), though these factors did not reach statistical significance. After adjusting for age and baseline severity, there were no statistically significant differences in surgical outcomes in patients with or without CSS. SCOR was correlated with TPR and spinal canal diameter at C3 but not C5. A SCOR $\geq$65% identified patients with a younger age and a lower TPR and canal diameter at C3, but showed no differences in baseline neurological impairment when compared to patients with a SCOR <65%. **Conclusion:** SCOR's conceptual validity derives from its inclusion of both the size of the spinal canal and cord. A SCOR cut-off of $\geq$70% has shown to objectively identify CSS in patients with DCM. This is supported by the finding that DCM patients with CSS are more likely to be younger and present with worse neurological impairment and function. However, despite greater functional impairment preoperatively, CSS patients have comparable duration of symptoms, MRI presentations, and surgical outcomes as DCM patients without CSS. On the basis of these findings, SCOR appears to be an effective alternative to TPR or spinal canal diameter as a diagnostic criterion for CSS.

A148: Multilevel Cervical Spondylo-arthopaty with or without Myelopathy: Evaluation of Long Term Follow-up between Anterior and Posterior Approach

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Introduction: Multilevel cervical disc disease is a common degenerative disease that is characterized by compressions in the cervical region of the spine; firstly, the interbody disk degeneration and secondly, the sub-sequent deterioration of the facet joints, the thickening of the posterior longitudinal ligament and of the legamentum flavum, lead to progressive compression of the nervous system and, thus, produce myelopathy. As we well know, the treatment is surgical but the gold standard of the technique, especially of the approach, remains controversial and is based on the surgeon experience. **Materials and Methods:** From 2008 to 2015 we have collected data from archive and we performed this retrospective study which included 304 consecutive patients (187 males and 117 females) that undergoing surgery for multilevel spondylotic disease. Then the patients have been divided into two groups according to surgical approach: anterior (n = 284) and posterior (n = 28). Among them, we selected only the patients of whom surgery has been involved $\geq$3 intervertebral segments. According to these strict criteria we enrolled 20 patients underwent posterior approach and 12 by the anterior one. The average follow-up was 4 year and 6 months long. We evaluated either clinical parameters and radiological issues before and after surgery. **Results:** Among the anterior group the patients selected, even with signs of myelopathy, had a better pre-op clinical status either under neurological and general point-of view. Apart that, the selection of the approach has been made on the surgeon preference and thus there's a slight predilection for the posterior one. The rate of clinical complications, such as temporary dysphagia and or dysphonia was obviously much higher on the anterior group than the posterior. On the posterior group, we had two cases of reoperation due to a screws pull-out, both of them over 1-year of follow-up. The neural recovery rate appeared to be the same between the two groups. **Conclusion:** Our study clearly shows that there are not significant differences, in terms of clinical and radiological outcome, on the follow-up, even on a long-term one between anterior and posterior approach for multiple level spondylotic cervical disease.

We noticed that patients underwent anterior approach tend to have a better post-operative neural function than posterior ones; in the meantime, there is no substantial difference in the clinical recovery rate. This apparently paradoxical result could be explained by better neurological pre-op status of the anterior approach group. We might assume that, when the surgeon is sufficiently skilled on the posterior approach, the choice of the approach should be tailored made, case by case.

A149: Prediction of Outcome following Surgical Treatment of Cervical Myelopathy Based on Features of Ossification of the Posterior Longitudinal Ligament: A Systematic Review

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Introduction: Ossification of the posterior longitudinal ligament (OPLL) is defined as ectopic bone formation within the posterior longitudinal ligament. Although various OPLL features (the extent, shape, and thickness of OPLL as well as the presence of dural ossification) have been defined in the literature, there are no systematic reviews that summarize the associations between these features and clinical outcomes following surgery. The objective of this study was to conduct a systematic review of the literature to determine whether OPLL characteristics are predictive of outcome in patients undergoing surgery for cervical myelopathy. **Material and Methods:** An extensive search was performed using four electronic databases: MEDLINE, MEDLINE in Process, EMBASE and Cochrane Central of Controlled Trials. Our search terms were OPLL and Cervical. We identified studies in English or Japanese that evaluated the association between cervical OPLL features and surgical outcome. The overall body of evidence was assessed using a scoring system developed by the Grading of Recommendation Assessment, Development and Evaluation (GRADE) Working Group with recommendations from the Agency for Healthcare Research and Quality (AHQR). This systematic literature review is formatted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. **Results:** The search yielded a total of 2318 citations. A total of 28 prognostic cohort studies were deemed relevant following a rigorous review process. Among them, only seven retrospective studies conducted a multivariate analysis that controlled for potential confounding variables. Sample sizes ranged from 47 to 133 surgical patients. The main outcome was postoperative Japanese Orthopedic Association (JOA) score and/or recovery rate in six studies and Nurick grade in one. Of these, two were rated as Level II and five as level III evidence. Based on our results, low evidence suggested that patients with a hill-shaped ossification have a worse postoperative JOA score following laminoplasty than those with a plateau-shaped lesion. Based on low evidence, the space available for the spinal cord cannot predict postoperative JOA scores. Furthermore, there is no association between occupying ratio and improvement on the Nurick scale (moderate evidence). There is insufficient evidence to determine the association between JOA outcomes and type of OPLL, presence of dural ossification and occupying ratio. **Conclusion:** Patients with hill-shaped OPLL have a worse postoperative JOA score than those with plateau-shaped ossification after laminoplasty. Occupying ratio, type of OPLL and the presence of dural ossification are not predictive of surgical outcomes following either anterior or posterior decompression. There are limited articles that used a multivariate analysis to evaluate the association between clinical outcomes and OPLL features. Further high quality studies are needed.

A150: Correlation and Profile of Quality of Life and Functional Outcome Measures for Cervical Spondylotic Myelopathy after Surgery

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Introduction: In the present study we sought to 1) investigate the profile of functional outcome assessment by evaluating the modified modified Japanese Orthopaedic Association (mJOA) and quality of life by SF-36, 2) investigate the correlation between quality of life and functional outcome measures at different follow-up time, and then 3) further understand the ability of the various measures to predict favorable quality of life (health transition item) at different follow-up time for patients undergoing operation for CSM. **Material and Methods:** We used mJOA assessment and the SF-36 to preoperatively evaluate the patients and again in continuous follow-ups conducted at three months, one year and more than two years after surgery. For evaluating the profile of health status measures (HSMs), changes in clinical effects in each group after surgeries were analyzed by the Wilcoxon rank-sum test. For investigating the correlation between the two HSMs, we computed the Spearman rank correlation analysis. To assess each HSMs' ability to discriminate HTI, we performed receiver operating characteristic (ROC) curve, area under the curve (AUC) and Spearman rank correlation analysis. **Results:** 280 CSM patients were enrolled and the mean time of last follow-up was 50.5 months. 1. The mJOA score was improved significantly at any follow-up time. At three months after surgery, the recovery of sensory function was better than motor function, while at one year after surgery and at the final follow-up time, the recovery of sensory and motor function had no significant difference. The mJOA score peaked 16.4 months after the surgery. Before surgery, all patients' QoL showed

varying degrees of decreases in all sections compared to normal population. Two sections—role-physical, and role-emotional—showed the most significant declines. After surgery, with the exception of general-health and social-function at three months after surgery, all the other items at every follow-up time all showed significant improvement. The maximum recovery time point of the physical component score (PCS) was 20.1 months and mental component score (MCS) was 24.1 months after surgery. 2. We found a correlation between improvement in the mJOA score and PCS at 3 months after surgery, but not in MCS. While at 1 year after surgery and the final follow-up, the improvement of mJOA was associated with both PCS and MCS. 3. The AUC and correlation coefficient of PCS showed the highest of the four measures. The recovery rate of mJOA appeared to be the most accurate discriminator at one year after surgery. As for the final follow-up, the results were not consistent as the recovery rate of mJOA showed the highest AUC and the highest correlation coefficient was for MCS. **Conclusion:** CSM patients can benefit from surgical treatment by significant improvement of neurological function and quality of life, with sensory function and PCS recovering more quickly than motor function and MCS. mJOA (16.2 months), PCS (20.1months) and MCS (24.1 months) reached their maximum recovery points in order. The most responsive indicator varies depending on the follow-up time.

A151: Functional and Clinical Outcome after Circunferential Decompression (360 Degrees) Surgical Treatment of Severe Degenerative Cervical Spondylotic Myelopathy in the Elderly Patients

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Introduction: Cervical spondylotic myelopathy (CSM) is a chronic-degenerative disease and one of the most common causes of spinal dysfunction associated with high morbidity in elderly patients as a result of the diagnosis is made at a very advanced stage of the disease and the only surgical treatment option to benefit this age group with moderate or severe myelopathy. The objective of this paper is to present our results of decompressive spinal surgery for anterior and posterior (surgery 360) via a surgical time, in patients with CSM with severe stenosis of the cervical canal, evaluating functional benefit vs risk, retrospective, linear analysis. **Material and Methods:** Registration of elderly patients aged 65old was obtained, with diagnosis CSM severe by scale clinical evaluation with Nurick, and m JAO <12, correlated by severe compression by imaging studies (x-ray, MRI) all received strong pulmonary physiotherapy preoperatively and those surgery 360 was performed with anterior corpectomy and Laminectomy Posterior instrumentation for fusion and fixation with neurophysiological monitoring intraoperative, analyze surgical results (operative time, blood loss) and complications 12 months of treatment. **Results:** We collected 37 patients with severe cervical myelopathy, Nurick V; 86.4% mJAO > 95%, 22 men, 15 women, mean age of 75 years (range 65-81 years) to 12 months was obtained acceptable clinical changes, Nurick 1; 10%, 2; 54%, 3; 29%, 4; 8%. By analysis of mJAO 78% change to moderate myelopathy, our morbidity prevalence was 16% in the first three months of preoperative disability related to increased monitoring. **Conclusion:** These results show that surgery 360 decompressive in a single surgical time, is an effective procedure that improves functional neurological outcome and quality of life in patients with CSM severe than one year, which detect which is mainly influenced by the preoperative duration of symptoms, with minimal morbidity and acceptable fusion, maintains cervical lordosis as demonstrated in other reports in the literature.

A152: Increased Segmental Range of Motion is Correlated with Spondylolisthesis in the Cervical Spine after Laminoplasty

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Introduction: Cervical laminoplasty for cervical spondylotic myelopathy causes reduced range of motion (ROM), possibly due to the unintended contracture of the facet joint or a bony union. Though it is rarely studied, ROM may also increase following laminoplasty. Thus far, there are no reports describing the correlation between increased segmental ROM and segmental spondylolisthesis after laminoplasty. The aim of this study was to determine the incidence of increased segmental ROM after laminoplasty and to clarify whether increased ROM is associated with spondylolisthesis. Finally, we explored the effect of increased segmental ROM on clinical results. **Material and Methods:** We evaluated 187 segments from 39 cervical spondylotic myelopathy patients who underwent bilateral open door laminoplasty from C2 to C7. The segmental ROM and spondylolisthesis were measured using dynamic radiographs that were obtained preoperatively and 2 years postoperatively. The Japanese Orthopaedic Association (JOA) score was used for clinical evaluation. To compare the clinical results, we compared the cases with increased ROM in at least one segment to the remaining cases. **Results:** Increased segmental ROM (ie, $\geq 5^\circ$ increase) was observed in 25/187 segments (13.4%) from 14 cases. There was a strong correlation between increased ROM and spondylolisthesis. A high preoperative disc height was associated with increased segmental ROM 2 years post-operation. Regardless of the correlation with spondylolisthesis, there was no statistically significant correlation between increased segmental ROM and JOA score. **Conclusion:** The decrease in segmental ROM after laminoplasty was not uniform. Approximately 13.4% of all segments showed increased ROM. The preoperative disc height might influence the risk for increased segmental ROM. Furthermore,

increased ROM was correlated with spondylolisthesis in the segment, though it was not correlated with clinical results.

A153: Cervical Fusion with Expandable Corpectomy Device

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Introduction: Cervical spondylotic myelopathy represents the most common indication for surgical treatment in cervical spine, with multiple therapeutic options and implants for treatment. Objective: To evaluate the clinical and radiological results when using an expandable vertebral body prosthesis PEEK plate based along a dynamic anterior plate for the ventral reconstruction of the cervical spine after several levels corpectomy. **Materials and Methods:** From April 2008 to April 2015, 39 adult patients with the diagnosis of cervical spondylotic myelopathy, underwent corpectomy by anterior approach and application ECD implant (expandable cervical device) and osteosynthesis with dynamic anterior plate. Their clinical course was evaluated by the modified scale of Japanese Orthopaedic Association (M-JOA) and Nurick grading system. The fusion and keeping the correct cervical lordosis was measured with cervical spine radiographs obtained pre-operative, immediate post-operative and 12 months after surgical intervention. **Results:** 97.4% of patients achieved segment fusion at 12 months, the average correction of lordosis was 13.43 $\pm$ 0.76 degrees ϖ, the interbody height at 12 months posterior to surgery decreased on average 0.82 $\pm$ 0.37 mm ϖ, clinical evaluation presented significant improvement in both used scales. By comparing the number of segments and specific approached segments, we found that the group with better improvement in Nurick and M-JOA scales is that of two-segment corpectomy in the C3 and C4 levels, followed by the one-level corpectomy at C4 group. The one with less segment height loss at 12 month follow-up was the two-level group at C5 and C6. **Conclusion:** Utilizing ECD after a cervical corpectomy is an effective and valuable technique as an alternative in the treatment of spondylotic myelopathy cervical and other conditions that may require it, concentrating its benefit in correcting lordosis at a long term compared to other techniques and implants available nowadays.

A154: To Evaluate the Results of a Single Staged Simultaneous Decompression Surgery for Tandem Spinal Stenosis: A Review of 149 Patients

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Introduction: Tandem spinal stenosis (TSS) is defined as spinal stenosis that combines cervical and lumbar spinal stenosis. The primary manifestations include intermittent neurological claudication, progressive gait disturbance, and mixed symptoms and signs of the upper and lower extremities. The incidence of tandem spinal stenosis among patients requiring surgery for spinal stenosis is low, and there is limited existing literature on this topic. There is a controversy in the management of these patients. **Aim:** The Aim of our study is to evaluate the results of a single stage simultaneous decompression surgery for patients with TSS. **Methods:** Between 1994 and 2014, 149 patients were diagnosed with TSS in a series of 3196 patients who underwent surgery for spinal stenosis (4.6%). Medical records of these 149 patients were studied. Results were evaluated using Nurick's grade, modified Oswestry disability index (ODI), blood loss, operative time and complications. **Results:** The ODI score improved from a mean of 69.14 preoperatively to 31.12 at 12 months and 22.04 at final follow-up. The average Nurick's grade improved from 3.7 preoperatively to 1.82 at 12 months and 1.21 at last follow-up. The average blood loss was 750 ml and average operating room time was 170 min. We had one patient with post op paraplegia who did not recover and 2 patients with Upper limb weakness, which completely recovered at subsequent follow-up. **Conclusions:** TSS is a rare condition that requires surgical treatment. A single stage simultaneous decompression surgery is an effective approach with excellent outcomes.

Lumbar Surgery 1

A155: Reposition of Vertebra in Low-Grade Lumbar Spondylolisthesis: Influence on the Clinical Outcome and Shape of Lumbar Lordosis

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Introduction: Many studies on sagittal balance in spondylolisthesis have been published; most of them investigate isthmic spondylolisthesis, yet only a few address degenerative spondylolisthesis. North American Spine Society (NASS) clinical guidelines in diagnosis and treatment of degenerative lumbar spondylolisthesis advocate that there is insufficient evidence for or against the use of reduction with fusion. The purpose of current study was to find out whether reduction of the slipped vertebra influences postoperative sagittal spino-pelvic parameters and clinical outcome following posterior fusion in patients with low-grade degenerative spondylolisthesis of a

single L3/L4 or L4/L5 lumbar segment. **Materials and Methods:** Seventy-six patients were included in the prospective study. Full-spine lateral radiographic scans in standing position were taken before and after the procedure, where parameters of sagittal balance, reduction of slipped vertebra and the shape of the lordosis were measured. Clinical improvement was monitored by Oswestry disability index (ODI) questionnaire and Visual Analogue Score (VAS) before surgery and one year after surgery. **Results:** No direct relation between reduction and clinical outcome could be demonstrated. There was a significant positive correlation between reposition and lumbar lordosis ($r = +0.29$, $P = .005$) and lordosis of the segments above the slipped vertebra ($r = +0.191$, $P = .049$). There was a weak negative correlation between reduction and lordosis of segments below the affected level ($r = -0.138$, $P = .117$) and lordosis of the disc L5/S1 ($r = -0.149$, $P = .098$). Insignificant negative correlation existed between reposition and sagittal vertical axis ($r = -0.116$, $P = .158$); when patients were divided in groups according to progression or reduction of the slip again no statistical significance was found ($+21.6 \pm 28.9$ mm vs. $+16.7 \pm 38.5$ mm, $P = .59$). **Conclusion:** Results of the current study imply that although reduction of slippage cannot significantly enhance the clinical improvement, it does have effect on sagittal re-balancing of the spine.

A156: Can Liposomal Bupivacaine Be Safely Utilized in Patients Undergoing Spine Surgery?

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Introduction: Post-operative pain management in surgical patients is strongly correlated with patient satisfaction. There are many strategies utilized, however, most of these strategies are based on narcotics. Given the multiple adverse effects related to narcotics, other strategies have been used. Among these different strategies, the use of liposomal bupivacaine (LB) has provided successful pain relief but the safety has never been evaluated in patients undergoing spine surgery. We attempted to report preliminary results on the side effect profile of LB in patients undergoing posterior laminectomy and instrumented spinal fusion procedures. Our secondary outcomes were readmission rates and length of stay (LOS). **Material and Methods:** Under Institutional Review Board (IRB) approval, a retrospective review of patients from August 2015 to July 2016 who underwent posterior decompression and instrumented spinal fusion procedures in which LB was used for pain management was performed ($N = 33$) and compared to a placebo cohort of patients who received sterile saline in similar procedures ($N = 21$) from an ongoing prospective trial. An alpha error of less than 5% was used to set the threshold for significance for statistical analysis. The study cohort had a mean age of 60.8 years, which was equivalent to the mean age of 61.5 years in the control group ($P = .825$) and the BMI was also equivalent (29.7kg/m^2 versus 31.1kg/m^2, $P = .402$). Both cohorts were similar with the number of decompressed (3.30 versus 3.71; $P = .151$), and number fused vertebrae (2.91 versus 2.38; $P = .053$). **Results:** No significant difference in rates of most common complications between study and control groups including surgical site infections requiring antibiotics 6.1% versus 0%(OR = 3.4, 95% CI of 0.2 to 74; $P = .4355$), hypotension of less than 90 mmHg systolic 21.2% versus 14.3%(OR = 1.6, 95% CI of 0.37 to 7.1; $P = .53$), or urinary retention requiring a straight catheter or replacement of Foley catheter 12.1% versus 14.3%(OR = 1.3, 95% CI of 0.30 to 6.0; $P = .71$), respectively. Interestingly, there was a significant difference between the study and control groups in regards to nausea and/or emesis: 36.4% vs 9.52%(OR = 5.4, 95% CI of 1.1 to 27; $p = 0.041$). Readmission rates were 0 out of 33 for our study group and 1 out of 21 for our control group (OR 4.9, 95% CI of 0.2 to 126; $p = 0.3$). One patient from the study group expired secondary to causes unrelated to surgery after being discharged from the hospital. LOS between study and control groups were, 89.0 vs 92.2 hours($p = 0.760$), respectively. **Conclusion:** LB did not lead to increased rates of complication, with the exception of nausea and/or emesis. While the increased rate of nausea and/or emesis was significant, further higher powered studies are necessary to make definitive conclusions on this significance given large uncertainty seen in the wide confidence interval. We also aimed this review at determining if a rebound pain phenomenon leads to readmissions after LB use. With no readmissions, we suspect the extended half-life provides gradual enough decrease in effect to prevent a rebound pain phenomenon. These preliminary results support that LB can be utilized safely in this subset of spine surgery.

A157: The Long-term Clinical Efficacy of Single Segment Lumbar 4-5 Fusion and Its Effect on the Lumbar –Pelvis Sagittal Alignment Parameter

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Introduction: The effect of lumbar fusion of single segment 4-5 (SL4-5) with lumbar healthy adjacent segments on the Lumbar-Pelvis Sagittal Alignment parameter, radiographic ASD (rASD) and its clinical efficacy was discussed according to lumbar types (Roussouly Type). **Material and Methods:** Between March 2008 and March 2012, 317 patients with lumbar fusion of SL4-5 were collected. 51 cases of them met the inclusion and exclusion criteria (25 males and 26 females, with an average age of 43.45). They were categorized to 4 types

according to the types of Roussouly. We compared the VAS, ODI, and JOA scores, and the Lumbar-pelvic parameters, such as pelvic incidence (PI), sacral slope(SS), pelvic tilt (PT), lumbar lordosis (LL), UP arc and intervertebral lordosis of lumbar 4-5(IVA4-5), C7 plumb line /Sacro-femoral distance ratio (C7PL/SFD ratio), of the patients in the preoperative and postoperative and final follow-up. MRI was adopted to evaluate ASD before the surgery, and the UCLA Grading Scale and intervertebral stability criteria of lumbar degeneration were introduced to evaluate ASD after the operation. Changes of the parameters in different periods were statistically analyzed. **Results:** Mean follow-up time was 42.58 months (36 to 67 months). The distribution of patients according to Roussouly types was high proportion: Type II:15 cases (29.42%)and Type III: 20 cases (39.22%).In Type I group: There were significant improvement ($P < .01$)in LL, UP arc, IVA4-5and SS in Postoperative and final follow-up, compared with that in preoperative, but PT was decreased. In Type II and III: IVA4-5 significantly improvement ($P < .05$) in the postoperative and final follow-up compared with that in preoperative, the LL in follow-up significantly increased ($P < .05$) compared with that in preoperative, while the SS, PT, and PI showed no significant differences. In TypeII UP arc was significantly increased in the final follow-up .In Type IV: The IVA4-5 ($P < .05$) significantly increased with statistically significant differences to the preoperative, but there was no significant difference in LL, UP arc, SS, PT and PI between preoperative and postoperative. The ratio of C7PL/SFD was significantly decreased in the postoperative and final follow-up compared with that in preoperative in all types .Postoperative and follow-up of patients had significant improvement over preoperative in VAS, ODI, JOA scores. The general prevalence of rASD was 17.64% in all patients. Analysis of rASD risk factors found that: Age, follow-up time, PI, IVA4-5 is a major factor. **Conclusion:** SL4-5 can significantly increase IVAL4-5, but have different effects to spine-pelvis Sagittal Alignment parameters according to types of Roussouly. IVA4-5 is a significant risk factor, the greater the age, the longer follow-up time, higher PI values more prone to rASD. The view of select the appropriate intervertebral fusion angle is possible to change the adjacent segment degeneration process, reduce the incidence of rASD and improve patient prognosis.

A158: Continuous Outcome Monitoring to Improve Quality of Spine Surgery in Patients with Degenerative Lumbar Spine Disorders

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Introduction: Systematic and continuous patient-related outcome monitoring is important to assess future value (outcomes relative to cost) of care delivered.[1,2] Outcome monitoring through a registry is expected to contribute to quality improvement. A recently performed systematic review showed a lack of evidence that registries had an impact on the quality of spine care.[3] To improve the quality of evidence recommendations were presented to improve the underlying methodology; eg, a standardized approach in outcomes registration and a systematic feedback of outcomes of interventions to care professionals.[3] Surgical interventions in patients with degenerative lumbar spine disorders are controversial. To improve the institutional quality of surgical care, since May 2012 all new patients are web-based registered (pre-treatment response rate: 97%, n = 6705) and when surgically treated patients are systematically followed over time (global one-year follow-up response rate: 77%). Purpose: to evaluate whether an institutional spine outcome registry could improve the quality of care in surgically treated patients with degenerative lumbar spine disorders. **Material and Methods:** Definition of two surgical cohorts with baseline (T0) and 1-year follow-up (T1) data: decompression surgery (1-level) (T0 n = 71; T1 n = 54) and interbody fusion surgery (1-level) (T0 n = 169); T1 n = 132). Patient-reported outcome measures (PROMs): functional status (ODI), back and leg pain intensity (NRS), health-related quality of life (EQ5D). Relevant patient-related factors (pre-treatment characteristics, surgery-related) and clinician-based outcomes (complications, revision surgeries) are registered. The feedback to professionals is organised in an online and real-time 'dashboard' (ie, complications and outcomes, corrected for influencing factors) and related to known norm values (ODI, EQ5D). For each outcome measure the 10 best and 10 worst performing patients are presented. Currently, these patients are studied in a case series design. The results will be discussed trimestral within the surgical team and after consensus actions to improve the care are defined. **Results:** *Decompression*—The PROMs improved: ODI 41.6 (SD 9.6) to 24.1 (SD 14.1), NRS_{back} 7.2 (SD 0.8) to 3.4 (SD 2.3), NRS_{leg} 4.9 (SD 2.9) to 3.0 (SD 2.9), and EQ5D 0.42 (SD 0.23) to 0.74 (SD 0.10). 2015: post-operative complication rate 17%, revision surgery in 2%. *Interbody fusion*—The PROMs improved: ODI 43.7 (SD 8.3) to 23.5 (SD 13.5), NRS_{back} 7.1 (SD 1.2) to 3.8 (SD 2.2), NRS_{leg} 5.9 (SD 2.1) to 3.3 (SD 2.7), and EQ5D 0.41 (SD 0.28) to 0.74 (SD 0.10). 2015: post-operative complication rate 12%, revision surgery in 20%. **Conclusion:** Patients in both surgical cohorts improved in relevant outcomes. The support among professionals is high, mainly due to the fact that outcomes are visualised both pooled in the real-time dashboard and individually in the electronic patient file. The one-year follow-up response on PROMs is acceptable.[3] Continuous active efforts are needed to improve the response.

Currently, the best and worst responders on PROMs of each cohort are studied. The results will be presented at the conference. With these results clinical policy could be improved; eg, through identification of patients with a risk of worse outcomes. This feedback contributes to awareness, peer-to-peer learning and ultimately to improvement of surgical outcomes and value-based spine care.

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A159: Quality of Life in Patients Who Underwent Lumbar Spine Fusion Surgery Compared with Adjusted Normal Italian Population: A Pilot Study

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Introduction: There is an increasing interest in patient self-reported outcome measures (PROs) after spine surgery.[1] PROs include patient's perspective about quality of life and improvement in functional recovery after surgery, and can provide evidence for the efficacy of surgical treatment. The purpose of this study was to assess whether the health-related quality of life reported by patients who underwent lumbar spine fusion surgery for degenerative spinal disorders, at one year, is similar to the normal adjusted Italian population. Materials and Methods: Consecutive patients who underwent lumbar decompression and transpedicular instrumentation using pedicle screws and rods at L-S levels in 2015 at the Orthopaedic Department of the University of Ferrara were eligible for the study. The study inclusion criteria were: age 18-85 y, absence of pre-existing cognitive or neurological disease, degenerative spine condition and no previous spinal intervention. The patients who consented completed the Italian validated version of Oswestry Disability Index (ODI)[2] and SF-36 questionnaire[3], during routine follow-up assessment at one year. For each SF-36 dimension, we computed the normal values for the Italian population matched to our study patients for gender and age (adjusted)[4] Pain after surgery, and patient satisfaction with surgery were measured by Numerical Rating Scale (0-100) at one year. Results: Of the 45 patients who underwent lumbar spine fusion surgery in 2015, we excluded 12 patients because surgery was due to vertebral fractures, 1 for spine malignancy, and 4 who had any previous surgical intervention for the same disease. One patient had Parkinson's disease, 4 patients were lost at follow-up and 1 refused the interview. In the 22 patients studied (7 M and 15F, mean age 66 ± 12 y, BMI 28 ± 5) radiological evaluation at the routine follow-up assessments of the vertebral levels fused showed a successful arthrodesis without evidence of pseudoarthrosis. One year after operation, the level of physical function of SF-36 of the study patients was similar to that of the adjusted normal population, and the levels of all the other dimensions of SF-36 of the study patients were slightly better than that of the normal population. According to ODI, 15 patients reported no or minimal disability (range 0-20), five had a moderate disability (range 21-34) and two severe disability (47 and 62, respectively). Median pain score at one year was 2 (Q1-Q3: 1-5). The patients who reported high ODI scores complained of persistent postoperative back and leg pain. In six patients with persistent postoperative pain radiating to the buttock, provocative test for sacroiliac joint involvement as a pain generator were positive. Eighteen out of 22 patients reported a satisfaction with the surgical operation ≥ 70. Conclusion: This is a pilot study on a small number of patients, with a successful arthrodesis at the radiological evaluation. However, the patients showed a quality of life similar to that of the healthy adjusted population. These results differ from those of Pekkanen et al[5], who found a patients' Physical Component Score worse than that of a Finnish general population sample. These findings need to be confirmed in a large population including patients with previous surgical interventions.

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A160: Comparison of Peri-operative and Short Term Outcomes between Minimally Invasive and Conventional Lumbar Interbody Fusion

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Objectives: To identify the difference between minimally invasive thoraco lumbar interbody fusion (MI-TLIF) and conventional lumbar fusion for the peri-operative and 12 month lifestyle outcome measures. **Method:** It was a retrospective secondary data analysis. 36 MI-TLIF patients and 60 conventional surgery patients undergoing single-level lumbar interbody fusion between October 2012 and May 2014 were studied. The peri-operative factors such as duration of surgery, length of hospital stay and peri-operative complications were analysed from patient notes. The 12 month lifestyle measures (pain and discomfort, mobility, anxiety and depression, ability to perform daily tasks, and self-care) were analysed from the patient's feedbacks via the Euro-Spine Spine Tango forms. **Results:** There was a statistically significant result in favour of MI-TLIF for all the peri-operative measures. The operative time for MI-TLIF patients was 260.44 minutes ($\pm$9.95) in comparison to 297.05 minutes ($\pm$9.28) for open patients. The mean length of hospital stay for MI-TLIF was 3.25 days ($\pm$0.38) in comparison to 6.92 days ($\pm$1.13) for open surgery. MI-TLIF patients had fewer complications from surgery in comparison to the conventional surgery group (MI-TLIF 16.7%, Conventional 43.3%, $P = .004$). The 12 month lifestyle outcome measures also showed similar advantage for MI-TLIF over the conventional surgery in 3 areas; severe pain (open 29%, MI-TLIF 17% $P = .039$), moderate mobility (open 69%, MI-TLIF 53% $P = .011$), and severe anxiety (open 14%, MI-TLIF 3% $p = 0.034$). **Conclusion:** For the measures compared MI-TLIF appears to have an advantage over the single level conventional open surgery at the peri operative and short term follow up periods.

A161: The Use of Cortical Bone Trajectory Technique in Preventing Implant Loosening in Osteoporotic Spines

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Introduction: Cortical bone trajectory (CBT) technique has been revisited in recent years with regard to its use in instrumenting the osteoporotic spine. This is most relevant in current practice where we are witnessing a rising elderly demographic index. We looked at the theoretical forte of this technique – its effectiveness in preventing implant loosening. **Material and Methods:** From December 2012 till June 2014, 64 adult women underwent lumbar spine decompression and instrumentation using the CBT technique by a single surgeon. They were post-menopausal women with ages ranging from 62 till 92 years old. The surgical indications were for lumbar spine stenosis presenting with radiculopathy. The number of levels operated on ranged from one till four. We excluded patients with metastatic spine disease, infective spine lesions and spondylolisthesis greater than Grade 2. All patients received bi-laminar decompression and 60 had at least one level of interbody fusion. These patients were then followed up for a minimum of 24 months. Of the 64 cases, 3 were lost to follow-up. One patient succumbed to a cerebrovascular event during the follow-up period, another was uncontactable while another declined to be studied. We studied the incidence of loosening with quarterly radiographs in the first year and twice annually in the second, and a CT scan at 12 and 24 months. The films were read and interpreted separately by the author and 2 radiologists, with statistical adjustment of inter-observer variation. **Results:** Five patients suffered screw loosening, 2 of them having it at the sacral level and the remaining, on the cephalad last-instrumented vertebra. Of the 372 screws implanted, 4 sacral and 7 lumbar were loosened. Loosening was detected at time periods ranging from 3 months to 9 month after surgery, and was invariably associated with failure of fusion at that level. **Conclusion:** The rates of loosening in our study compare favourably against loosening rates found in classical pedicle screw constructs. Cortical bone trajectory holds the possibility of preventing implant loosening by virtue of its good cortical purchase. Such a likelihood calls for the audit of a larger series to further validate its results.

Disclosure

The author did not receive funds or benefits in any kind pertaining to this subject during the conduct of this study.

A162: Correlation between Outcome Measurement Tools in Patients with Lumbar Spine Fusion for Degenerative Disease

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Introduction: Degenerative lumbar disc disease is a chronic condition with wide impact over patient's functional status. Several questionnaires were developed to assess the functional status in patients with chronic low back pain, but the more frequently adopted in published studies are the Oswestry Disability Index (ODI) and the Scoliosis Research Society-22 (SRS-22). The aim of this study is to correlate the different scales of quality of life with each other, trying to determine which individual factors are more decisive for worse or better clinical and functional post-operative outcome. **Material and Methods:** This is a transversal and observational study considering patients who underwent lumbar spine fusion due to degenerative disc disease, who completed a minimum of 12

months postoperative follow-up. The ODI and SRS-22 questionnaires were applied to all patients and the Pearson's correlation coefficient was calculated between the ODI and the SRS-22 domains. **Results:** 61 patients met the inclusion criteria and had data regard the ODI and SRS-22 recorded. 19 were males and 42 females. The mean age of patients was 60.4 years old (19-88 y) and the mean of postoperative follow-up was 29 months (12-67 m). The mean of the questionnaires' scores were ODI: 43.4 (SD: $\pm$21.7) and SRS-22: 2.74 (SD: $\pm$0.59), while the mean of the SRS-22 domains were Function: 2.66 (SD: $\pm$0.91), Pain: 2.83 (SD: $\pm$0.9), Appearance: 2.64 (SD: $\pm$0.92), Mental 3.03 (SD: $\pm$0.9) and Satisfaction: 3.38 (SD: $\pm$1.15). There was no statistically significant difference in none score between patients gender. The ODI presented inverse significant correlation with SRS-22 total and all domains, except Satisfaction. Significant correlation was also observed between the SRS-22 total and their domains, except between Function. **Conclusion:** Our results reinforce the reliability of the ODI and SRS-22 (Total and their domains) as outcome measurement tools for lumbar spine fusion follow-up. The lack of correlation between ODI and SRS-22 Satisfaction as well as between SRS-22 Function and Satisfaction suggests that the satisfaction with the surgical treatment was independent of the postoperative disability.

A163: Trends and Costs of External Electric Bone Stimulators and Grafting Materials in Anterior Lumbar Interbody Fusion

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Introduction: Electric bone growth stimulators have been used to enhance spinal fusion, but there is a lack of published clinical data demonstrating how often they are used and with which specific procedures. The aim of our study was to identify trends in stimulator use, pair those trends to various grafting materials, and determine if stimulators reduced the risk of revision surgery. **Materials and Methods**: Through insurance billing records, we identified patients with lumbar disc degeneration who underwent a single- or multi-level anterior lumbar interbody fusion (ALIF). We identified the grafting material used with surgery, if electrical stimulators were used, and the amount reimbursed by Humana to facilities and physicians for each patient subgroup. **Results**: There was a slight increase in stimulator use from 2008 to 2014 ($R^2 = .08$ multi-level, $R^2 = .05$ single-level). Patients who underwent a multi-level procedure were more likely to receive stimulators than patients who underwent a single-level procedure ($P < .05$). Grafting options associated with most frequent stimulator use were BMA plus autograft or allograft for single-level and allograft alone for multi-level procedures. Patients treated with BMP were the least likely to be treated with electrical stimulators in both cohorts ($P < .05$). Patients who received stimulators generally had higher reimbursements. Concurrent PLF (ALIF+PLF) increased the likelihood of being given stimulators, as did obesity ($P < .05$). Patients who received stimulators had similar revision rates as patients without stimulators ($P > .05$) except in the multi-level ALIF+PLF cohort, where stimulated patients had higher rates of revision surgery. **Conclusions**: Stimulators appeared to have little impact on rates of revision surgery. Stimulators were used more often with multi-level ALIFs than single-level ALIFs. Concurrent PLF increased the likelihood of patients' receiving stimulators. Of patients who received electrical stimulators, most had an ALIF with BMA and autograft or allograft, and the least had an ALIF with BMP. On the day of surgery and over a one year time period, patients who received stimulators were associated with greater reimbursements, potentially an indicator for the added severity of their underlying diagnosis.

Spine Infections 2

A164: Evaluation of Intra-wound Povidone-Iodine Irrigation and Intra-wound Vancomycin Powder in the Prevention of Surgical Site Infection in Spinal Surgery

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Introduction: Surgical site infections (SSIs) are a feared complication of spinal surgery, with substantial patient morbidity and high associated costs. Lately, several methods have been reported to try to prevent SSI through decontamination of the wound before closure. These involve adding vancomycin powder to the wound or irrigation of the wound, usually with povidone-iodine. This last method has the advantage of not contributing to antimicrobial resistance. As of yet, the efficacy of both methods are still unclear. We investigated whether the use of intra-wound vancomycin powder or intra-wound povidone-iodine irrigation was associated with a lower

incidence of SSIs. **Material and Methods:** We performed a comparative study with a retrospective control cohort and two consecutive prospective experimental cohorts. All adult patients with instrumented, posterior, open spinal surgery in the period from January 2012 up to April 2016 were included. Patients with fewer than 3 months of follow-up or with a spinal infection at time of surgery were excluded. The control group consisted of the patients before March 2014. From March 2014 until June 2015, patients were irrigated with a 1.3g/L povidone-iodine solution for 2 minutes (first prospective cohort). From June 2015 until April 2016, patients received 1-2 grams of intra-wound vancomycin (second prospective cohort). During the study period, standard peri-operative prophylactic measures did not change. Demographic variables and the incidence of superficial and deep SSIs were registered and compared between the three groups. Deep and superficial SSIs were defined according to the criteria published by the Centers for disease control and Prevention.[1] **Results:** We included a total of 766 patients. Demographic variables did not differ significantly between groups. In the control group of 325 patients, 45 (13.8%) developed an SSI, of which 31 (9.5%) were deep. In the povidone-iodine group, 29 of 261 patients (11.1%) developed an SSI, of which 24 (9.2%) were deep. Compared to the control group, there was no significant difference in the incidence of SSIs. In the vancomycin group, 8 of 180 patients (4.4%) developed an SSI, of which 5 (2.8%) were deep. This reduction was statistically significant when compared to the control group, both for the total risk of SSIs (Relative Risk 0.32, 95%CI 0.16-0.67), and for the risk of deep SSIs (Relative Risk 0.29, 95%CI 0.12-0.74). **Conclusion:** In this study, intra-wound application of 1-2 grams of vancomycin was associated with a significant reduction in SSIs in instrumented spinal surgery, as has also been reported in other cohort studies. A 1.3g/L povidone-iodine solution did not show a significant difference. It is possible that the povidone-iodine concentration used was too low or the irrigation time too short. Since vancomycin has the disadvantage of promoting bacterial resistance, further research into both forms of intra-wound treatment should be continued.

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A165: Predicting the Need for Surgical Intervention in Patients with Spondylodiscitis: The Brighton Score

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Introduction: Spondylodiscitis represents a condition with significant heterogeneity. A significant proportion of patients are managed without surgical intervention, but there remains a group where surgery is mandated. The aim of our study was to create a scoring system to guide clinicians as to which patients may require surgery. **Material and Methods:** A retrospective analysis of patients between 2005 to 2014 was performed. Data for 35 variables, characterised as potential risk factors for requiring surgical treatment of spondylodiscitis, was collected. Logistic regression analysis was performed to evaluate the predictability of each. A prediction model was constructed and the model was externally validated using a second series of patients from 2014-2015 meeting the same standards as the first population. The predicted odds were calculated for every patient in the data set. Receiver operating characteristics (ROC) curves were created and the area under curve (AUC) was determined. **Results:** 65 patients were identified with 21 requiring surgery. Six predictors: distant site infection, medical co-morbidities, immunocompromised, MRI findings, anatomical location and neurology were depicted to be the most consistent variables for surgical intervention. An internally validated scoring system with an AUC of 0.83 with an AIC of 115.2 was developed. External validation using a further 20 patients showed an AUC of 0.71 at 95% confidence interval of 0.50-0.88. **Conclusion:** A new validated scoring system has been developed which can help guide clinicians as to when surgical intervention may be required. Further prospective analyses are required to further validate the model.

A166: Vertebral from Non-bacterial Osteomyelitis in Children

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Introduction Chronic non-bacterial osteomyelitis (CNBO or NBO) is a heterogeneous group of immune-mediated inflammatory diseases primarily affecting children and adolescent, often associating with rheumatic diseases (RD). The spine involvement is most severe, but relatively rare NBO form; some cases are need the surgery. **The Aim of Study**: to evaluate the clinical and laboratory peculiarities and efficacy of different treatment strategies for NBO with spine involvement. **Materials and Methods:** 29 from 91 pediatric patients with NBO were selected due to the spine involvement. The bone affects were confirmed by X-ray, CT, MRI and bone scan. The diagnosis based on the clinical and laboratory tests, incl. WBC, platelets, ESR, C-reactive protein (CRP) levels; it was confirmed by

"inflammatory" morphology and negative bacterial (isolates and PCR) bone biopsy and blood tests. The peculiarities of "spinal forms of NBO" (SpNBO) were evaluated in compare with non-spinal ones (non-SpNBO). The efficacy of NSAIDs, bisphosphonates (pamidronate) and TNFα-inhibitors treatment were evaluated by next criteria: dynamics of pain, subjective patients' feelings and objective tests characterized clinical and laboratory activity, reflecting patients (PVAS) and physicians (MDVAS) impressions and counting according to the 100-degree scale. **Results:** The mean age of onset of SpNBO was 8.2 years (4.7; 12.8); it was more common in girls - 19/29 (65.5%). Concomitant rheumatic diseases were noted in 58.6%. Multifocal bone lesions more typical for SpNBO (82.8%) with the number of foci 5.0 (3.0; 7.0) in compare with non- SpNBO 2.0 (1.0; 4.0, ρ = 0.0006). The spinal affects more common associated with sternum (24.1%, ρ 0.03) and rib (13.8%, ρ 0.08) lesions and rare - with a foot bone ones (17.2%, p 0.003). There were no any significant differences in quantity of leukocyte, platelets, hemoglobin level, ESR, CRP, frequency of fever, severity of pain syndrome between SpNBO and non-SpNBO groups. NSAIDs as monotherapy was not effective for patients with spinal lesions: the dynamics of patient's (PVAS), pain and physician's (MDVAS) assessment were 50.5 (38.5-64.0), 52.0 (33.5-71.5), 56.0 (40.0-77.0) before and 60.0 (45.0-85.0, ρ 0.07), 59.0 (46.5-83.5, ρ 0.27), 66.5 (51.0-90.0, ρ 0.14) after treatment respectively. The NSAID with pamidronate was most effective as a first line therapy in SpNBO patients without associated rheumatic diseases: PVAS, pain and MDVAS were calculated as 76.5 (65.0-90.0), 84.0 (67.0-95.0), 91.0 (80.0-95.0) before and 11.0 (5.0-15.0, ρ 0.028), 10.0 (0.0-14.0, ρ 0.028), 91.0 (80.0-95.0, ρ 0.028) after treatment. TNFα-inhibitors were effective in cases, associated with RD: 45.0 (32.0-45.0), 42.0 (10.0-50.0), 39.0 (35.0-49.0) before and 23.0 (3.0-40.0, ρ 0.11), 15.0 (0.0-37.0, ρ 0.11), 10.0 (5.0-41.0, ρ 0.11) after treatment. The ability to achieve the remission for NSAID was 52.6%, for pamidronate – 88.8%, for TNF α-inhibitors – 73.3%. Only 9/29 patients were operated due to severe spinal instability, deformity progression or back pain. **Conclusions:** Multiple axial and peripheral skeleton lesions are characterized for SpNBO. NSAID + pamidronate therapy is most effective for it treatment; TNFα-inhibitors could be preferred in NBO accompanied by RD. Despite the rare indications for surgery, it should be indicated in severe spinal instability, deformity and back-pain.

A167: One or Two-Level Spondylodiscitis between D11 and L5 Treated with Mini-Open Extreme Lateral Debridement and Fusion in Combination with Posterior Percutaneous Fixation

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Introduction: Medical management is the first line treatment for spondilodiscitis but open debridement and stabilization can be required. XLIF is an increasingly popular interbody fusion technique which is performed through a fast and minimally invasive approach, sparing the anterior longitudinal ligament, and allowing sufficient visualization of the intervertebral discs and bodies to debride as well as possible lateral collections. The limitation of this approach is the levels that can be reached, generally L1-L5 even though a rib resection can permit its proximal amplification to T11-T12. We present 4 patients who underwent surgical treatment utilizing extreme lateral interbody fusion (XLIF) with posterior percutaneous instrumentation. **Material and Methods:** A retrospective study between January 2010 and September 2015 was performed at Hospital Clinico San Carlos, Madrid. 45 pyogenic spondylodiscitis were found at cervical, dorsal or lumbar levels with at least 1 year follow-up. 32 patients were male and 13 female, mean age was 76 years (range 58-93). Of these 37 cases affected T11 to L5 whereof 4 failed to respond to antibiotherapy being therefore submitted to an XLIF with concomitant posterior percutaneous instrumentation. In the cases an ethiology was found 7 belonged to a urinary tract infection, 6 to abdominal events, 4 to cardiac valve disease, 4 had been submitted to prior spinal surgery, 1 had a catheter infection and 1 an infection of a surgical wound of a femoropoliteal bypass. **Results:** Bacterial cultures were obtained in 24 patients: 9 were negative, 3 positive to Escherichia coli, 3 to Staphylococcus aureus, 3 to Streptococcus viridans, 3 to Mycobacterium tuberculosis and 1 to Streptococcus mitis, 2 to Enterococcus faecium and faecalis and 1 to Propionibacterium acnes. Mortality rate was 10,9%, none of the deceased patients had been treated surgically. Of the intervened patients 50% presented a 2-level-infection being therefore submitted to a vertebrectomy and a cage with graft was inserted while the other 50% had 1-level-infection where a debridement and insertion of a cage was performed. A postoperative antibiotherapy was maintained at between 6 and 8 weeks postoperatively according to the antibiogram. No postoperative complications were found and no reinterventions were needed. All operated patients presented a normalization of the inflammatory markers and a complete clinical remission of the infection. **Conclusion:** XLIF with concomitant percutaneous posterior instrumentation is a minimally invasive procedure that allows an adequate exposure to the vertebral bodies and discs to aggressively debride necrotic and infected tissue with little surgical trauma and intraoperative blood loss. It could therefore be a safe alternative to a conventional posterior approach is one or two level spondylodiscitis between D11 and L5.

A168: Detection and Quantification of Bacteria in Degenerating Intervertebral Discs

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Introduction: Lower back pain (LBP) is the world's leading cause of disability, with over 632 million people affected. A major etiological factor contributing to LBP is the progressive degeneration of intervertebral discs (IVD), which leads to disc herniation. The current surgical treatment for LBP is lumbar fusion - an invasive surgery which carries considerable risk. In a recent study, the inflammation and edema seen in LBP patients post disc hernia has been attributed to bacterial infection by Proprionibacteria acnes (P. acnes). A recent double blind randomized study demonstrated that antibacterial treatments significantly reduced lower back pain, but the relationship between bacterial infection and disc degeneration remains largely unexplored. **Materials and Methods:** To further investigate the role of P. acnes in LBP, we first developed a model for reliably detecting a bacterial load in IVDs. This was done by taking samples of bovine IVDs, infecting them with various known concentrations of P. acnes, extracting the DNA following a Chondroitinase digest, and ultimately determining the lowest amount of bacterial genetic material detectable by qPCR. We then isolated DNA from 8 separate surgical samples of deteriorated human IVDs. **Results:** At a genomic load of 3 ng, which is comparable to an infection of 10,000 cfu/ml, we reliably detected P. acnes presence in an IVD. Three of the eight samples tested positive, indicating that 37.5% of the samples have a bacterial infection of at least 10,000 cfu/ml. **Conclusion:** These preliminary data support the notion that bacterial infection may be a source of back pain in patients with degenerative discs. More experimental work is required to further substantiate the relationship between P. acnes and IVD deterioration. Our novel qPCR methodology for detecting bacteria in IVDs should progress this research at an accelerated pace, as it is more precise, immediate, and reliable than previously described PCR procedures.

A169: Spinal Reconstruction in Early-Age Pediatric Patients with Vertebral Lesions: 3 Years Follow-up of 20 Consecutive Cases

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Introduction: Infectious spondylitis and tumors are the most common causes for vertebral destruction in patients under 4 yrs old. The multilevel lesions which complicated by early vertebral collapse and kyphosis is obligatory for surgery. Radical debridement with spinal reconstruction are main treatment goals for continued vertebral growth. **Material and Methods:** Study design: clinical cohort. 20 children (mean age - 3 yrs, min - 8 mns, max 3 yrs 11 mns) underwent two-stages one-narcosis surgery incl. radical debridement, anterior fusion by titanium mesh cage with autograft and posterior instrumentation. Group 1 (n = 15) – active tuberculous spondylitis; group 2 (n = 3) – sequela of late onset neonatal sepsis (LONS) with spinal affect; group 3 (n = 2) – malignant tumors. The diagnosis were confirmed by morphology and bacteriology data. All infectious cases were accompanied with severe kyphosis; neurological disorders. Clinical and radiographic results were analyzed. **Results:** The mean follow-up was 36 (24 ÷ 45) mns. Significant difference ($P = .024$) between the groups 1 and 2 were identified in post-op kyphosis angles ($M_1 = 18.4°$, $M_2 = 27.5°$) and degree of angle correction ($M_1 = 22.3°$, $M_2 = 43.2°$). During long-term follow-up, the loss of correction was 1-5° in group 1 and 3.7° in group 2. According to Frankel sc. pre-op neurologic deficit was estimated as grade B 1 in case (TB spondylitis) and grade D in 1 case (GNB); complete neurologic recovery reached postoperatevely. There was not implant-related complication during long term follow-up. The mean duration of the combined (anterior and posterior) surgery was 171 minutes (90 – 240), the mean blood loss - 122 ml (60 to 250). **Conclusions:** One-stage anterior and posterior surgery in an early age patients has the advantages of reduce blood loss, operation time and early mobilization. It was not detected severe retardation of spinal growth during the study period limited by 45 mns. In our opinion, radical debridement and three spinal column reconstruction with titanium mesh cage and posterior instrumentation is safety and effective procedure for management of spinal infectious and tumors in early aged patients.

A170: Pyogenic Spondylodiscitis: Epidemiology, Diagnosis and Treatment of 205 Patients with Two-Year Follow-up

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Introduction: Pyogenic spondylodiscitis represents 3-5% of all cases of osteomyelitis with annual European incidence ranging from 0.4 to 2.4/100000. Diagnosis is often delayed due to paucisymptomatic onset and its low prevalence. The estimated mortality ranges from 0 to 11% and, without an appropriate treatment, recrudescence and residual disability may often occur. **Materials and methods:** 205 patients (132 males and 73 females) consecutively diagnosed with pyogenic spondylodiscitis from 2009 to 2016 were enrolled. Mean age was

64.98 ± 0.97. Data from each patient were collected using ad hoc built forms including clinical history and onset, radiological findings, microbiological diagnosis, inflammatory markers, antibiotic and orthopedic treatments, pain VAS score. Each patient has been evaluated at 1, 3, 6, 12 and 24 months from diagnosis. **Results:** Mean diagnostic delay was 49.90 ± 5.53 days from onset. Most common reported symptoms were: back pain (94.25%), fever (63.64%), limbs radiating pain (42.60%), weight loss (33.54%). 46 patients (22.44%) presented neurological deficits. C-reactive protein was abnormal in 196 patients (95.61%) with higher values in hematogenic infections (74.53 vs 45.73; $P < .05$), while only 78 patients (38.05%) presented leukocytosis. Diagnostic delay was lower for patients presenting fever ($P < .05$). 51 patients (24.88%) developed spondylodiscitis after surgical procedures. Lumbar spine was the most frequently involved tract (73.65%). Microbiological diagnosis was assessed in 156 patients (76.10%) with 60% sensibility for surgical biopsy, 57.64% for blood culture and 46.27% for CT-guided biopsy. Staphylococcus aureus was the most frequently isolated pathogen (28.08%). 16 patients (7.80%) presented polymicrobial infections. MR presented higher diagnostic sensibility (96.30%) compared with CT (77.97%) and X-ray (15.38%). Mean duration for antibiotic therapy was 171.91 ± 8.35 days. Intravenous antibiotic therapy was significantly longer in hematogenic and multiple levels spondylodiscitis compared with direct inoculation or single levels infections (47.29 and 37.79 vs 33.40 and 22.71; $p < 0.05$). 181 patients (88.29%) underwent conservative orthopedic treatment: 123 (67.96%) rigid orthoses made from plaster-cast molds and 58 (32.04%) semi-rigid orthoses. Mean duration for immobilization was 218.17 ± 9.89 days. 62 patients (30.24%) underwent surgery: 53 (85.48%) open surgery and 9 (14.52%) percutaneous stabilizations. Statistically significant differences were observed in VAS scores between conservative and percutaneous treatments at 1 month (6.97 vs 4.4; $P < .05$). Observed healing rate was 91.47%. E. coli and MRSA spondylodiscitis showed the lowest healing rate (75.00% and 83.33%; $P < .001$). Residual disabilities occurred in 53 patients (25.85%). Mean diagnostic delay was significantly higher in unhealed patients (106.25 vs 48.04; $P < .001$). Mortality rate was 6.59%. **Conclusion:** Pyogenic spondylodiscitis incidence is raising in the last years. Our multidisciplinary approach to spondylodiscitis leads to a lower diagnostic delay, higher efficiency in etiological diagnosis and lower mortality rate compared with literature findings. Lower diagnostic delay statistically correlates with higher therapy success rate. The variability of clinical onset and the diagnostic role of MR are confirmed by our findings. Among laboratory markers, only C-reactive protein showed a significant sensibility, its values correlate with systemic diffusion without statistically significant prognostic role. Hematogenic spondylodiscitis require longer therapy and showed worst clinical outcomes. Appropriate orthopedic treatment ensures a very high healing rate even in patients with neurological impairment.

A171: Spinal Infections: Analysis of 600 Patients Over 11 Years

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Introduction: Infection of the spine is older than written history that an evidence of vertebral osteomyelitis has been found in prehistoric man as far back as 7000 BC. It encompasses a broad range of clinical entities and accounts for approximately 2% to 7% of all cases of osteomyelitis. Primarily, it is a disease of adults affecting predominantly those in their fifth decade of life. The age-adjusted incidence increases with every decade thereafter. The overall incidence of pyogenic spinal infection is on the increase. **Methods:** Retrospective analysis of prospectively collected data between 2005 and 2015. Over these eleven years the data of 600 consecutive patients had been reviewed. The patients previously operated at the spinal region of infection and postprocedual infections had been excluded from the study. In patients with haematogenous spinal infection, the collected demographic, clinical, radiological and laboratory data had been analysed and the effects of various causative organisms on these parameters has been studied. **Results:** The study included 250 females (41.7%) and 350 males (58.3%) (F:M = 1:1.4). The mean age was 66.1years (4-88), which has been increased from 65.5 in 2005 to 67.6 in 2015. The mean bulk (73.7%) of patients were older than 60 years. In this study, 67.3% of patients were overweight or obese (p-value 0.000*). Other comorbidities were found in 83% of the patients; DM in 253 patients (42.2%), Cardiac diseases in 289 (48.2%), renal diseases in 207(43 patients were on renal dialysis), liver cirrhosis in 34 patients. According to ASA- Score, 56.7% of the patients were in class III and IV and it had a positive correlation with age (p-value 0.000*). Other site of infectionwas found in 310 patients (51.7%) as a possible source of infection or a coincident infection. 94% of the patients were referred to us from other hospitals and departments, 59.8% had received antibiotics before admission in our center(one dayand reached 250 days in cases of TB). In 307 patients (51.2%), neurological deficit (ASIA A-D) was found at the presentation. The incidence increased with age (p-value 0.001*), amounting to 54.5% in patients older than 60 years (p-value 0.003*) and reaching 57.4% in patients older than 80 years. It had a significant relation to the infected spinal region; being higher in patients with cervical than thoracic or lumbar affection (p-value 0.000*, 0.543 and 0.997 respectively). The most common region infected was lumbar spine in 402 patients (67%), thoracic spine in 195 (32.5%), cervical spine in 45 (7.5%) and in 11 patients sacroiliac joint infection. Non–contiguous spinal infection was detected in the neuroimaging in 69 patients (11.5%).Multifocal (non-contiguous) infection was detected in 68 patients (11.3%). It had a significant correlation with specific comorbidities such as renal insufficiency in 35 patients (p-value 0.003*) and presence of other sites of infection in 47 patients (p-value 0.003*). The incidence of neurological

deficits was higher (p-value 0.000*). The culture-positivity was specifically higher in those patients, that a causative organism could be isolated in 56 of them (p-value 0.005*).Laboratory, mean CRP of 88.7 mg/dl (range 0.8-450), 48.4 in cases of TB.It was normal (<8) in 54 patients (9%); in 36 (66%) of these patients no organism could be isolated.The mean WBC of 10.1 x 10^3/mm^3 (1.6-37). It was elevated only in 197 patients (32.8%) and in 16 patients (2.7%) leukopenia was found (<4 x 10^3). The mean ESR was 83.2 mm/h (4-140). It was normal (<15) in 19 patients (3.2%).The commonest type of infection was pyogenic in 574 patients (95.6%), fungal infection in 6 patients, TB in 14, combined pyogenic with TB in 5 and in one patient pyogenic with fungal infection has been found. More than one organism could be isolated from the same infected region in 26 patients (4.3%). Staph. aureus was the most commonly isolated organism (33.5%) (MRSA in 30 patients of them). It showed no age predilection (p-value 0.074) and frequently occurred in patients who had other sites infections (p-value 0.005*) and/or epidural abscess (p-value 0.000*).Gram-negative organisms could be isolated in 45 patients (7.5%); E. coli in 20 of them.The most commonly associated infection was located in the urinary tract (p-value 0.000*). The lumbar spine was affected in 33 patients (73.3%); the lumbosacral junction in 5 cases of them.More than one organism could be isolated from the infection site in 22 patients (3.7%). All of them were older than 50 years, 16 had DM (p-value 0.004*), 17 patients (77.3%) had other sites of infection including bed sores at the time of presentation (p-value 0.003*). **Conclusion:** The elderly patients are more susceptible to spinal infections due to the associated comorbidities and immunocompromise than the other age groups.Thanks to the advent of various techniques which helped to improve the diagnostic efficiency to early diagnose these cases and to isolate various causative organisms in spinal infections and hence improve the prognosis of the disease in the recent years.Yet, even with improved diagnosis tools and procedures, the delay in diagnosis remains an important issue. This review aims to highlight the importance of a methodological attitude towards accurate and prompt diagnosis of spinal infections. The Introduction of PCR as well as special media for organism culture, especially in patients with low inflammatory parameters, can facilitate the identification of the causative organism and reduce the number of culture with 'No Growth'.

Deformity

A172: Technical Report of an Oblique Osteotomy of the Spine for Surgical Correction of Severe Scoliosis

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Introduction: Several types of osteotomies have been described such as the Smith-Peterson, pedicle subtraction or vertebral column resection. The decision regarding the choice between the different surgical options is usually made based on severity and curve location, rigidity, patient´s age among others. Severe, complex and rigid deformities can be a challenge and often require a combined anterior and posterior approach and the use of a more aggressive osteotomy. We described the surgical technique of an oblique or asymmetric osteotomy for surgical correction of scoliosis by posterior spinal approach. **Material and Methods:** An oblique osteotomy used for correction of scoliosis by posterior approach is described, and the outcomes of the last two years 2014-2015 are reported. A case series study was designed. Patients operated for correction of scoliosis in which the oblique osteotomy was used were included. Demographic variables of the population and the pre and postoperative radiological measurements were reported, the correction of the deformity, the sagittal and coronal balance and major complications were assessed. **Results:** Fourteen patients fulfilled the inclusion criteria, with an average age of 13 years (range 2-22 years), 29% male and 71% female. The most frequent diagnosis was neuromuscular scoliosis 43%, followed by congenital scoliosis 36% and idiopathic 21%. The average length of surgery was 6 hours (range, 4 - 9 hours), blood loss average was 1308 cc (range, 300-3000 cc). Preoperative Cobb angle was on average of 97° with a 44°-144° range, after surgery the average Cobb angle was 45° (range, 22° - 85°). The sagittal imbalance was present in 71% of patients preoperatively and was reduced to 36% of patients in the postoperative period. In the coronal plane preoperative imbalance of 79% of patients decreased to 43% of patients postoperatively. As intraoperative complications one dural tear and two pleural lesions were presented. No death or permanent neurological complications related to surgery were reported. **Conclusion:** In the literature there is little information about oblique or asymmetric osteotomies for the management of scoliosis in the pediatric population, most of the current literature is based on case reports and in most of the cases this osteotomies are done by a combine anterior and posterior approach; hence the description of this procedure with successful outcomes and low complications provides a safe alternative for the management of this population with severe and rigid deformities mainly in the coronal plane.

A173: Progression of Untreated Scheuermann's Kyphosis: Radiographs after Mean Follow-up of 46 Years

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Introduction: According to long-term follow-up studies, the natural history of untreated Scheuermann's kyphosis is benign. Yet there is no data available on the radiographic development of the deformity. Our purpose was to investigate the rate of radiographic deformity progression and the relation between kyphosis progression and clinical outcome in patients with untreated Scheuermann's kyphosis. **Materials and Methods:** Prospective study. Thoracic kyphosis was measured between Th4 and Th12 from standing lateral radiographs in 19 patients after mean 46-year follow-up. Mean baseline age was 19.2 (range 13 – 36) and at follow-up it was 64.7 (range 56 – 76) years. General health and quality of life questionnaires were administered. A representative sample of a national health examination survey, namely Health 2000, served as a control group. **Results:** The mean thoracic kyphosis increased from 46° (range 25°-78°) at baseline to 60° (34°-82°) ($P < .001$) at follow-up. Mean of the vertebrae wedge increased from 8.8° to 9.9° ($P = .046$). There was no correlation between degree of kyphosis at baseline, age at baseline or length of follow-up and rate of kyphosis progression. Nor was any correlation between extent of kyphosis progression and function at follow-up found. After adjustment for age at follow-up and BMI at 20 years, male Scheuermann's patients had more often disability due to back pain over the past five years (OR 5.4, 95% CI 1.70-16.85, $P = .004$) and back pain during the past 30 days (OR 3.6, 95% CI 1.12-11.78, $P = .031$) than general population. **Conclusions:** Among patients with moderate Scheuermann's disease the degree of radiographic deformity progressed slightly during long-term follow-up. However, progression did not predict symptoms, although patients have more back symptoms than general population.

A174: Is Use of Posterior Spinal Instrumentation Beneficial in Surgically Treating Myelopathy Associated with Posterior Longitudinal Ligmanet of the Thoracic Spine?

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Introduction: Ossification of the posterior longitudinal ligament (Th-OPLL) of the thoracic spine sometimes causes severe myelopathy. Since Th-OPLL provides frequent perioperative complications, especially when approached from anteriorly, decision making in the surgical treatment for Th-OPLL is difficult. Recently, use of posterior spinal instrumentation, which enables indirect decompression by maintainance of sagittal alignment and dekyphosis procedure, is favored by many spinal surgeons. However, there has been no study comparing anterior procedure vs posterior procedure using spinal instrumentation. In this study, we compared surgical outcomes for TH-OPLL between anterior procedure and procedures using posterior instrumentation. **Material and Methods:** Between 1998 and 2016, 32 consequtive cases (Male 10 patients, Female 22 patients, average age at operation 57, follow-up period 1-17 years) of symptomatic TH-OPLL were surgically treated in our group. There were 4 strategies in the surgical management (A method; single anterior approach n = 19, P method; single posterior approach using spinal instrumentation n = 8, PA method; P method followed by A method n = 4, AP method; A method followed by P method n = 1). Additionally, all cases were divided into 2 groups by the use of posterior instrumentation (non-inst method, inst method). Surgical outcomes were evaluated by the Japanese Orthopaedic Association Score (JOA score; total point = 11), improvement ratio of the JOA score, and perioperative complications. **Results:** In the selection of surgical approach, one case treated by P method was additionally treated by anterior approach due to postoperative paralysis and one case which could not be treated by prone position because of worsening of paralyses was initially treated by anterior approach. Average increase of the JOA score was 25% in the A method, 45% in the P method, 39% in the PA method, and 40% in the AP method. Average increase of the JOA score was 25% in the non-inst method and 42% in the inst method, showing significantly ($P < .05$) better improvement in the inst method. Complications included specific ones in the anterior approach (cerebrospinal fluid leakage and intracranial hemorrhage) and instrumentation related ones (malposition of screw and back-out of implants). Serious complications were more frequent in the anterior approach. **Conclusion:** Overall, use of posterior instrumentation seems to be a reasonable strategy in the Th-OPLL. Importantly, in the posterior instrumentation surgery, serious complication was less than in the anterior decompression for Th-OPLL. However, while use of posterior instrumentation showed that anterior decompression is unnecessary in some cases, a few cases did require anterior direct decompression. Therefore, surgical team should be capable of performing both of anterior and posterior procedures for the Th-OPLL and is required to be flexible in choosing approach depending on each case.

A175: Management of Severe Kyphosis in Spina Bifida Patients

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Introduction: Spinal kyphosis is a very common deformity in spina bifida patients. Kyphotic deformity is particularly common in thoracic and upper lumbar level paraplegics. The combine kyphotic deformity includes congenital (aplasia of posterior spine column) and paralytic components. The paralytic kyphosis is much more common and can be divided into three groups: I - collapsing kyphosis; severe rigid, II - sharpangled kyphosis and III - kyphosis complicated of bedsore on the apex of deformity. Untreated, progressive kyphosis leads to loss of truncal height, difficulties with sitting, and quite often is complicated with skin ulceration on the apex of kyphosis. Progression of the kyphosis may lead to breathing, eating and urination difficulties because of the abdominal contents, which press into the diaphragm, reducing the chest cavity volume with development Thoracic Insufficiency Syndrome. **Materials and Methods:** The aim of the study was to determine the dynamics of the functional status of the patient with kyphosis due to spina bifida and myelodysplasia, in the result of the surgery. A retrospective analysis of 27 children with kyphosis and spina bifida in age from 18 months to 17 years was performed. All of them previously operated for meningomyelocoele. X-ray, spine CT, MRI of the spine and head were performed to all patients. The results of surgeries were followed in the period from 7 months up to 3 years after surgery. Functional status before and after surgeries was estimated according to the FIM scale (Functional Independent Measure). We performed three types of surgery: 1. growing rods system was applied to the patients of I group; 2. more aggressive surgery was performed to the patients of II group – vertebral column resection (VCR) on apex of kyphosis with stable screw fixation at this level. In the cases of kyphosis with scoliotic component, growing rods system above or/and below the level of VCR, was performed; 3. to patients with severe kyphosis, complicated with skin ulceration, was performed halo-pelvic or halo-spine traction, to reduce the tension of soft tissue. After healing ulcer, we used VCR kyphectomy with screw fixation. **Results:** 9 children initially had sever neurological disorders (Frenkel Type A and B), one had moderate paraparesis (Frenkel Type D). The quality of life before surgery was, in average, 2-3 point FIM scale. The mean kyphosis correction was 71%. Improvement of neurological status was observed not in one of the cases, but at the same time, the improvement in functional class (FIM scale 4-5 points) and respiratory function of patients were present. **Conclusion:** Bracing to patients with meningomyelocoele and spinal deformity is usually ineffective. We divided kyphotic deformation of such patients into 3 groups: initial, sever kyphosis, and sever kyphosis with skin ulceration. Surgical correction improves body balance and quality of life. Surgical treatment of patients with kyphosis and spina bifida should be already applied, when the initial kyphosis is more than 10°. Kyphectomy is a challenging procedure with high complication rates, but in the case of heavy rigid kyphosis, it doesn't have alternatives.

A176: No Relation between Lumbopelvic Mismatch and Poor Outcome in Thoracic Hyperkyphosis Corrections

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Introduction: Spinopelvic parameters are of great value when planning sagittal deformity correction. Many studies describe strong correlations between spinopelvic parameters, which could predict clinical outcome. For sagittal realignment, the formula for postoperative lumbopelvic mismatch (LPM; Lumbar Lordosis (LL) minus pelvic incidence (PI) > $\pm 10°$) has recently been described to predict failure and functional outcome after lumbar fusion corrections in adult spinal deformity.[1] However, for selective thoracic kyphosis correction in patients with Scheuermann's kyphosis the relation between these lumbopelvic parameters and functional outcome is unknown. **Material and Methods:** In 28 surgically treated Scheuermann's patients (mean age 26.5 years) full spine radiographic assessments at preoperative (PO), 3-months postoperative (FU1) and 14-21 years follow-up (FU2) were available as well as the functional outcome measure (Oswestry Disability Index; ODI) at FU2. ODI $\leq$ 22 was used as a threshold indicating a healthy population.[2] Thoracic kyphosis (TK), LL, PI, Pelvic tilt and the sagittal vertical axis (SVA) were measured to analyze sagittal realignment. Correlations between lumbopelvic mismatch and ODI at FU2 were determined. **Results:** The average TK was corrected by 26% at FU1 and by 18% at FU2. No strong relation and no clear trends were found in the postoperative sagittal realignment. Pearson's coefficients of the differences in spinopelvic parameters were not stronger than ± 0.63. Calculated LPM occurred in at least 24/28 (86%) patients at FU1 and in 19/28 (68%) at FU2. No relation between LPM and dichotomized functional outcome, based on ODI $\leq$ 22, could be determined ($X^2 = 0.146$, $P = .70$). Moreover, at FU2 the average ODI was 20 (SD 18) in this cohort. **Conclusions:** Sagittal realignment and with that LPM was not predictable in this cohort of surgically treated Scheuermann's patients. Although measurement accuracy was hampered by poor quality hardcopy X-rays, the variability in the relationship between measured parameters was extremely wide

and no strong correlations were found over time between any of the lumbopelvic sagittal parameters. No relationship was found for selective thoracic kyphosis between lumbopelvic parameters and functional outcome. Moreover, despite significant mismatch in lumbopelvic parameters in many patients, the average functional outcome in our cohort was good. We hypothesize that in young and flexible lumbar spines, as is generally the case in Scheuermann's hyperkyphosis correction, other mechanisms such as hamstrings shortening, loss of correction, body habitus and individual neuromuscular control, *also* play a role in the realignment of the spine in combination with the mathematical sagittal parameter relationships. Therefore, the planning formula (LL-PI < $\pm$10) derived from degenerative adult spine deformity surgery seems not applicable in planning spinal corrections in Scheuermann's kyphosis.

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A177: Cervical Sagittal Alignment in AIS

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Introduction: Pedicle screw constructs have emerged as the leading method of posterior spinal instrumentation, providing excellent correction of adolescent spinal deformities with stable and rigid fixation. Pedicle screws, however, bring about a unique set of potential complications. As an alternative to all-pedicle screw fixations, hybrid constructs intermittently substituting sublaminar hooks have been reported. **Materials and Methods:** We analysed a cohort of 77 patients (mean age was 16.7 $\pm$ 1.9 years old) with adolescent idiopathic kyphoscoliosis, we classify them according to Lenke classification. We divided patients into two groups: patients treated with all-pedicle screw fixation composed Group A; patients treated with hybrid fixation composed Group B. We retrospectively analysed preoperative and postoperative radiographical findings: cervical, thoracic, lumbar and spino-pelvic indexes were recorded. Average follow-up was 30 months. **Results:** In Group A the mean Cobb angle for the main curve was of 55.78° ($\pm$7.4); the mean residual scoliosis after surgery was 15.89° ($\pm$14.96). In Group B the mean Cobb angle for the main curve was of 51° ($\pm$18.57); the residual scoliosis after surgery was 19° ($\pm$16.35). The amount of curve correction of the primary scoliosis curve was statistically significant ($P < .001$). In the evaluation of the whole groups after surgery, we observed a significant modification of spinopelvic indexes. The C7PL tends to move posteriorly after surgery. T1 slope, global cervical kyphosis and upper cervical kyphosis were reduced after surgical realignment of the trunk. **Discussion and Conclusions:** The hybrid technique is an excellent adjunct in the correction of spinal deformity in patients with idiopatic scoliosis. Sublaminar bands utilized in a hybrid construct can achieve corrections equivalent to all-pedicle screw constructs. We found an adaptive behavior of the cervical spine in malalignment of the thoracic and lumbar spine. The sagittal alignment of the cervical spine depends on the alignment of the trunk, and improvement in thoracolumbar alignment is followed by reduction of the cervical lordosis.

A178: Tilt on Traction: A New Parameter to Decide the Lower Instrumented Vertebra in Scoliosis Correction

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Introduction: The selection of distal fusion level remains controversial in adolescent idiopathic scoliosis. Description of Lenke in his classification is widely used in selecting fusion levels. We have postulated a new parameter, tilt of vertebrae on traction x-ray view to decide lower instrumented vertebrae. **Materials and Methods**: Prospective cohort of 26 adolescent idiopathic scoliosis patients who were operated in our institute by single surgeon during June 2013 to July 2014 with minimum two years follow up were included in our study. Preoperative traction x-rays were taken in all patients with standard anteroposterior, lateral and bending films. Tilt of vertebra were measured on anteroposterior and traction view. The vertebrae whose tilt came down $\leq$10 degree on traction x-ray were taken as lower instrumented vertebrae. Post operative x-rays were taken at 1 week, 6 months and 2 years. Post operative x-rays were analysed for coronal imbalance, lower instrumented vertebrae tilt. **Results**: Among the 26 patients with mean age of 14.1 years 23 patients were females. 16 patients with lenke 1, one with lenke 2, 3 with lenke 3, 6 with lenke 5 curves. The vertebra with an average tilt of 19.3 degree on anteroposterior x-ray which came down to 8.4 on traction image was selected as lower instrumented vertebra. Cobb angle correction was 74 $\pm$ 6.7%. All patients had maintained coronal balance up to recent follow up. Lowest instrumented vertebrae tilt of more than 10 degree was found in 2 patients but none of them required revision surgery (no adding on). **Conclusion**: Tilt of vertebrae on traction x-ray can be used as one of the parameters to decide lower instrumented vertebrae in adolescent idiopathic scoliosis that may restrict the level of fusion to some extent. Large case series with comparative study require proving this hypothesis.

A179: "Anterior Spinal Overgrowth" Is Not Exclusive for Idiopathic Scoliosis, and Is Located in the Disc

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Introduction: Relative anterior spinal overgrowth (RASO) has been described as a potential driver for the onset and progression of adolescent idiopathic scoliosis (AIS). Whether this anterior overgrowth is specific for AIS or also present in non-idiopathic scoliosis has not been reported. The objective of this study is to investigate the presence and magnitude of anterior spinal overgrowth in neuromuscular (NM) scoliosis and to compare this to the same measurements in idiopathic scoliosis and healthy spines. **Material and Methods:** Supine CT scans of thirty AIS patients (thoracic Cobb angle 21-81°), thirty NM scoliotic patients (thoracic Cobb angle 19-101°) and thirty age-matched non-scoliotic controls were investigated. The relative difference in length in the thoracic curves and corresponding levels in controls ((A-P)/P%) between the anterior (A) and posterior (P) side of each vertebral body and intervertebral disc were determined by using our previously validated 3-D software. Positive values of the height ratio indicate greater anterior length (lordosis). **Results:** The anterior overgrowth of the thoracic curves did not differ significantly between the AIS ($+1.2 \pm 2.2\%$) and NM patients ($+0.9 \pm 4.1\%$, $P = .663$). However, both did differ from the same measurements in controls ($-3.0 \pm 1.6\%$; $P < .001$). Overgrowth correlated linearly with the Cobb angle (AIS r = 0.678, NM r = 0.687). Additional anterior length was localized in the intervertebral discs (AIS: disc $+17.5 \pm 12.7\%$ versus body $-2.5 \pm 2.6\%$; $P < .001$, NM: disc $+19.1 \pm 18.0\%$ versus body $-3.5 \pm 5.1\%$; $P < .001$). **Conclusion:** Anterior overgrowth has been postulated as a possible cause for idiopathic scoliosis, but apparently it occurs in scoliosis with a known origin as well. This suggests that it is part of a more generalized 3-D scoliotic mechanism, rather than its cause. The fact that the intervertebral discs contribute more to this increased anterior length than the vertebral bodies suggests an adaptation to altered loading, rather than a primary osseous growth disturbance.

A180: Distal Adding-on and Risk Factors in Severe and Rigid Scoliosis

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Introduction: Previous work has evaluated the challenges in the treatment of patients with severe and rigid scoliosis and the risks of complications. Furthermore, although several studies have investigated postoperative distal adding-on and attendant risk factors in Lenke type 1A scoliosis, very few have focused on distal adding-on in severe and rigid scoliosis. The aim of this study was to identify associated risk factors of distal adding-on in severe and rigid scoliosis. **Material and Methods:** In this retrospective study, 48 consecutive patients with severe and rigid scoliosis underwent posterior spinal fusion surgery. The parameters of preoperative, immediately postoperative, and minimum 2-year follow-up radiographs were evaluated. The patients were classified as positive or negative for distal adding-on at follow-up, and risk factors were comparatively analyzed in the two groups. **Results:** The average Cobb angle and flexibility of the main thoracic curve (MTC) were 107.48 15.98 and 16.4% 10.2%, respectively, before surgery. Distal adding-on was observed in 12 patients (25.0%) at follow-up. Univariate analysis identified several factors significantly associated with distal adding-on. Furthermore, significant independent risk factors identified by stepwise logistic regression analysis included the correction rate of the MTC immediately after surgery (odds ratio: 1.107, 95% confidence interval: 1.024 – 1.197, P 1/4 0.011) and the difference between the lower instrumented vertebra (LIV) and last touching vertebra (LTV) levels (odds ratio: 0.121, 95% confidence interval: 0.028–0.518, P1/40.004). **Conclusion:** In severe and rigid scoliosis, a high correction rate of the MTC immediately after surgery and the LIV level above the LTV were significantly associated with distal adding-on.

Cervical Surgery

A181: Inpatient Outcomes in Dialysis Dependent Patients Undergoing Elective Cervical Spine Surgery for Degenerative Cervical Conditions

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Introduction: Due to advancements in medicine, increased rates of diabetes, and an aging population, the number of dialysis dependent patients undergoing elective spine surgeries is increasing. Their general poor health predisposes them to complications. Large studies assessing immediate post-operative outcomes in dialysis dependent patients in this population are lacking in the literature. The purpose of our study was to evaluate inpatient outcomes in dialysis dependent patients undergoing elective cervical spine surgery **Material and Methods:** Utilizing data from the National Inpatient Sample from 2002 to 2012, an estimated 1,205 dialysis dependent patients undergoing elective primary or revision anterior cervical decompression and fusions (ACDF) and posterior cervical fusions for degenerative conditions were identified and compared to 1,322,737 non-dialysis dependent patients undergoing the same procedures. We selected minor complications, major complications, and inpatient mortality as our primary outcome measures. Major complications included acute myocardial infarction, cardiac arrest, septicemia, septic shock, stroke, and pulmonary embolism. Minor complications included deep vein thrombosis, pneumonia, surgical complications, post-operative anemia, and urinary tract infections. Additionally, we evaluated hospital length of stay, and total hospital costs. **Results:** Dialysis dependence was associated with higher inpatient mortality rates (5.2% compared to 0.1%; $P < .001$) and major complication rates (9.2% versus 0.5%; $P < .001$) versus non-dialysis dependent patients. Dialysis dependence was an independent risk factor for major complications (OR = 2.18, 95% CI = 1.73 – 2.76; $P < .001$) and inpatient mortality (OR = 10.9, 95% CI = 7.64 – 15.6; $P < .001$). Dialysis-dependent patients had substantially increased mean lengths of stay (6.0 days compared to 1.9 days; $P < .001$) and total hospital charges ($31,027, SD = $28,181 compared to $16,764, SD = $11,365; $P < .001$). **Conclusion:** Dialysis-dependence is associated with drastically increased complication rates, risk of mortality, and represent a significant financial and psychosocial burden to patients undergoing elective cervical spine surgery. Both surgeons and patients should be aware of these risks while planning elective surgeries.

A182: Impact of C1 Laminectomy without Fusion on Upper Cervical Instability

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Introduction: Although several studies have reported that cervical laminectomy causes cervical instability, few have reported that C1 laminectomy without fusion causes upper cervical instability. We investigated whether C1 laminectomy without fusion causes upper cervical instability. **Material and Methods:** We retrospectively analyzed the records of 16 patients who had undergone C1 laminectomy without fusion between January 2004 and December 2014. Upper cervical instability was determined by evaluating atlantoaxial instability and atlanto-occipital dislocation using dynamic radiography. Patients who had upper cervical instability preoperatively were excluded. Follow-up images were examined at 1, 3, 6, and 12 months after discharge, and every year thereafter. **Results:** Four patients experienced atlantoaxial instability: two with chiari malformation type I, one with calcium pyrophosphate dihydrate (CPPD) crystal deposition disease, and one with a cervicomedullary junction tumor. In two patients with chiari malformation, the atlantodental interval (ADI) was 4.5 mm and 3.5 mm, respectively. In those with CPPD, the ADI was 6.4 mm. In the patient with a cervicomedullary junction tumor, the ADI was 6.2 mm. Two patients experienced atlanto-occipital dislocation: one with chiari malformation and one with CPPD. The basion-dens interval was 15 mm in the patient with chiari malformation and 13 mm in the patient with CPPD. **Conclusion:** C1 laminectomy usually has little impact on upper cervical instability, such that additive fusion is not demanded. However, we identified several cases of patients without preoperative instability who developed upper cervical instability following C1 laminectomy. Therefore, upper cervical instability should be carefully observed with periodic follow-up imaging.

A183: Adjacent Segment Disease after Anterior Cervical Interbody Fusion using Conventional Plate versus Zero-Profile Implant: A Preliminary Report

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Introduction: Anterior cervical discectomy and interbody fusion is a common treatment for cervical myelopathy or radiculopathy. However, due to mechanical stress and motion of the adjacent segment to index segment, 3% of adjacent segment disease is occurred annually. Recently, zero-profile implant is devised for less contact of adjacent structures and limited contact with adjacent segments. This study compared the occurrence of adjacent segment disease using zero-profile implant versus conventional plate. **Material and Methods:** 60 patients who underwent anterior cervical discectomy and interbody fusion for single level cervical spondylotic myelopathy, radiculopathy, or intervertebral degeneration that showed no improvement after conservative treatment and were able to follow up for at least 1 year were included in this study. 30 cases that used conventional plate from April 2007 to January 2011 (group A) and 30 cases that used zero-profile implant from March 2011 to February 2014 (group B) were retrospectively reviewed. All operations were performed by our senior surgeon (JS Ahn). Cases with history of trauma, infection, tumor, or previous posterior approach surgery and revision surgery were excluded from the study. Group A consisted of

16 males and 14 females and group B consisted of 17 males and 13 females. The index levels of fusion of group A were 1 case of C3-4; 5 cases of C4-5; 15 cases of C5-6; and 4 cases of C6-7 and of group B were 1 case of C3-4; 3 cases of C4-5; 16 cases of C5-6; and 6 cases of C6-7. The radiologic finding of degenerative change of adjacent segment and clinical manifestation were checked. **Results:** The average follow up periods were 19.23 months for group A and 14.85 months for group B. Adjacent segment degeneration findings such as osteophyte anterior to vertebral body, narrowing of disc space, and ossification of anterior longitudinal ligament were seen in 8 cases (26%) of group A (7 cases of grade II and 1 case of grade III) and 4 cases (13%) of group B (all 4 cases of grade II), which showed no statistical significant difference between two groups. No clinical manifestation of adjacent segment was found during follow up. **Conclusion:** Though it was hypothesized that conventional plate will show higher rate of adjacent segmental disease compared to zero-profile implant, the actual result were similar between two groups. This result suggests that adjacent segment degeneration is affected by interbody fusion more than the implant insulting the adjacent tissue

A184: Influence of Neck Postural Changes on Cervical Spine Motion and Angle during Swallowing

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Introduction: Occipito-cervical fixation in a neck retraction position could be dangerous due to the risk of post-operative dysphagia. No study previous study has demonstrated an association between the cervical posture change and cervical spine motion/angle during swallowing. So, the purpose of this study is to analyze the influence of neck posture on the cervical spine motion and angle change during swallowing. **Methods:** Thirty seven asymptomatic volunteers were recruited for participation this study. A videoflurographic swallowing study was performed in the neutral and retracted neck posture. We analyzed the images of the oral and pharyngeal phases of swallowing and compared the angle and the position changes of each cervical segment. **Results:** In the neutral posture, C1 and C2 were flexed, while C5, C6, and C7 were extended. C3, C4, C5, C6, and C7 moved posteriorly. All cervical levels, except for C5, moved superiorly. In the retraction posture, C0 and C1 were flexed, while C6 was extended during swallowing. All cervical levels moved posteriorly. C1, C2, C3, and C4 moved superiorly. The comparison between two postures shows that angle change is significantly different between C0, C2, and C5. Posterior translation change is significantly different in the upper cervical spine (C0, C1, and C2) and C7. Superior movement is significantly different in C0. **Conclusion:** C0 segment is most significantly different between neutral and retraction posture in terms of angle and position change. These data suggest that upper cervical spine including C0 segment could be a critical level of compensation which allows swallowing in the retraction neck posture regarding motion and angle change.

A185: Malnutrition Is More Than Just Low Serum Protein and Is Associated with Poor Outcomes and Increased Hospital Costs in Patients Undergoing Elective Cervical Spine Surgery

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Introduction: Risk factors for malnutrition include advanced age and chronic disease. Low serum protein markers such as albumin are commonly used to diagnose malnutrition. However, recent studies have demonstrated that these markers lack specificity in assessing nutritional status and can be influenced by a multitude of factors, most significantly, an underlying inflammatory state. The ICD-9 diagnoses of malnutrition are often made using more thorough criteria such as functional status, recent weight loss, caloric intake, and physical exam findings during nutritional assessments conducted by healthcare staff. According to these criteria, even patients undergoing elective cervical spine surgery may be malnourished and large studies evaluating inpatient outcomes in this population are limited. **Material and Methods:** Utilizing *International Classification of Diseases, Ninth Edition, Clinical Modification* codes and data from the National Inpatient Sample from 2002 to 2012, an estimated 2,313 malnourished patients undergoing elective cervical spine surgeries for degenerative cervical disease were compared to 1,307,651 patients who were not diagnosed with malnutrition undergoing the same surgeries. Length of stay, post-operative complications, mortality, and total hospital charges were the primary outcome measures. Complications were classified as major or minor. Major complications included acute myocardial infarction, cardiac arrest, septicemia, septic shock, stroke, and pulmonary embolism. Minor complications included deep vein thrombosis, pneumonia, surgical complications, post-operative anemia, and urinary tract infections. **Results:** Mean age upon admission of malnourished patients was 65.8 (SD = 11.8) compared to 52.8 (SD = 11.8) in patients not diagnosed with malnutrition ($p = < 0.001$). Major complications in malnourished patients were significantly increased when compared to patients with normal nutritional status (18.9% compared to 0.5%; $P < .001$). The rate of mortality was forty-five times greater in the malnourished population (4.5% compared to 0.1%; $P < .001$). Malnutrition was an independent risk factor for both major complications (OR = 6.35, 95% CI = 5.6 – 7.2; $P < .001$) and inpatient mortality (OR = 4.9, 95% CI = 3.9 – 6.2; $P < .001$). Patients

who were malnourished had a more than seven-fold increase in their mean lengths of stay (15.1 compared to 1.9; $P < .001$) and three-fold increase in total hospital charges ($52,975 versus $16,566; $P < .001$.). **Conclusion:** Risk factors for malnutrition include advanced age and chronic disease and the diagnosis of malnutrition is best made with a formal nutritional assessment. Recent literature has shown that serum protein markers are, oftentimes, not an accurate reflection of underlying nutritional status. As malnutrition substantially increases the risk of postoperative complications, mortality, length of hospital stay, and consequent total hospital charges, screening for malnutrition in those that are at higher risk of being malnourished may be prudent even in the setting of elective cervical spine surgery.

A186: Dose Additional Uncinate Resection Increase Pseudarthrosis following Anterior Cervical Discectomy and Fusion?

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Introduction: In many patients with cervical radiculopathy, neural foramens narrow by osteophyte or hypertrophy of uncovertebral joints. For this neural foraminal stenosis, uncoforaminotomy (uncinate resection; UR) simultaneously performed with anterior cervical discectomy and fusion (ACDF) is known to be helpful for a better and faster improvement of patient's arm pain. However, uncovertebral joints may be an important structure to maintain the stability between two vertebral bodies in the subaxial cervical spine. If they are resected during ACDF procedures, it might affect on the fusion process by causing segmental instability. The purpose of this study was to investigate whether unilateral or bilateral uncinate resection combined with ACDF for the decompression of neural foramen would increase the risk of pseudarthrosis at long-term follow-up. **Material and Methods:** We retrospectively analyzed 167 patients (89 men, 78 women; mean age, 58.4 $\pm$ 10.5 years) who consecutively underwent 1- or 2-level ACDF for cervical spondylotic myelopathy or radiculopathy and were followed for more than 2 years. In all the patients, allografts filled with local chip bone were inserted after discectomy and anterior plating was performed. If a patient had stenotic neural foramens on preoperative MRI and clinically concordant arm pain also, then the involved uncinate processes were totally resected. Uncinate resection was not performed in 46 patients who did not have foraminal stenosis (N-UR group). On the other hand, 121 patients underwent uncinate resection for at least one foramen (UR group). Among them, 89 patients underwent UR unilaterally (U-UR group) and 32 patients, bilaterally (B-UR group)(Table1). Solid fusion was diagnosed as interspinous motion <1 mm with superjacent interspinous motion $\geq$4 mm on the magnified plain dynamic lateral radiographs at final follow-up. Fusion rate was compared between N-UR and UR groups, and also between U-UR and B-UR groups. Chi-square and student t-test were used to analyze demographic data, surgical characteristics, and fusion rates. **Results:** There was no significant difference between N-UR and UR groups on gender, age, and smoking history. The fusion rates after 1-level ACDF were not significantly different among N-UR, U-UR, and B-UR groups; 91.4% (32/35) in N-UR group, 97.8% (44/45) in U-UR group, and 88.2% (15/17) in B-UR group ($P = .290$). Solid fusion was achieved in 72.7% (8/11) in N-UR group, 95.5% (42/44) in U-UR group, and 86.7% (13/15) in B-UR group after 2-level ACDF. There was no statistical difference on fusion rates among three groups ($P = .071$), either. **Conclusion:** Uncoforaminotomy could be helpful to ameliorate arm pain more promptly in the cervical radiculopathy patients who have stenotic neural foramens. One of concerns on this procedure is that a unilateral or bilateral resection of uncinate process would result in excessive segmental instability, which could increase the risk of pseudarthrosis following ACDF. In this study, unilateral or even bilateral resection of uncinate process did not affect on the fusion rate after single- or double-level ACDF. Hence, additional uncoforaminotomy during ACDF could be applied without worry about nonunion if it is necessary.

A187: Associations between Modic Changes and Cervical Degenerative Disease

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Introduction: Modic changes are signal intensity changes in adjacent vertebral bone marrow on magnetic resonance imaging (MRI). Few studies have investigated these changes with regard to the cervical spine. Therefore, this study aimed to determine cervical spine degenerative diseases associated with Modic changes. **Methods:** We conducted a retrospective collection of radiological data in patients with neck pain at our hospital from January 2010 to December 2014. A total of 733 patients were included in this study. Disc herniation grade and disc space height for each cervical segment were evaluated. If Modic changes were present, we recorded the Modic change type based on the literature, vertebral level, age, sex, and surgical requirement. **Results:** MRI scans of the 733 patients were reviewed, 99 patients exhibited Modic changes in the cervical spine (13.5%). Out of these 99 patients, Modic change type II (87 patients, 87.9%) and C5–6 vertebral level (41 patients, 41.4%) were the most predominant categories. Patients with Modic change showed worse outcomes in regard to disc herniation grade and disc space height than patients without ($P < .01$). Among 733 patients, 38 patients had undergone anterior cervical discectomy with fusion (ACDF). Patients with Modic changes (13/99 patients, 13.1%) had a greater probability of undergoing ACDF than those without (25/634 patients, 3.9%; $P < .01$). **Conclusion:** Modic changes may be an important indication of disc degeneration requiring surgery.

A188: Is There a Need to Bridge the Cervico-thoracic Junction in Posterior Multi-segmental Instrumentation of the Lower Cervical Spine?

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Introduction: At the level of the cervico-thoracic junction, the flexible cervical spine meets the more rigid thoracic segments. This, multi-segmental cervical instrumentations ending at this junction may be prone to pronounced adjacent segment degeneration or even failure of the instrumentation. The objective of this study was to compare patient groups with a primarily cervical instrumentation ending at C7 versus an instrumentation including the cervico-thoracic junction ending at T1 or T2 in regard to the rate of consecutive pathologies in the segment adjacent to the lowest instrumented vertebra. **Methods:** All consecutive patients who had undergone a multi-segmental posterior cervical instrumentation ending either at C7 ("Cis") or at T1 or T2 ("Trans") between 04/2007 and 07/2014 were identified (n = 98) and a retrospective chart review and radiographic assessment was performed. Radiographic parameters of degeneration at the adjacent segment below the instrumentation were determined postoperatively and at follow-up, and the need for secondary interventions was documented. **Results:** Seventy-four patients had a follow-up of at least six months (Cis: n = 58, age 63 ± 11, FU 36 ± 26 months; Trans: n = 16, age 65 ± 13, FU 37 ± 21 months). While the whole cohort showed progressing degeneration at the adjacent segment below the instrumentation at follow-up ($P < .001$), there were no significant differences between the Cis and Trans groups with regard to the change in kyphosis ($P = .162$), disc height ($P = .204$) or disc degeneration according to the Mimura grading system ($P = .718$). Secondary interventions due to symptomatic lower adjacent segment instability were necessary in 18/58 (31.8%) of the Cis-cases and in 1/16 (6.3%) of the Trans-cases ($P = .038$). Patients who required a secondary intervention for adjacent segment pathology showed a higher degree of kyphotic change ($P = .050$). **Conclusion:** In this retrospective cohort, patients with multi-segmental posterior cervical fusions ending at C7 showed a higher rate of clinically symptomatic degeneration and instability at the adjacent level below the instrumentation when compared to patients with instrumentations spanning the cervico-thoracic junction. Thus, it might be advantageous to bridge the cervico-thoracic junction and to end the instrumentation at T1 or T2 in those cases.

A189: Radiographic Evaluation of the Reliability of Neck Anatomic Structures as Anterior Cervical Surgical Landmarks

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Introduction: Accurate location of the skin incision is helpful to decrease the technical difficulty and save the operative time in anterior cervical spine surgery (ACSS). Spine surgeons usually use the traditional neck anatomic structures (hyoid bone, thyroid cartilage and cricoid cartilage) as landmarks during the surgery. However, the reliability of these landmarks has not been validated in actual practice. The purpose of this study is to find out which one of the landmarks is the most accurate for identifying the corresponding cervical levels during ACSS. **Materials and Methods:** The lateral flexion and extension radiographs of cervical spine on standing position from 30 consecutive patients were obtained from January 2015 to February 2015. The cervical vertebral bodies from C2 to C7 were equally divided into two segments. The cervical segments corresponding to the surface landmarks were recorded on the flexion and extension radiographs, respectively. And the displacement of corresponding cervical segments from the flexion to extension radiographs for each landmark was calculated. **Results:** Based on the measurement, the mainly corresponding cervical levels for mandibular angle were C2 on both of the flexion and extension films, hyoid bone were reference to C3-4 interspace on flexion film and C3 on extension film, thyroid cartilage corresponded to C5 on both of flexion and extension films, and cricoid cartilage corresponded to C6 on flexion film and C5-6 interspace on extension film, respectively. The ratios of landmark displaced within 2 segments from flexion to extension were 83.3% (25/30) in mandibular angle, 56.7% (17/30) in hyoid bone, 66.7% (20/30) in thyroid cartilage and 56.7% (17/30) in cricoid cartilage, respectively. The mean displacement from flexion to extension films were significant less than 2 segments in mandibular angle, but greater than 2 segments in hyoid bone, thyroid cartilage and cricoid cartilage. Significant differences were found between mandibular angle and the other three landmarks for the displaced segments from flexion to extension (P values were 0.024, 0.049 and 0.024, respectively). **Conclusions:** The angle of mandible was found to be the most accurate landmark for identifying the cervical level, which corresponded to C2 and C2-3 disc space. Furthermore, the hyoid bone, thyroid cartilage and cricoid cartilage were not reliable to predict the cervical levels during ACSS.

Spine Trauma

A190: Quality of Life after Spinal Cord Injury: Results from a Canadian National Cross-sectional Survey

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Introduction: Traumatic spinal cord injury (SCI) is a leading cause of worldwide disability, healthcare expanse and lost productivity. The goal of SCI management is to prevent secondary injuries in the acute period and restore functional autonomy through intensive rehabilitation once the patient's medical condition has stabilized. Underlying all medical and physical interventions is the assumption that maximizing neurological function and improving functional autonomy will improve the patient's long-term quality of life (QoL). As such, many interventional studies in SCI management use QoL as a primary outcome. The goal of this study was to provide overall QoL, health-related QoL and health utility values for patients with traumatic SCI stratified by injury level and neurological status. **Material and Methods:** The Canadian SCI Community Survey was sent to Canadians living in the community following SCI. The survey covered demographics, SCI classification, secondary complications, comorbidities, needs, community participation, activities and employment, QoL, health care utilization, overall health status and overall QoL. QoL was measured using the LiSAT-11, the SF-12 v2 and a direct question. SF-12 v2 answers were used to generate a health utility score using published preference weights. The impact of demographics, complications and SCI classification on QoL was assessed using ANOVA, multiple linear regressions and ordinal logistic regression analyses. **Results:** There were 1109 respondents with traumatic SCI. 70% were male. Mean age was 48.3 years at a mean of 18.5 years following injury. ASIA Impairment Scale grade was cervical A or B in 20%, cervical C or D in 28%, thoracolumbar A or B in 32%, thoracolumbar C or D in 16% and E (any level) in 1%. Injury level or AIS grade had no impact on either health utility or QoL assessed by a direct question. Factors affecting QoL included (in decreasing order of importance) a depressed mood, fatigue, injuries caused by a loss of sensation, not working, diabetes, concomitant renal disease, neuropathic pain, constipation, sleep problems, hypertension, sexual dysfunction, pressure ulcers and joint contractures. With a mean health utility score of 0.64 ± 0.12, SCI patients living in the community reported having QoL similar to patients with rhinosinusitis, symptomatic hand osteoarthrosis and healed hip fracture. **Conclusion:** Once in the community, SCI patients report having a very good QoL. In the years after the injury, chronic medical conditions have more impact on QoL that strictly SCI-related complications. Moreover, injury level and AIS grade do not affect long-term QoL. As such, we believe QoL should not be used as outcomes to assess the effectiveness of interventions targeting neurological function and autonomy in traumatic SCI.

A191: Missile Injuries of the Spine

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Introduction: Gunshot wounds of the spine are not very frequently reported and there is a paucity of neurosurgical literature on the subject. We share our experience of managing 27 patients with thise injuries, sustained in militancy and warlike situations and civilian injuries. **Methods:** Between 1995 and 2015, 27 cases with low velocity missile injuries of the spine and spinal cord were treated in three service hospitals. All were adult males, with a mean age 30.7 years. The wounds were caused by splinters in eighteen (82%) and bullets in four (18%). Twelve patients received more than one splinter. The cervical and thoracic spines were most frequently involved. In seven cases, there were injuries to other organs. There was extensive initial deficit (quadriplegia, paraplegia) in 18 (82%) cases, while four (18%) had partial deficits. The patients were evaluated by spine radiographs; Myelography was done in four, CT myelography in thirteen and MRI in four patients. Two patients had intramedullary haematoma without any skeletal injury, and were treated conservatively. Seventeen patients were treated operatively, and associated injuries of other organs received priority management. Surgery was in the form of debridement, exploration of spinal cord, haemostasis, decompression and dural repair. Steroids and antibiotics were given routinely. **Results:** Three patients (two with cervical and one with thoracic spine injury) died preoperatively, and one (with dorsolumbar injury) died in the postoperative period due to multi-organ injury. Patients with complete injury remained completely paralysed, while those with incomplete injury showed improvement in their neurological grades. Initial neurological grade is the best prognostic indicator, and these injuries are often accompanied by multi-organ injuries. There was no instance of postoperative meningitis or CSF leak. These injuries should be explored for debridement and dural repair. **Conclusions:** Gunshot wounds of the spine are infrequent, and in miltiary settings, are routinely explored. Surgery affords debridement, dural reconstruction, prevention of postoperative CSF leaks and infection, and early rehabilitation.

A192: Steroid Use for Acute Spinal Cord Injury in Latin America: A Potentially Dangerous Practice Guided by Fear of Lawsuit

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Introduction: Recent guidelines do not recommend routine administration of methylprednisoline (MP) in patients with acute traumatic spinal cord injury (SCI). The objective of this study was to identify patterns of practice and reasons for MP prescription in Latin America (LA). **Materials and Methods:** Portuguese and Spanish modified-versions of a questionnaire published by Hurlbert and Hamilton were used to evaluate the opinion about MP administration in acute SCI in LA. An e-mail request to participate in the survey was sent to members of AOSpine LA (AOSLA) with a cover letter explaining the objective of this study and an attached link to Survey Monkey. Bivariate and multivariate analyses were conducted with SPSS. **Results:** A total of 970 AOSLA members from 20 countries answered the electronic questionnaire, a response rate of 69%. Of the total sample, 834 surgeons (86%) reported that they routinely treat patients with acute SCI, and 56.1% of them reported routine administration of MP for these patients. Use of MP was associated with country, specialty, length of clinical practice and number of SCI treated yearly. Among the 468 surgeons that reported routine administration of MP, 56.1% believe in the clinical benefit, 29.3% do this because of fear of litigation, 27.1% because this is a protocol in their hospital, 3.5% because they believe that MP has no major adverse effect, and 30.7% administer it only to young patients. The rationales for MP administration in acute SCI were different among countries and specialty. It was observed that 63.9% of neurosurgeons believe that corticosteroids improve clinical outcomes versus 49.6% of orthopedic surgeons (Chi-square 9.24; $P = .002$). However, 38.5% of orthopedic surgeons reported that they administer MP because of fear of litigation versus 17.8% of neurosurgeons (Chi-square: 23.12; $P < .0001$). Regarding country, MP administration in Brazil, Argentina and Mexico is more associated with litigation fear and less associated with belief in clinical efficacy compared with the other countries. Fear of litigation) was reported by 50.8% of Brazilians, 53.8% of Argentines, and 29.1% of Mexicans. This reason was less likely to be mentioned in Chile (15.8%), Colombia (15.2%), Venezuela (12.2%), and Peru (3.0%). Logistic regression analyses demonstrate that fear of litigation as a reason for prescribing MP was independently associated with the orthopedic specialty (Adjusted OR: 2.45, CI95%: 1.49 – 4.02, $P < .0001$), and working in Brazil (Adjusted OR: 20.29, CI95%: 2.55 – 161.12, $P = .004$) or Argentina (Adjusted OR: 22.48, CI95%: 2.83 – 178.39, $P = .003$). **Conclusion:** Despite increasing evidence against routine MP administration in SCI and international guidelines not recommending its use, this potentially dangerous practice remains common in this continent. More than 50% of prescriptions are based on fear of lawsuit or hospital protocol. Educational campaigns are needed in LA to promote adherence to the current guidelines on MP for acute SCI and this would reduce incorrect practices guided by misperception of lawsuit issues.

A193: Adverse Effects of Vasopressor Support for the Maintenance of Mean Arterial Pressure in Acute Spinal Cord Injuries

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Introduction: Management of mean arterial blood pressure (MAP) is used to theoretically optimize neurologic recovery following spinal cord injury (SCI). When vasopressors are utilized, unique complications have been noted. The maintenance of MAP through vasopressor support may result in an increased risk of unacceptable complications. **Material and Methods:** Patients that sustained acute SCI from blunt trauma were identified from a trauma database. Demographic data was collected, including patient age, gender, ethnicity, and BMI. Injury data included injury severity score, severity and level of neurologic injury (initial and final ASIA impairment scale), and number and length of vasopressor usage. Patient outcome data included myocardial infarction, cerebrovascular accident, pneumonia, deep vein thrombosis/pulmonary thromboembolism, acute kidney injury/dialysis, albumin/prealbumin levels, length of ICU stay, hospital length of stay, and in-hospital mortality. An unexposed cohort of trauma patients that did not undergo MAP management was identified and matched to the exposed cohort based on similar injury severity scores. Demographics and outcome data were obtained for the unexposed cohort. Of note, none of the SCI patients received steroids in their management. **Results:** 67 acute SCI patients receiving MAP management were identified and matched to 67 patients from the trauma registry with similar injury severity scores that did not undergo MAP management. Patients in the MAP management cohort had similar average age (45.54 +/− 18.50 vs. 46.06 +/− 18.79), BMI (29.67 +/− 8.07 vs. 28.64 +/− 6.61), and injury severity score (23.40 +/− 8.87 vs. 23.18 +/− 8.65) to patients in the unexposed cohort. Patient in the MAP management cohort received significantly higher median number of vasopressors (1.00 vs. 0.00, $P < .05$) and longer duration of vasopressor use (3.90 +/− 2.55 days vs. 0.33 +/− 1.43 days,

$P < .05$). Patients in the MAP management cohort had significantly longer ICU length of stay (14.94 +/− 15.06 days vs. 6.50 +/− 8.95 days, $P < .05$), longer hospital length of stay (23.31 +/− 22.17 days vs. 12.08 +/− 10.14 days, $P < .05$), and higher incidence of pneumonia (41.79% vs. 16.42%, $P < .05$). There was a non-significant trend toward higher incidence of deep vein thrombosis for the MAP management cohort (10.45% vs. 2.99%, $P = .0956$). Other outcome measures between the cohorts were not statistically different. Regarding neurologic recovery of SCI patients, 41% of patients had a complete injury and 59% had an incomplete injury. 57% of patients had a cervical injury, 41% had a thoracic injury, and 3% had a lumbar injury. Patients had an average recovery of −0.0476 +/−1.75 levels and 0.386 +/− 0.689 ASIA grade. **Conclusion:** Patients that underwent MAP management protocol had higher number and duration of vasopressors, higher incidence of pneumonia, longer ICU stay, and longer hospitalization than matched patients that did not undergo MAP management. The use of vasopressors may be associated with an increased risk of adverse complications and costs when compared to a physiologically similar cohort, with minimal gains in terms of neurologic improvement. Future prospective studies should be conducted to determine the efficacy of this practice.

A194: A New Concept of Outcome Measurement in Spine Trauma: The AOSpine Clinician Reported Outcome Spine Trauma (AOSpine CROST)

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Introduction: Besides a patient reported outcome measure, there is a need for a simple, reliable and quick to administer tool that formalizes the most relevant clinical and radiological assessment parameters to reflect the spine surgeons' perspective adequately. Therefore, the AOSpine Knowledge Forum Trauma initiated the development of a new concept of a clinician reported outcome measure for spine trauma (AOSpine CROST). This tool can be used by the treating surgeons, enabling them to evaluate and predict the clinical and functional outcomes of spine trauma patients on the short term (≤12 months) and long term (>12 months) post-trauma. Together with independent patient reported outcome, this tool will provide a holistic view of patients' health in relation to their spine injury. **Materials and Methods:** Two separate cross-sectional online surveys were conducted among highly experienced spine surgeons from all world regions to identify relevant clinical and radiological parameters when evaluating clinical and functional outcomes of spine trauma patients. The first survey focused on the thoracic and lumbar spine (TL-survey), the second survey on the subaxial cervical spine (C-survey). Based on a systematic review, the recently developed AOSpine TL- and C-classification systems as well as expert interviews, 16 parameters were included in the TL-survey and 21 in the C-survey. Participants were asked to give their opinion on the relevance of each parameter on a 5-point scale. The results of these surveys formed the basis for the development of a draft version of the AOSpine CROST. This draft version was discussed and pilot tested in an expert committee meeting, and resulted in a definitive version to be validated. **Results:** Out of the 279 invited spine surgeons, 118 (42.3%) participated in the TL-survey and 108 (38.7%) in the C-survey. The most relevant clinical and radiological parameters were identified, and formalized in a draft version of the AOSpine CROST. After discussing and pilot testing this draft version among clinical cases during an expert committee meeting, a definitive version to be validated was developed, consisting of 10 parameters: neurological status, radiographic sagittal alignment, general bone quality, stability of the injured spine level, spinal column mobility, general physical condition, general psychological condition, functional recovery, wound healing, and implants. **Conclusion:** The perspectives of a highly generalizable cohort of worldwide experts were explored on clinical and radiological parameters most relevant to evaluate and predict outcomes of spine trauma patients. The identified parameters were formalized and pilot tested, which resulted in the development of a final version of the AOSpine CROST, consisting of 10 parameters. After further validation, the AOSpine CROST will be a helpful tool in clinical practice and research.

A195: International Validation of the AOSpine Patient Reported Outcome Spine Trauma (AOSpine PROST)

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Introduction: There is no outcome instrument specifically designed and validated for traumatic spinal column injury patients, which makes it is difficult to measure the effect size of various treatment options in a variety of traumatic spinal column injuries. The AOSpine Knowledge Forum Trauma aims to develop and validate such instruments that include both the patients' and clinicians' perspective. The International Classification of Functioning, Disability and Health (ICF) is used as the basis for the Patient Reported Outcome Spine Trauma (AOSpine PROST). **Material and Methods:** Based on the results of 4 preparatory studies and a consensus conference, the AOSpine PROST was developed. A pilot test of the first draft of the Dutch version was conducted among a consecutively selected representative sample of 25 traumatic spinal column injury patients from a level-1 trauma center in the Netherlands. Subsequently, this draft version was cross-culturally translated and adapted into English according to established guidelines in order to develop a final English version of AOSpine PROST. Currently, an international study among 4 Dutch and North-American centers is ongoing to assess the validity of both the Dutch and English versions of the AOSpine PROST. A preliminary analysis was performed to assess the test-retest reliability of the Dutch version, using Intraclass Correlation Coefficient (ICC). **Results:** The preparatory studies and consensus conference resulted in the selection of 25 ICF categories as core categories for patient reported outcome measurement in adult traumatic spinal column injury patients. Agreement was also reached on the response scale for use in the AOSpine PROST: the Numeric Rating Scale 0-100, with 0 indicating no function at all and 100 the pre-injury level of function. The AOSpine PROST was developed by clustering those 25 core categories into 19 items and implementing them in the selected scale: household activities, work/study, recreation and leisure, social life, walking, travel, changing posture, maintaining posture, lifting and carrying, personal care, urinating, bowel movement, sexual function, emotional function, energy level, sleep, stiffness, loss of strength, and pain. The pilot study of the Dutch version showed very good results for the comprehensibility, relevance, acceptability, feasibility, completeness and internal consistency (Cronbach's alpha = 0.926). A preliminary analysis including 58 patients from the international validation study showed excellent results for the test-retest reliability of the Dutch version (ICC = 0.898). The average interval between the first and second administration was 9.4 $\pm$ 4.1 days (range: 6-27). **Conclusion:** Following the ICF methodology and including 4 different preparatory studies and a consensus conference, led to the development of a disease-specific patient reported outcome instrument for traumatic spinal column injury patients. Very good results were obtained from a pilot study. Currently, an international multicenter study is ongoing to subject the Dutch and English versions of AOSpine PROST to further validation. A preliminary analysis showed excellent results for test-retest reliability. Ultimately, the AOSpine PROST will be a helpful tool to compare various treatments and improve the quality of health care.

A196: Outcome of Early Surgical Intervention in Spinal Trauma Patients, An Overview of 109 Spinal Trauma Patients

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Background: The prognosis for spinal cord injuries varies depending on the severity of the injury. There is always hope of recovering some function with spinal cord injuries. The completeness and location of the injury will determine the prognosis. The sooner treatments are implemented to strengthen muscles below the level of the spinal cord injury, the better the prognosis. The first year of recovery is the hardest as the patient is just beginning to adjust to his or her condition. The use of physical and occupational therapy during this time is the key to recovery. The extent of the function fully returning is typically seen in the first two years after the initial injury. To determine the neurological outcome of patients who presented early with those whose presented late. **Materials and Methods**: It is a descriptive case series done in the Department of Orthopaedics And Spine between Jan 2014 to dec 2016. 5.109 patients who presented to ER or OPD with spinal trauma were included.Those patients who were operated else where or having trauma of more than 10 days or those who were managed conservatively were excluded. After admission, history, examination, and investigations, surgical intervention was done on same day. Every patient was followed regularly for 2 years to assess the neurology.The data was analyzed using SPSS 17.00 Version. **Results:** There were 109 total patients that presented with spine trauma. 74 (67.9%) were male and 35 (32.1%) were females. Male to female ratio was 2.11:1. Of the 109 total patients that presented 78 (71%) were below 40 years of age and 41(28.5) patients were above 40. 17 (15.6%) had trauma to the cervical spine, 34 (31.2%) to the thoracic spine, 3 (2.8%) to the thoracolumbar spine and 55 (50.5%) to the lumbar spine. 79 (72.5%) patients had a fall from height. 26 (23.9%) were involved in road traffic accidents. 1 (.9%) had assault and 3 (2.8%) had sports injuries. At the time of

presentation out of 109 patients, 97 (89%) had their neurology involved while 12 (11%) had intact neurology. 18 (16.5%) presented within the first 24 hrs while 91 (83.5%) presented after 24 hrs. All the patients were operated on the same day of admission.Among the 18 patient who presented with in 24 hours, 17 patients having full recovery with in 12.66 $\pm$ 1.2 months. While the late presenters only 15 patients got fully recovered after 2 years follow up while 42 patients having partial neurology recovery and 24 having just sensory improvement and 28 having no improvement after two years follow up. **Conclusion:** Spinal trauma is an emergency and having high morbidity and mortality rate. Early presentation and surgical intervention in spinal trauma patients having good neurological outcome as compared to delayed presentation and surgery.

A197: Spinal Fractures in Ankylosing Spondylitis Patients: A Systematic Review of the Literature

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Introduction: Ankylosing Spondylitis (AS) is a chronic inflammatory disease that predominantly involves the axial skeleton. At its final stage AS is responsible for the spontaneous fusion of all spinal segments as well as sagittal imbalance and osteoporosis. Together these pathologic changes lead to higher risk of falls from height and a 3.3 times greater risk of vertebral fractures. The development of strategies for the treatment of vertebral fractures in AS patients seems to be a good asset for investment. The authors present a descriptive literature review regarding the treatment of vertebral fractures in AS patients. **Material and Methods:** A systematic review of PubMed was performed, using the terms "spinal fracture" and "ankylosing spondylitis". The descriptive review included systematic reviews, prospective randomized control trials, prospective/retrospective cohort studies, case-control, and expert opinion, published from 2011 to 2016. **Results:** After assessment 38 publications were included, 60% of them published between 2014 and 2015 and 55% published in surgery related journals. The majority of the publications corresponded to retrospective cohort studies (53%), 11% cross-sectional studies and 10% prospective cohort studies. From 5 to 15% of AS patients suffers a vertebral fracture. The main mechanism is the hyperextension of a rigid and kyphotic spine, resulting in highly unstable fracture patterns. Previous back pain and structural damage are mostly attributed to disease-related inflammation making diagnose extremely difficult and delaying it in 60% of the cases. Neurologic deficit appears in 33-58% of the thoraco-lumbar fractures, being irreversible in most cases. Neurologic damage secondary to delayed diagnosis occurs in 15% of the patients. Computed tomography is considered critical for confirming the diagnosis of spinal fracture in AS, as well as MRI for a better lesion characterization. Non-operative treatment is an option, however the kyphotic deformity makes bracing difficult. Patients with AS often exhibit a number of co-morbidities, being more prone to complications, especially infection (14% after open surgery). Percutaneous instrumentation has gain popularity, mainly due to a lower amount of blood loss and infection rate. Due to osteoporosis, long lever arms and consequently, a high rate of implant loosening (10% to 15%), most authors recommend multi level internal fixation, with cemented pedicle screws in selected cases. Concerning cervical fractures, the posterior approach allows to reduce the lever arm, being recommended due to biomechanical superiority. Many studies report a higher life expectancy after surgical treatment of vertebral fractures in AS patients, when compared with non-operative treatment. **Conclusion:** Prevention as wells as early diagnosis and treatment of vertebral fractures in AS patients are the key for a successful outcome. This group of patients present a higher rate of morbidity and mortality, but surgical treatment, especially minimally invasive techniques allow a better outcome. Literature is scarce and high evidence level studies are needed.

A198: Acute Traumatic Spinal Cord Injury: Determinants of Outcome and Challenges of Care at the National Hospital Abuja

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Introduction: Acute Traumatic Spinal Cord Injury (TSCI) is very common and is often associated with significant morbidity and mortality. Optimal management is impaired by lack of pre hospital care, near absence of universal health insurance and inadequate support services despite improved training and availability of spine surgeons in our practice. The purpose of this study is to evaluate the impact of patient and injury characteristic on patient care and outcome as well as to highlight challenges associated with care of these injuries in our facility. **Materials and Methods:** This is a retrospective review of patients with spine/ spinal cord injury managed in our institution over 24 months (1st September 2014 to 31st August 2016) using a predesigned proforma. Data collected include biodata, prehospital transport and care, time between injury and presentation, spinal cord segment involved, ASIA score at admission and at time of death or discharge from hospital. The data were analyzed using Statistical Package for Social Sciences (SPSS) 20.0 (SPSS Inc. Chicago, Illinois, USA); p-value $\geq$ 0.05 was set as significant. **Results:** A total of 105 patients with suspected spine injury were seen during the period. 83 patients with clinical and radiological evidence of spinal cord injury were studied. Most of the patient were male (81%), the mean age of the patient is 37.39 $\pm$ 14.62. Motor vehicular crash

account for the commonest cause of injury 59.0%, followed by falls 25.6%. Most injury involved the cervical spinal cord (66.7%). most of the patient (69.2%) presented within 24 hours of injury and 51.3% of these patients were transported by relatives in private cars to the hospital, while only 33.3% were brought to the hospital in an ambulance. None of these patients had a standard pre hospital treatment. Injury was complete (ASIA A) in 35.9%. Pressure ulcer occurred in 12.8%. Thirty-two patients were to be operated based on injury pattern, however only 16 patients had surgical intervention. Most of the surgeries were delayed beyond 2 weeks mainly due to financial constraints, other reasons for delays include implants availability and complications. Most surgeries were anterior cervical approach including ACDF. Four patients died while waiting for surgery while 2 patients declined surgery for financial reasons. **Conclusion:** Despite improved training of spine surgeon and better facility for care, acute traumatic spinal cord injury remained a significant cause of morbidity and mortality in our practice due to challenges related to intervention.

Non-Operative Medical Treatments

A199: Complexities of Physical and Psychosocial Variables Independently Contribute to Resource Utilization after Lumbar Surgery

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Introduction: Effective management of patients after lumbar surgery requires acknowledging the complexities of coexisting physical and psychosocial variables. Preoperatively identifying these variables, particularly those leading to greater resource utilization, would facilitate in-hospital and discharge management. While effects of surgical and medical variables are well known and there are standard methods to measure them, less is known about the role of psychosocial variables and how to measure them preoperatively. The goal of this analysis was to assess whether preoperatively measured psychosocial variables predict longer length of stay and special discharge requirements after lumbar surgery, independent of surgical and medical variables. **Material and Methods:** This was a prospective cohort study of 532 consecutive patients undergoing lumbar surgery for diverse diagnoses. Several days before surgery patients completed several surveys, including the Geriatric Depression Scale, the Spielberg State Anxiety Inventory, and a question about tangible social support ("during the past four weeks, was someone available to help you if you needed and wanted help" with five response options ranging from "yes, as much as I wanted" to "no, not at all"). Medical comorbidity was scored according to the Charlson Comorbidity Index, and extent of surgery was described according to the Spine Surgical Invasiveness Index, a validated instrument accounting for vertebral levels, fusion, instrumentation, and approach. The primary outcomes were hospital length of stay (LOS), dichotomized according to routine hospital stay of $\leq$3 days or >3 days; and requiring services at discharge, dichotomized as to home or to an institution/home with services. Two logistic regression models were considered with LOS and required services at discharge as dependent variables. **Results:** Mean age was 56 years, 55% were men, 79% had a chronic spine diagnosis, 40% had a positive screen for depression, 62% had greater anxiety than population norms, 77% reported as much social support as they wanted, 2% reported no support, 30% had major medical comorbidity, and 35% were obese. Surgical invasiveness was not normally distributed and was divided into quartiles. 53% has LOS >3 days; in multivariable analysis, longer LOS was predicted by a positive screen for depression (OR 1.6, $P = .05$), less social support (OR 1.3, $P = .04$), obesity (OR 1.8, $P = .01$) more invasive surgery (OR 3.0, $P < .0001$), older age (OR 1.8, $P = .01$) and being female (OR 2.0, $P = .002$). 17% required services at discharge; in multivariable analysis, requiring services was associated with a positive screen for depression (OR 1.9, $P = .02$), more anxiety (OR 2.4, $P = .003$), less social support (OR 1.3, $P = .04$), more comorbidity (OR 1.7, $P = .04$), older age (OR 3.3, $P < .0001$) and more invasive surgery (OR 1.9, $P < .0001$). **Conclusion:** Psychosocial variables predicted LOS and requiring services after discharge independent of medical comorbidity and extent of surgery. Our analysis is unique because it included psychosocial variables, particularly social support, in the analysis of perioperative outcomes. Our study demonstrated that patients undergoing lumbar surgery are complex in terms of the variables that affect outcomes. In addition, our study showed that these variables can be measured relatively simply and thus can be used proactively to plan perioperative resource utilization.

A200: Dispersal Pattern of Injectate after Cervical Epidural Steroid Injection Evaluated with Magnetic Resonance Imaging

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Introduction: Epidural steroid injections (ESI) are an important diagnostic and treatment modality in spine pathology, most notably radiculopathy. The success of these injections has been attributed to the anatomic location reached by the injectate. Both the diagnostic and therapeutic applications for ESI assume that the injectate remains local to the injection site to achieve its effects. However, substantial injectate diffusion after lumbar epidurals has been demonstrated using computerized tomography assessments. While the clinical utility of cervical ESI has been established, little is known about the actual injectate diffusion. The purpose of the current study was to evaluate the injectate dispersal pattern after cervical interlaminar ESI using magnetic resonance imaging (MRI). To the authors' knowledge, there have been no studies evaluating spinal injectate dispersion using MRI. **Material and Methods:** After Institutional Review Board approval was obtained, patients were recruited from the spine clinics at the authors' institution. Patients undergoing standard-of-care cervical ESI who met study criteria were consented. A single fellowship trained musculoskeletal radiologist with extensive experience in administering interlaminar epidural steroid injections performed all of the injections under sterile technique. A 10.1 ml mixture containing 2 mL of 10 mg/ml dexamethasone, 8 ml normal saline, and 0.1 mL of gadolinium contrast was injected with a 22-gauge Tuohy needle into the posterior epidural space at the C7-T1 interval using the pressure release method under fluoroscopic guidance. Within 15 minutes of completing the injection procedure, study participants underwent a cervical spine MRI. T1-weighted sagittal and axial images were used to evaluate the post-injection dispersal pattern. A single board certified radiologist measured the dispersal patterns for axial and circumferential extent using calibrated internal measurement software. **Results:** A total of 20 patients were consented and enrolled in the study. Four patients were not included in the statistical analysis of the study; 2 patients withdrew and 2 patients were post-consent screen failures. A total of 16 patients (8 males and 8 females) completed the cervical ESI with gadolinium and subsequent MRI. The average age of study participants was 51.18 years old (range 39-64) with average BMI of 29.18 (range 23-35). MRI findings revealed all 16 patients had circumferential dispersal of the injectate. Average cranial migration was 8.11 cm (standard deviation 1.78 cm, range 3.3 to 10.7 cm). Average caudal migration was 6.63 cm (standard deviation 3.35 cm, range 0 to 10.7 cm). Average craniocaudal extent was 14.73 cm (standard deviation 3.15 cm, range 9.3 to 18.7 cm). The caudal epidural extent went below the field of view for 5 of the patients. There were no adverse events reported from the injectate or injection procedure. **Conclusion:** Fluoroscopy-guided cervical interlaminar ESI resulted in nearly uniform circumferential dispersal within the epidural space with multiple level migration in the cranial and caudal directions. A better understanding of spinal injectate dispersion can help to guide treatment, especially in patients with multilevel disc disease. This study supports using MRI as a safe and accurate tool to evaluate spinal injectate dispersal.

A201: Patient Satisfaction Does Not Correlate with Pain Medication Consumption in Postoperative

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Introduction: Despite increased focus on patient satisfaction as a measure of healthcare quality, the factors that influence it are incompletely understood. Postoperative pain, pain management, and patient satisfaction with both of these components are important considerations in postoperative patient care. The aims of this study were to determine the relationships between patient reported pain, inpatient pain medication consumption, satisfaction with pain control, and overall satisfaction with inpatient admission following spine surgery. **Material and Methods:** A retrospective review was performed for all patients with a completed Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey during the study period. Daily averages of patient reported pain using the numerical rating scale (NRS), narcotic usage converted to morphine equivalents, alternative pain medication usage, length of stay, and patient reported satisfaction obtained from HCAHPS surveys were recorded. Statistical analyses were performed to evaluate for correlations between these variables. **Results:** Of the 316 patients meeting inclusion criteria, 49.7% of patients reported that their pain was "always" controlled and 73.8% were "satisfied" with the hospital admission based on HCAHPS survey response data. There was no association observed between type or amount of pain medication use, including opioids, and satisfaction with pain control nor with the hospital in the postoperative inpatient admission setting ($P > .05$). The average NRS scores for patients that were satisfied versus those that were not satisfied was nearly identical (3.16 vs. 3.19, $P = .89$). The perception that staff did everything to provide pain control was significantly associated with hospital satisfaction ($P < .001$). **Conclusion:** This study demonstrates that increased narcotic consumption did not correlate with greater pain satisfaction while the perception by patients of the efforts provided by the care team to manage pain did significantly correlate with satisfaction. These results emphasize the importance of open communication and dialogue with patients regarding their experiences and treatment plans while questioning the assumption the provisions of greater amount of narcotics will increase satisfaction.

A202: Epiduroscopic Laser Neural Decompression: Clinical Significance and Complications for 8 Years

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Introduction: A novel ELND (Epidurscopic Laser Neural Decompression) provides an alternative less-invasive technique for treating lumbar spine pathology. This study reports on the outcomes and complications of ELND. **Material and Methods:** Between October 2008 and September 2015, a total of 219 patients underwent ELND. Indication is central canal stenosis, lumbar disc herniation, chronic lower back pain, post lumbar surgery syndrome. They are no improvement in back pain or radiating pain despite several conservative treatments for a minimum period of 3 months, where the conservative treatment included medication, physical therapy, and injection treatment. Clinical outcomes were evaluated using the visual analog scale (VAS) at follow up days. For the post-procedure complication, we reviewed the medical records and called to the patients. **Results:** The mean age was 67.1 $\pm$ 7.8 years and mean follow-up period was 34 $\pm$ 3.1 months. Distribution of disease is spinal stenosis, 94 patients (64%), lumbar disc herniation, 31 patients (21%), post lumbar surgery syndrome, 21 (14%), chronic low back pain, 2 patients (1%). In VAS flow for every disease, lumbar disc herniation is more effective pain improvement than other disease. There is no permanent or chronic complication. **Conclusion:** In back pain or radiating pain for spine pathology, epiduroscopic laser neural decompression is effective non-surgical treatment. It is more effective for lumbar disc herniation.

A203: Spondylolisthesis in Elite Athletes; Case Series of Effective Rehabilitation with Return to Peak Performance

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Introduction: Sport specific funding has increased in the UK to £543 m and prevalence of spondylolisthesis in the athletic population is shown to be 13.9% compared with the general population at 6%. There is limited literature of athletes with healed pars fracture (with bone scan evidence) or spondylolysis and spondylolisthesis returning to sport effectively after either exercise or bracing and this is poorly documented as to type of rehabilitation involved.(1) There is no evidence regarding sports specific retraining for this group of patients. This series demonstrates that a highly individualised assessment is paramount in designing a bespoke physiotherapy programme in returning athletes with bilateral non-union radiologically evident fractures to full performance level and potentially could be utilised in prevention of the injury. **Materials and Methods:** Four patients who were elite athletes with GB rankings presented with low back pain which was experienced during their sporting activity preventing them from competing. They were aged 17-20 years and participated at National GB Level, in the following sports; triple jump, 100 m, 200 m and 400 m sprint, hurdles and pairs ice-skating. All had radiologic evidence of bilateral spondylolysis and or spondylolisthesis grade one. Outcome measures used were Oswestry Disability Score (ODI) and return to specific sport competition. Highly individualised assessment incorporating sport specific positions and requirements revealed techniques and positions which pre disposed the athlete to injury and perpetuated back pain. A specific rehabilitation programme to target these areas of insufficiency was devised and progressed according to their achievement and demands of the sport. This included neuromuscular control and patterning incorporating multi-planar work from static to dynamic, video feedback and analysis. **Results:** All the athletes returned to sport at their previous level or higher and none underwent surgery. The triple jumper received a sport scholarship to USA and achieved PB 15.19 m after a year out of competition, qualifying nationally but missing Olympic qualification. The sprinter returned to national university championships, the hurdler returned to competition the following season with 100 m hurdles and the ice skater returned to skate in ice dance competitively. ODI ranged from 20% pre-treatment to 2% post -treatment with all scores significantly improved. Average change in improvement was 16%. **Conclusion:** This series shows how an individualised assessment and highly specific rehabilitation programme can be effective in returning athletes with radiological evidence of spondylolisthesis pain free to their original sporting levels. Although the prevalence of spondylolisthesis is low within the general population, it is double that within the athletic population and the high physical demands can result in "devastating consequences" on their careers. A specific bespoke programme is effective in realistic high level return to sport. It also suggests that a highly individualised assessment of specific sports techniques applied at an earlier stage of an athlete's development may result in less injury and loss of competition form.

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A204: Opioid Use in Relation to Treatment Outcome in Patients with Low Back Pain: Data from a Prospective Randomized Controlled Trial

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Introduction: Long-term opioid treatment of low back pain (LBP) is one of the main drivers of opioid dependency and abuse. In the US, opioid medication causes more deaths than any other routine medical treatment of nonfatal conditions and opioid abuse has recently evolved into a national epidemic. It is somewhat surprising that evidence on the efficacy of opioids in the treatment of LBP is lacking. The largest meta-analysis of randomized controlled trials (RCT) comparing opioids to placebo in the treatment of LBP found no evidence for long-term superiority of opioids and only moderate quality evidence for short-term superiority (<3 months). To examine potential associations between opioid use and treatment outcome after conservative management (CM) or minimally invasive surgical management (MISM) of LBP, we conducted a secondary analysis of data from the ongoing randomized controlled *iFuse Implant System Minimally Invasive Arthrodesis* (iMIA) trial. **Material and Methods:** The iMIA trial is an ongoing international multicenter randomized controlled trial aiming to compare treatment outcome of LBP originating from the sacroiliac joint (SIJ) after CM versus MISM using percutaneous transarticular titanium implants. Outcome was measured using visual analogue scale (VAS), Oswestry disability index (ODI), EuroQuol score (EQ-5D-3 L) and the Zung depression scale. All medications were recorded and opioid use was quantified using the oral-morphine equivalent daily dose (oMEDD). Patients were included at 9 study centers between June 2013 and May 2015 and randomized either to CM (n = 49) or MISM (n = 52). **Results:** The prevalence of opioid use at baseline was 55.1% in the CM cohort compared to 55.8% in the MISM cohort ($P = .95$). At 6 months of follow-up, we found no association between opioid use and good treatment outcome (odds ratio (OR) 1.22, $P = .47$) and observed higher degrees of disability in patients with daily opioid use after MISM (ODI 44.0% (interquartile range 36.0-54.0)) than in patients without any opioid use after MISM (ODI 24.0% (8.0-34.0); $P < .01$). Opioid users without continuous daily opioid use showed a significant decrease in oMEDD over 6 months after MISM ($P = .04$) but not after CM ($P = .10$). In contrast, patients with continuous daily opioid use did not show such a decrease in oMEDD over time, neither after CM ($P = .06$) nor after MISM ($P = .30$). Opioid users were more likely to incur serious adverse events (SAE; OR 2.58, $P < .01$) and at 3 months of follow up, opioid users with SAE displayed significantly higher oMEDD (52.5 mg (20.9-71.9)) than opioid users without SAE (16.6 mg (0.0-40.0); $P < .01$). Patients with opioid use also displayed higher Zung depression scores, both after CM and MISM. Opioid use had no effect on the quality of life. **Conclusion:** Our results support the view that the efficacy of long-term opioid use in the treatment of LBP may be limited and that its side effects should be carefully discussed with the patient.

A205: Back Pain X Leg Pain: Impact of Quality of Life in Degenerative Lumbar Disease

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Introduction: In lumbar spine degenerative disorders, the clinical presentation may course with pain typically affecting the back or have distribution into the leg or both. Regardless the pain component, the severity of the symptoms is associated with some degree of disability. However, it is still not totally clear which component of pain, if axial back pain or leg distribution, has the highest impact over patient quality of life. The purpose of this study was to characterize which pain component, if leg or back pain, have the more negative influence on functional disability of patients in nonsurgical treatment for degenerative lumbar disorders. **Material and Methods:** This is a retrospective study including patients undergoing nonsurgical treatment for degenerative lumbar disorders between March and December of 2015 at a single institution. Patients with lower limb disability were excluded. A numerical rating scale (NRS) of leg and back pain were collected and the Quality of Life (QOL) evaluated by the Oswestry Disability Index (ODI) and the SRS-22 questionnaires. The patients were divided in two groups: NRS back pain > leg pain and NRS back pain ≥ leg pain and the QOL parameters were compared between the groups. The NRS leg and back pain was correlated with scores on the SRS-22 and ODI profiles as well. **Results:** The 179 patients studied include 134 women (74.9%) and 45 men (25.1%). Comparison based on the pain component revealed most significant SRS-22 pain in patients with back pain ≥ leg pain ($P = .034$) as well as a trend to worst SRS-22 total score ($P = .078$). Significant correlation was identified of both NRS leg and back pain with ODI and SRS-22 (pain, appearance, activity, mental and total) scores, but greater correlation was obtained with back pain. **Conclusion:** This study provides evidence that, in lumbar degenerative disease, back pain has the most significant impact on the self-reported patient

disability, compared with leg pain. Patients with higher NRS back pain have worst SRS-22 pain score than patients with higher NRS leg pain.

A206: Influence on Non-specific Back Pain and Postural Trunk Control by Whole-Body Vibration Therapy

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Introduction: Low back pain imposes a considerable social and economic burden as one of the most serious public health issues in the developed nations and is one of the most common reasons for presentation to primary health care providers, outpatient or A&E departments. Currently point prevalence of acute low back pain adds up to 40%, one year prevalence exeeds 70% and life time prevalence equates 80%. In Germany therapy costs add up to 50.000.000 Euro per year matching 12.2% of Germany's gross national product. While risk factors impose in male gender, age, unmarried martial status, and low education level. While the clinical guidelines of the national and international scientific associations provide recommendations regarding medication and physical therapy many questions remain unanswered regarding therapy methods and their value. **Material and Methods:** 100 patients were matched within 2 groups (chronic back pain vs healthy patients). Amongst the parameters collected were: Patients history, clinical exam, questionaires (NASS, Oswestry, VAS, SF 36) and the MFT S 3 check. The difference in proprioceptive performance within the groups were adressed upfront and at the end of a 18-weeks programm (3 level programm 6 weeks each) of active physical therapy or vibration therapy measuring the sensomotoric index, stability index and symmetry index sitting and standing. **Results:** No significant difference was found concerning postural stability (sensomotoric index, stability index and symmetry index sitting and standing) within the 2 groups (Mann-Whitney-U-Test) upfront. Though the patients with chronic back pain showed a tendency towards depression in the questionaires. At the end oft he 18 weeks programm patients within the physiotherapy group showed significant improvement of the sitting and standing sensomotoric and stability index while the improvement within the vibration therapy group wasn't significant. None of the therapies showed superiority respect of absolute differences. No significant differences were seen concerning HADS, ODI, NASS, SF-36. While consisting depression influences pain no other covariables showed influence in outcome and improvement. **Conclusion:** Wholebody-vibration might be an effective tool to support proprioception and postural stability, improve balance and strength as an alternative to physiotherapy.

A207: Treatment of Chronic Low Back Pain via Ablation of the Basivertebral Nerve: Results of a Multicenter, Randomized, Double Blinded, Sham Controlled Trial (SMART Trial)

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Introduction: The basivertebral nerve (BVN) is a sensory nerve within the vertebral body, whose role in pain transmission is thought to be a source of chronic low back pain associated with degenerative vertebral bodies and endplates. The safety and efficay of a novel intraosseous bipolar radiofrequency system (INTRACEPT™) for ablation of the BVN was evaluated in this trial. **Material and Methods:** 225 patients with chronic low back pain refractory to >6 months of conservative care were enrolled at 18 sites in the United States and Germany in this prospective, double blinded, randomized, sham controlled trial (147 active vs 78 sham arm). MRI had to demonstrate Type 1or 2 Modic changes at <3 contiguous vertebral bodies. Follow-up was at 2 and 6 weeks, 3, 6, and 12 months. Patients and physicians providing postoperative care were blinded to allocation until the conclusion of the one year follow-up. For Sham patients, there was an optional crossover component after all 12-month evaluations were performed. **Results:** Targeting success according to postoperative MRI was achieved in 96.4% of vertebral bodies or 129 of 145 patients treated (89.0%). Primary end point analysis in the per protocol population at 3 months showed that the ODI improvement in the active arm was superior to the sham arm ($P = .019$) with a mean improvement of 20.5 points Sham 15.2 points). This result was sustained through one year of follow-up. Furthermore, an analysis of ODI responder rates found that 75.6% of patients treated with BVN ablation (vs 55.2% of the Sham patients) demonstrated a greater than 10-point, clinically meaningful improvement in their low back pain and associated disability at 3 months. There were no adverse device effects and no device related serious adverse events. The rates of neurological events reported were low and comparable between treatment arms. MRI evaluations at the 6-week and 6-month follow-up time points found no evidence of any spinal cord abnormalities, avascular necrosis or accelerated disc degeneration. MRI evaluations at the 6-week and 6-month

follow-up time points found no evidence of any spinal cord abnormalities, avascular necrosis or accelerated disc degeneration. **Conclusion:** Ablation of the BVN using a bipolar RF System is safe and effective for the treatment of CLBP, since the analysis of the primary study end point showed a significantly greater improvement in ODI for the investigational arm over the Sham arm in the PP population. The surprisingly high response rate in the Sham population does not invalidate the conclusion, that BVN ablation may provide a new, minimally invasive, treatment option for a subset of patients with chronic low back pain.

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A208: Modern Luque Trolley: Self-Growing Rod Construct to Manage EOS While Maintaining Spontaneous Spinal Growth

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Introduction: The ultimate goal in the surgical management of early onset scoliosis (EOS) is to prevent curve progression while maintaining longitudinal spine growth. Although current surgical techniques (dual growing rods, VEPTR) may prevent curve progression, repetitive interventions are required to lengthen the implants. The Modern Luque Trolley technique has been described in which no repetitive surgery is required for spinal growth. The construct consists of the standard proximal and distal fixed anchors found in dual growing rod with additional gliding spinal anchors capturing the apex of the curve. The aim of this study was to further assess the safety and efficacy of this self-growing rod construct in patients with EOS. **Material and Methods:** In this retrospective study, we reviewed x-rays and clinical chart of fifteen patients (including the original five) who underwent this self-growing rod construct between 2003 and 2014. Spontaneous spinal growth was measured on anteroposterior x-rays (from T1-L5), and was compared to the expected spinal growth predicted by Demiglio methos. (A. Demiglio et al. 2012). Demographics, underlying diagnosis, follow-up length, correction and maintenance of deformity, number of procedures, and complications were all recorded. **Results:** The mean age at surgery was 8.8 years (95% CI: 7.4-10.2) and the average follow-up length was 4.2 years (95% CI: 3.3-5.1). The average cobb angle measurements were 64.39 degree pre-operatively (95% CI: 54.18 - 75.68) and 24.79 degree post-operatively (95% CI:18.88-30.69). The average spontaneous spine growth was 1.1 cm per year of follow-up (95%CI: 0.5 -1.8), while the average Cobb angle progression (recurrence) after surgery was 0.31 degrees per year (95% CI: 0.21-0.41). The cohort achieve 65.3% of their expected spinal height with a 95% CI of 50-80%. Six out of fifteen cases grew to the expected growth for their age, while two failed to self-grow and were converted to a non-self-growing construct. The cases that had poor growth had large initial deformities, and large post surgery deformities. We found a moderately inverse correlation between the post-operative Cobb angle and amount of spontaneous height gain (Pearson's R: −0.575, p 0.012). Three cases outgrew their construct requiring revision surgery to lengthen their rods. **Conclusion:** Self-growing rod construct is an option for managing EOS without the morbidity of repetitive surgery. Patient selection is critical to ensure good outcome. To optimize spontaneous spinal growth, apical vertebra must be brought to midline by achieving maximal Cobb correction. However, questions such as the effect of wear debris and the risk of spontaneous fusions still remain.

A209: Could Shilla Procedure Prevent Crankshaft Phenomenon?

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Introduction: Shilla technique is a surgical procedure described by R. McCarty that allows the control of the scoliotic deformity in young growing children. The main complication in these patients with early onset scoliosis, operated by classic posterior instrumentation, is the continuation of vertebral body growth and curve deterioration that was described as the crankshaft phenomenon. The Shilla technique, by inserting pedicle screws in the apex of the deformity should theoretically prevent this phenomenon. The purpose of this study is to evaluate the capability of Shilla technique in preventing the crankshaft phenomenon in the treatment of the severe scoliosis in young growing children. **Material and Methods:** 11 scoliotic children (3 M, 8F), Tanner 0, with a mean age of 9 years (4 to 11 years), and a mean preoperative Cobb coronal angle of 57° (thoracic curve 67°, lumbar curve 55°), were operated by Shilla procedure and were reviewed with a mean follow-up of 4 years (3 years to 6 years 4 months). Seven patients had their final fusion. The number of procedures, except for final arthrodesis, was one in 5 patients and two in 6 patients. **Results:** The growth continued in all children from 67 cm of sitting height on initial examination to 72.5 cm at final follow-up. The coronal angle was corrected form a mean of 57° to 34° at immediate post-op then increased to 50° at final follow-up. In 7 children, the initial post-op correction deteriorated in both, the "bridged curves" which are the non-fused non instrumented apex curves (54° → 40° in immediate post op → 55° on final follow-up) and in fused instrumented apex curves (67° → 35° in immediate post op → 51° on final follow-up). In the 4 remaining children, there was no deterioration of the curve on the last follow up. **Conclusion:** The loss of correction we observed is due to Crankshaft Phenomenon. Even though this was expected to happen in bridged curves, it also occurred in the apex fused-instrumented curves. The mean age of the

children who deteriorated (10 years 9 months), appears to be its main cause, since these patients were in their ongoing growth spurt. The children with controlled curves having a mean age of 7 years 8 months had not reached yet the growth spurt. In conclusion, the Shilla technique, even in apex fused instrumented curves, was not able to control the Crankshaft Phenomenon during this growth period. This should be taken in consideration for the timing of the final fusion.

A210: Phenotyping Chronic Pain in Adolescents with Idiopathic Scoliosis: Preliminary Results of a Cohort Study

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Introduction: The development of chronic pain is well recognized as an expensive and debilitating public health issue. In the clinical context, knowing which aberrant process is at play would help clinicians to better treat the offending process. Identification of endogenous excitatory and inhibitory mechanisms that are involved in chronic pain seems to be a good indicator of the treatments that will be effective for patients, enabling a more targeted and personalized approach to alleviate pain. We hypothesize that even if two patients present apparently similar clinical diagnosis (eg, scoliosis, chronic pain), the implicated neurophysiological mechanisms will differ and therefore patients will not respond to the same treatments. **Material and Methods:** Seventy adolescents with idiopathic scoliosis aged between 10-18 years old and reporting persistent back pain (>6 months) were enrolled in a preliminary study. Patients were asked to perform a quantitative sensory testing (QST) to measure changes in regulation of the neurophysiology underlying the nociceptive processes based on the patient's pain interpretation. A conditioned pain modulation (CPM) procedure with hot water as conditioning stimulus and contact heat as test stimulus was performed. Patients were also asked to complete the following questionnaires to assess the various dimensions of pain: Neuropathic Pain Questionnaire (DN4); Functional Disability Index (FDI); Pittsburgh Sleep Quality Index (PSQI); Revised Children Anxiety and Depression Scale (RCADS) and The Adolescent Pediatric Pain Tool (APPT) assessing the location, intensity and quality of pain. **Results:** Mean pain intensity was of 7 (range 3-10) on a scale 0-10. Frequency of pain was reported to be everyday in 47% of patients. Location of pain was predominantly in the middle back region (93%) and was of duration of more than a year in 73% of patients. CPM results revealed variability in efficacy to inhibit a pain response, with 42% of the cohort demonstrating a sub-optimal endogenous inhibitory response. Presence of a neuropathic component of pain was found in 22% of patients. Sleep quality was reported to be poor in 78% of patients, and moderate to severe functional disability was reported by 25% of patients. Medication for pain relief was taken on a regular basis in 43% of the cohort. **Conclusion:** These results support the need to improve our understanding of pain processing in AIS patients. Identified sensory, functional and emotional differences in patients' pain profiles will allow for personalized therapeutic approaches to improve patient-oriented clinical care.

A211: Radiological Analysis of Pedicle Subtraction Osteotomies in Children

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Introduction: Spinal cord-level osteotomies are increasingly used for posterior-only kyphosis correction in children. The segmental distribution of correction after pedicle subtraction osteotomies (PSO) in children remains unclear. This is the first study to outline the distribution of kyphosis correction after cord-level PSO in children and evaluates its implications on the neurological safety after osteotomy. **Material and Methods:** 15 patients with severe thoracic kyphosis with normal preoperative neurology undergoing PSO above L1 were included. Average age was 12.3 years (range 7 to 14). Relative sagittal angle correction at the osteotomy and at the adjacent segments, sagittal vertical axis (SVA) and angle of osteotomy was measured utilizing pre & post-operative standing AP & lateral radiographs and measurement software. **Results:** There were no post-operative neurological deficits. Mean pre-op kyphosis was 107.3 degrees (range 93-133) and mean post-op kyphosis was 53.7 degrees. Mean percentage correction of kyphosis was 45.7% (SD = 6.6). The proportion of sagittal plane correction contributed directly by the osteotomy was 49.3 degrees (range 42-55), whereas the adjacent segments cepahlad and caudad contributed a total of 45 degrees of the correction (Apex+1 = 4.5°, Apex+2 = 2.3°, Apex+3 = 1.3°, Apex+4 = 1° and Apex-1 = 5.5°, Apex-2 = 7.8°, Apex-3 = 8.5°, Apex-4 = 7.5°, Apex-5 = 6.8°). Mean relative shift in the SVA was 17.1 mm (pre-op 26.2 to post-op 9.1 mm). **Conclusion:** The results document the safety of cord level PSO for severe thoracic kyphosis in children when performed with wide laminectomy in neurologically intact patients. Vertebral segments above and below osteotomy contribute an additional and nearly equal amount of sagittal plane correction to that achieved by osteotomy. Pedicle subtraction osteotomies in children are effective in obtaining sagittal plane correction by focal correction at the level of the PSO and also at adjacent segments of the spine Surgeons can

take advantage of the flexibility of the pediatric spine in severe kyphotic deformity correction.

A212: Patient-Related Outcomes in Adolescent Spine Deformity Surgery: A Cohort Study Based on a Single Centre Spine Outcomes Registry

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Introduction: In an AOSpine knowledge forum deformity study concerning adolescent idiopathic scoliosis deformity surgery international consensus was reached to systematically monitor and registration of patient-related outcomes (ie, patient-reported outcome measures [PROMs] and clinician-based outcome measures).[1] Fusion surgery in adolescent deformity is commonly performed and aimed to prevent progression of the curvature and to improve clinical symptoms. Studies evaluating surgical outcomes are mainly based on radiographic measurement of the curvature.[2] Evaluation of outcome domains as functioning and health-related quality of life from the patients' perspective after surgery is recommended,[3] but often remain relatively underexposed. Standardization of patient-related outcomes and continuous outcome monitoring of outcome measures covering relevant domains from a patient's perspective, will play an important role in future reimbursement and in healthcare systems (ie, value-based healthcare).[4] The purpose of this study is to evaluate the one-year follow-up patient-related outcomes in consecutively enrolled patients undergoing adolescent spine deformity surgery measured with a standardized and continuous outcome measurements. **Material and Methods:** This is a single institution prospective consecutive enrolment cohort study. Since March 2014 all patients undergoing scoliosis surgery are systematically monitored over time and registered in an online web-system, which is connected to the patients' electronic file. Routinely, relevant patient characteristics, radiological, and peri-operative parameters are measured and reported. Patient-reported outcomes used: ODI (functional status), SRS22r and EQ5D (health-related quality of life). Preoperative and one-year follow-up data of patients aged $\leq$20 years, were studied. Improvement over time is evaluated with the Student's *t*-test. The clinical relevancy of patient-reported outcomes is determined by means of previously reported minimal clinical important changes (SRS)[5] and a satisfactory symptom state comparable to healthy persons (ODI).[6] Clinician-based outcome measures were post-operative complications and revision surgery. **Results:** 83 patients with adolescent deformities were included for analysis (age 15.1years [SD1.80], range 12-19; females [n = 68; 81.9%]): adolescent idiopathic scoliosis (n = 72), congenital scoliosis (n = 8), secondary scoliosis (n = 3). PROMs response rates: preoperatively 97.1% (134/138), at 1-jaar follow-up 60.1% (83/138). Pre-operatively, the non-responders did not differ from those who completed the PROMs. Patients improved significantly on ODI, EQ5D, SRS-pain, SRS-self-image, SRS-satisfaction, and SRS-total ($P < .05$). At the 1-year follow-up 76 (91.6%) reported to be satisfied with their back, which is comparable to the 'normal' healthy population (preoperatively n = 58 [69.9%]) and 65 patients were relevantly improved on SRS-self-image (78.3%). The number of registered complication was 7 (8.2%) and in 2 patients (2.4%) revision surgery was performed. **Conclusion:** After adolescent spine deformity surgery patients experience a relevant improvement in functioning health-related quality of life, self-image and satisfaction. The number of registered complications and performed revision surgeries are relatively low. The one-year response to the questionnaires is acceptable, a higher response is recommended to use the results for future studies and to use the as reliable and valuable information for quality control. As scoliosis is surgery is regarded as high complex care, insight in results continuous and standardized outcome monitoring is important to improve outcomes and with that the quality of spine care, which is the basis for value-based spine care.

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A213: Vertebral Modulation through Posterior Tethering Technique for Correction of Early Onset Scoliosis

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Introduction: The aim of this study is to address the progressive modulation of the most wedged vertebra by evaluating the role of the non-fusion instrumented procedure with posterior tethering as adjunct to lengthening by distraction in facilitating spinal modulation of the wedged peak vertebra, in patients with congenital thoracolumbar kyphosis/kyphoscoliosis according to the Hueter-Volkmann law. The authors seek to address the progressive modulation of the most wedged vertebra by analyzing the subjects' pre-operative and latest follow-up sagittal radiograph. **Material and Methods:** Ongoing data collection of 14 peak wedged vertebra modulation during surgical management of 13 patients with Type I congenital thoracolumbar kyphosis (5 patients) or kyphoscoliosis (8 patients). Analyzing the subjects' pre-operative and latest follow-up sagittal radiograph was done .Age at initial surgery averaged 58.6 months, with mean follow-up of 55.6 months (24-78). All were done with Hybrid Rib Construct with clawing fashion through a single posterior approach with at least 4 lengthenings. **Results:** Two vertebral bodies were selected, the peaked deformed vertebrae within the instrumentation compression level (WICL) and the vertebrae nearest but outside the instrumentation compression process (OICL). Anterior vertebral body height (AVBH) and posterior vertebral body height (PVBH)were measured in both vertebral bodies. Regarding measured vertebrae (WICL) average preoperative anterior/posterior vertebral body height ratio significantly increased from 0.54 to 0.77 in the final follow-up. Regarding measured vertebrae (OICL), the average preoperative AVBH/PVBH ratio increased from 0.76 to 0.79 in the final follow up. Modulation can be confirmed in the most deformed vertebrae (WICL) as the difference between the change in AVBH/PVBH ratio between vertebrae (OICL) and (WICL) was statistically significant ($P < .001$). **Conclusion:** Through the compression model adjunct to lengthening through distraction implemented in the surgical management of Early Onset Scoliosis, wedging improves through vertebral modulation (WICL) in comparison with the (OICL). This calls for further studies on the impact of surgical correction of EOS on modulation of the vertebrae.

A214: Radiographic and Biomechanical Study on Co-Cr Rod in Adolescent Idiopathic Scoliosis Surgery

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Introduction: Correction maneuvers employed in spine deformity surgeries require the application of high forces and torques, and may induce plastic strains in the posterior instrumentation. Aim of the study was to quantify the plastic strains, which arise during the surgical correction of spinal deformity and estimate Co-Cr rod deformation in surgical treatment of patients affected by adolescent idiopathic scoliosis (AIS) and its possible correlation with different risk factors. **Material and Methods:** From March 2011 to December 2015 150 patients affected by AIS underwent posterior instrumented fusion. Two 5.5 mm Co-Cr rod were implanted in all patients. Cobb angle value, sagittal balance, rod curvature angle (RC) were evaluated. RC changes were registered and correlated to each factor in order to establish a possible statistically significance in a multivariate analysis. A four point bending tests was experimentally conducted on cobalt-chrome rods in order to quantify their fatigue life. A finite elements analysis (FEM) was conducted in order to establish the percentage of Co-Cr rod deformation after prebending and intraoperative correction maneuvers. **Results:** Radiographic analysis showed a different mean rod deformation for concave and convex side; 7.8° and 3.9° respectively. At 1 year minimum follow-up RC value increases of 1.5° only for the concave side. At 3,5 years mean follow-up RC value increases of 2,7° for the concave side and 1,3° for the convex, $p > 0,05$. FEM showed as prebending influences rod biomechanical properties and its resistance to fatigue. In situ compression and distraction manoeuvres seems to affect more than prebending the biomechanical properties of Co-Cr rod. Comparisons with the experimental tests showed that plastic strains are compatible with a reduced fatigue life of the rods, and thus with an increased risk of early mechanical failure. **Conclusion:** The use of prebent rods and adequate manufacturing techniques may improve the endurance of spinal instrumentation. Not only rod biomechanical properties but also BMI, age, Risser grade, type of instrumentation, surgical release play an important role in deformity correction and its maintenance over time.

A215: Corrosion of the Internal Mechanism of Magnetically Controlled Growth Rods Explains the Mechanism of Failure

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Introduction: Magnetically Controlled Growth Rods (MCGRs) received their EU approval in 2009 and FDA approval in 2014 to be used in the treatment of severe cases of early onset scoliosis (EOS). Main advantage of the design is the non-invasive lengthening of the rods in Outpatients Clinic using an external remote controller, thus reducing the number of surgeries and decreasing the chances of infection. However, there have been reports documenting failure of distraction and severe patient reactions, alerting the surgical community about the use of this device and the best monitoring of patients. **Material and Methods:** This is the first retrieval study

involving 17 MCGRs, of the same manufacturer, from 10 patients, revised for metal staining of the skin, progression of scoliosis, swelling, failure of distraction and final fusion. We also collected imaging data for each patient, while all patients and their guardians consented for these implants to be used for this study. First we macroscopically and microscopically inspected the implants, documenting the patterns on the telescopic part of the rods using DSLR photography and optical microscopy, respectively. All implants were radiographed to determine the state of the internal mechanism, while two of them were scanned using a micro-CT prior to sectioning. Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDX) were performed to identify the surface changes and the elemental composition of debris in the internal mechanism and the telescopic part of the rod. **Results:** Plain radiographs revealed that 6 out of the 17 MCGRs had a fractured pin in the internal mechanism, while all of them showed signs of surface degradation on the telescopic part of the rod. Surface degradation is linked to the relative movement between the actuator and the telescopic part of the MCGR. The rods with intact pin shared the same pattern of surface degradation, described as distinct lines, parallel to the direction of lengthening, the number of which was indicative of the number of the lengthening procedures. The rods with the fractured pin had increased surface degradation in a continuous and more sever pattern. In all cases, we found fretting and pitting on the damaged area of the telescopic part, using optical microscope and SEM. Sectioning of one rod with intact pin and one rod with fractured pin revealed black debris build up on both rods. EDX indicated that the debris were products of corrosion, while further analysis of the parts of the internal mechanism suggested that parts were considerably corroded as well. **Conclusion:** We identified a mechanism of pin fracture in MCGRs which may be due to corrosion of the internal mechanism. We recommend surgeons to monitor patients with this implant more closely, especially in cases of loss of distraction ability that could indicate debris build inside the mechanism, preventing normal function.

A216: The Importance of Selective Thoracic Fusion in Thoracic Adolescent Idiopathic Scoliosis

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Introduction: Determination of distal fusion levels and direction of rod derotation (RD) and direct vertebral rotation (DVR) are very important factors for deformity correction and preservation of motion segments in the treatment of adolescent idiopathic scoliosis (AIS). This study is to validate the importance of distal fusion level in the treatment of thoracic AIS using RD and DVR following selective thoracic fusion (STF) with pedicle screw instrumentation (PSI). **Materials and Methods:** Sixty-five patients with thoracic AIS treated by segmental selective thoracic fusion from neutral vertebra (NV) to NV or NV-1 with RD and DVR with a minimum 10-year follow-up were retrospectively analyzed. An adding-on or a lowest instrumented vertebra (LIV) tilt of more than 10° or coronal balance of more than 15 mm were considered unsatisfactory results. **Results:** The mean Cobb angle of the main thoracic curve was 55.8° before surgery, 16.0° after surgery, and 19° at last follow-up. In the compensatory cranial curve, the preoperative Cobb angle of 27.9° was corrected to 15.2° postoperatively and was 14.9° at last follow-up. In the compensatory caudal curve, the preoperative Cobb angle of 34.9° improved to 11.3° postoperatively and 11.1° at last follow-up. There were 13 cases of unsatisfactory results (10 cases of AD and 3 cases of CB progression) which showed relatively short fusion between distal fusion level and NV and insufficient DVR compared to satisfactory results. **Conclusions:** Selective thoracic fusion with proper distal fusion level using RD and DVR for thoracic AIS could achieve satisfactory deformity correction as well as compensatory lumbar curve that is maintained at a long-term follow-up. Therefore, distal fusion level which should be extended to NV or NV-1 and sufficient DVR which should be opposite to that of the vertebral rotation were inevitable to achieve satisfactory deformity correction and prevent a distal adding-on phenomenon in the treatment of thoracic AIS.

Cervical Myelopathy Imaging

A217: Multi-Parametric Microstructural Spinal Cord MRI Applied to Degenerative Cervical Myelopathy

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Introduction: Diffusion tensor imaging (DTI), magnetization transfer (MT), and spinal cord (SC) cross-sectional area (CSA) are established measures of microstructural changes and tissue injury, including axonal loss, demyelination, and atrophy. T2*-weighted imaging (T2*w) has previously shown white matter (WM) hyperintensity in focal lesions and disseminated disease,

and we introduce WM/grey matter (GM) signal intensity ratio (T2*-WM/GM) as a novel measure of tissue injury. This study in patients with degenerative cervical myelopathy (DCM) assesses how well CSA, FA, MTR, and T2*-WM/GM, extracted at the maximally compressed level (MCL) and in regions rostral (C1-C3) and caudal (C6-C7) to SC compression, quantify WM injury. **Material and Methods:** 56 DCM patients (age 56.7; 61% male; 32 mild, 14 moderate, 10 severe) underwent comprehensive clinical assessments and DTI, MT, and T2*w (3 T, 13 axial slices, C1-C7). Images were semi-automatically analyzed with Spinal Cord Toolbox (SCT). Metrics extracted at MCL were converted to T-statistics to facilitate group analysis across different rostro-caudal levels. Group comparisons with healthy subjects used T tests, and univariate relationships were analyzed with Spearman correlations. Metrics from total WM were analyzed against global disability, measured using modified Japanese Orthopedic Association (mJOA) score, while metrics from lateral corticospinal tract (LCST) and fasciculus cuneatus (FCun) were analyzed against ipsilateral upper extremity (UE) power (10 myotomes) and UE sensation, respectively. Backwards stepwise linear regression (predicting mJOA) and logistic regression (diagnostic tool) were used for multivariate analysis with age, sex, height, weight, and neck length included as covariates. **Results:** T2*-WM/GM showed robust group differences at all cord levels (rostral: $p = 5 \times 10^{-7}$, MCL: $p = 3 \times 10^{-9}$, caudal: $p = 4 \times 10^{-4}$), outperforming FA (rostral: $p = 0.001$, MCL: $p = 2 \times 10^{-5}$, caudal: $p = 0.01$) and MTR (rostral: $p = 0.02$, MCL: $p = 0.006$, caudal: $p = 0.98$). T2*-WM/GM also provided stronger correlation with mJOA (rostral: $r = -0.62$, MCL: $r = -0.63$) than FA (rostral: $r = 0.39$, MCL: $r = 0.53$) and MTR (rostral: $r = 0.28$, MCL: $r = 0.38$). Rostral T2*-WM/GM predicted ipsilateral weakness ($r = 0.65$) and sensory deficit ($r = 0.71$) better than FA ($r = 0.57$, 0.61, respectively) and MTR ($r = 0.27$, 0.39, respectively). Linear regression generated a final model that accurately correlated with mJOA ($R^2 = 0.53$, $p = 9 \times 10^{-13}$), retaining only 2 variables: CSA_{MCL} ($p = 1 \times 10^{-7}$) and T2*-WM/GM_{MCL} ($p = 0.001$). A logistic regression diagnostic model was developed that showed excellent discrimination between healthy and DCM subjects (area under curve = 0.965), retaining 5 variables: MCL CSA ($p = 0.01$), MCL T2* WM/GM ($p = 0.01$), rostral FA ($p = 0.17$), caudal T2* WM/GM ($p = 0.17$), and rostral CSA ($p = 0.20$). **Conclusion:** Our multiparametric approach accurately characterize SC tissue injury, correlating well with global functional impairment (mJOA) and focal neurological deficits, while providing a highly accurate diagnostic tool. T2*-WM/GM ratio shows better correlation with global and focal impairment than FA and MTR. The rostral cord provides unbiased assessment, free of anatomical and magnetic distortions, and shows strong correlations with clinical measures similar to MCL. These methods have potential to provide improved diagnostics, monitoring of disease progression, and prediction of outcomes in DCM and other spinal pathologies.

A218: Quantitative Multiparametric Spinal Cord MRI Detects Subclinical Tissue Injury in Asymptomatic Cervical Spinal Cord Compression

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Introduction: Degenerative cervical myelopathy (DCM) is a condition in which extrinsic compression of the spinal cord (SC) occurs due to degenerative changes, causing neurological symptoms and signs of spinal cord dysfunction. These degenerative changes have also been observed in 6-25% of the asymptomatic population, with increasing prevalence in older individuals. We previously demonstrated that quantitative MRI measures of microstructure and atrophy accurately quantify SC tissue injury in DCM, but it is unknown if asymptomatic patients with cord compression also experience similar changes. **Material and Methods:** 2 subjects without neurological symptoms/signs underwent 3 T MRI including T2-weighted (T2w), diffusion tensor imaging (DTI), magnetization transfer (MT), and T2*-weighted (T2*w) imaging covering C1-C7. Subjects were divided into groups with and without cord compression (defined as indentation, flattening, or focal torsion). SC cross-sectional area (CSA), fractional anisotropy (FA), MT ratio (MTR), and T2*w white matter to grey matter signal intensity ratio (T2*w WM/GM) were calculated at the maximally compressed level (MCL) and uncompressed rostral (C1-C3) and caudal (C6-7) levels and normalized for confounding variables (including age). One-tailed T tests assessed if cord compression subjects exhibited the same differences as DCM subjects ($N = 56$) in 10 metrics, diagnostic accuracy was assessed with area under receiver operating characteristic curves (AUC), and a binomial test assessed if the same directionality pattern was present. **Results:** The cord compression group ($N = 12$, 38%) was older than the uncompressed group (53.9 vs. 38.9, $p = 0.004$) and showed decreased rostral MTR (50.8 vs. 53.5, $p = 0.005$, AUC = 0.765), decreased MCL MTR (T statistics: −0.255 vs. 0.254, $p = 0.05$, AUC = 0.604), and increased rostral T2*w WM/GM (0.875 vs. 0.857, $p = 0.05$, AUC = 0.675). The other 7 metrics did not show significant differences between groups. However, 8/10 measures showed the same directionality of changes in the cord compression group as previously seen in DCM subjects ($p = 0.05$). **Conclusion:** Asymptomatic individuals with spinal cord compression show a pattern of macro- and microstructural changes similar to DCM subjects, suggesting that this group experiences subclinical tissue injury. While these results require further validation, they offer the intriguing possibility that detection of SC tissue injury may be possible in the pre-myelopathic state, once quantitative spinal cord MRI

techniques mature sufficiently. These findings have far-reaching implications for all spinal pathologies, including the potential to allow for the diagnosis of myelopathy prior to the onset of tangible neurological symptoms and signs.

A219: Dynamic Compression of Cervical Spinal Cord in Symptomatic Patients: A Study With The Help of Kinetic MRI

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Introduction: Discrepancies between clinical symptoms and signs of spinal cord compression on static MRI are not uncommon when evaluating cervical spine myelopathy (CSM) patients. However, with the application of kinetic MRI (kMRI), dynamic compression of the cord becomes a new concept to be widely accepted. **Material and Methods:** Symptomatic CSM patients were selected to have static and dynamic MRI of the cervical spine. Space available for cord (SAC) were measured in T2 weighted sagittal plane at each disc level of the lower cervical (from C2-3 to C7-T1), in three different positions: full flexion, neutral and full extension. The difference of the mean SAC in different positions is analyzed by Mann Whitney U test. $P < .05$ is considered as statistically significant. **Results:** There were 32 patients (20 male and 12 female). The mean age of the group was 42. The most affected levels were C5-6 (100%), C4-5 (75%) and C6-7 (63%). The mean SAC in full flexion, neutral and full extension position were 10.54, 9.38 and 8.28 mm respectively, and they differ to each other with statistic significance ($P < .05$). In all cases, the bulge of the disc and ligamenum flavum was most pronounced in extension position, and became attenuated in flexion position. Interestingly, new compression sites revealed in full extension MRI (hidden hypertrophic ligamentum flavum) were noted in 7 cases (21%). **Conclusion:** Kinetic MRI is useful for evaluating dynamic compression of the spinal cord. Decision making of treatment as well as preventing adjacent segment syndrome should be based on the status of the disc and ligamentum flavum, not only in static images but also in the permanent dynamic process of the cervical spine.

A220: Impact of Pre-operative Flexion and Extension MRI on Decision-Making for Cervical Spondylotic Myelopathy

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Introduction: Cervical spondylotic myelopathy (CSM) is related to static and dynamic narrowing of the cervical canal. The decrease in diameter of the vertebral canal secondary to disc degeneration and osteophytic production compresses the spinal cord at one or several levels, producing direct damage or secondary ischemic changes. Magnetic resonance imaging (MRI) is the best imaging method to evaluate CSM due to cord compromise by the spinal canal. To date, preoperative CSM evaluation is based on MRI performed in the neutral position. However, some patients presented with CSM and their MRI may even showed intramedullary signal intensity changes but without significant evidence of cord impingement or even obliteration of the subarachnoid spaces that surrounded the cord. **Materials and Methods:** The objectives of this study were to evaluate the impact of preoperative flexion-extension MRI on decision-making for patients with CSM. Forty patients with CSM were prospectively enrolled. Patients with other causes of myelopathy were excluded. MRI scanning was performed at the maximum active neck flexion and extension the patient could easily achieve. These positions were maintained using custom-built positioning sponges alternatively under the head and shoulders. The authors determined cervical cord sagittal diameter, number of stenotic levels, and severity of cord impingement in flexion, extension, and the neutral positions. **Results:** MRI demonstrated functional cord impingement (grade 3 of Mühle) in 10% patients in flexion, in 37% in the neutral position, and in 72% in extension. Dynamic MRI, extension position in particular, is a very useful tool to evaluate the true number of levels involved and the degree of narrowing of the cervical canal. Folding of the ligamenta flava explained the increasing of number of spinal cord impingements that were observed. **Conclusions**: The use of flexion-extension MRI is more precise exploration tool of the spinal cord in CSM. New information provided by flexion-extension MRI dramatically changed our surgical strategy for CSM management.

A221: Comparison of Pre-Operation Diffusion Tensor Imaging versus T2 Signal Intensity in a Large Series of Cervical Spondylotic Myelopathy Patients for Assessment of Disease Severity and Prognostication of Recovery

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Introduction: Cervical spondylotic myelopathy (CSM) is a common cause of spinal cord dysfunction. T2 signal intensity (T2SI) on magnetic resonance imaging (MRI) is used to assess the clinical severity of patients and post-operative outcome. Recently, diffusion tensor imaging (DTI) which detects microstructural abnormalities beyond the resolution of conventional MRI has been used for assessment of patients with CSM. While both DTI and T2SI have been evaluated as possible biomarkers

for CSM, there has not been any study to our knowledge to compare DTI to T2SI to assess disease severity biomarker for recovery. **Material and Methods:** A retrospective analysis of 44 patients with preoperative DTI was done. Presence or absence of T2SI at the level of maximum compression (LMC) was determined. Normalized T2SI regardless of presence or absence of T2SI at (LMC) was determined by calculating T2SI at LMC/T2SI at level of foramen magnum. LMC Normalized T2SI, +/− T2SI, and FA were obtained and correlated to preop mJOA and ΔmJOA at 3, 6, 12, 24 months. Regression analysis and independent t-tests were used for analysis of the data. **Results:** There was a significant correlation between preop mJOA and LMC FA ($P = .048$). There was no significant correlation between LMC normalized T2SI and preop mJOA ($P = .47$). There was no significant difference in the preop mJOA score for patients with +T2SI versus -T2SI ($P = .524$). There was an inverse relationship of both LMC FA and LMC normalized T2SI with ΔmJOA at 3 months, R2 = 0.053/$P = .133$ and R2 = 0.28/$P = .243$ respectively. No significant difference was found between the ΔmJOA at 3 months of +T2SI and −T2SI groups ($P = .729$). At 6 months, there was an inverse relationship with ΔmJOA and LMC FA (R2 = 0.068, $P = .087$). There was an inverse correlation as well between LMC normalized T2SI and ΔmJOA at 6 months (R2 = 0.43, $P = .159$). Comparison of ΔmJOA at 6 months of -T2SI group to +T2SI group did not show any significant difference ($P = .678$). At 12 months, there was a significant inverse correlation with FA and ΔmJOA at 12 months (R2 = 0.24, $P = .003$). However, the P value was 0.227 (R2 = 0.05) for LMC normalized T2SI and ΔmJOA at 12 months. No significant difference was noted for of ΔmJOA at 12 months of -T2SI group to +T2SI ($P = .527$). There was non-significant inverse correlation for both LMC FA and LMC normalized T2SI with ΔmJOA at 24 months, R2 = 0.1/$P = .095$ and R2 = 0.015/$P = .568$ respectively. There was no significant difference in the ΔmJOA at 24 months for patients with +T2SI versus −T2SI ($P = .557$). **Conclusion:** In this larger retrospective study of CSM patients, FA at LMC shows to be a better biomarker for determining the disease severity, and both short and long term outcomes compared to T2SI at LMC. Further studies are needed with larger cohorts to assess whether use of both FA and T2SI in combination would add to FA alone.

A222: MRI Analysis of the Combined AOSpine North America and International Studies: The Prevalence and Spectrum of Pathologies in a Global Cohort of Patients with Degenerative Cervical Myelopathy

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Introduction: Degenerative Cervical Myelopathy (DCM) encompasses a spectrum of age-related conditions of the cervical spine, including spondylosis, which result in progressive spinal cord injury through static and dynamic injury mechanisms. Unfortunately, little is known of the prevalence and constellation of anatomical pathology that presents in these patients and if there are differences between genders. Through detailed review of MRIs from prospective AOSpine multicenter studies, it is the purpose of the present research to report on the global prevalence of degenerative cervical pathologies of surgically treated DCM patients. Such information would be potentially helpful in uncovering etiological factors, provide insight into the natural history, and determine risk factors for DCM. **Material and Methods:** MRIs of 458 patients were reviewed for the type of pathology, source of stenosis, level of maximum cord compression, levels of spinal cord compression (SCC), and signal changes on T2WI and T1WI. Additionally, a spinal cord occupying ratio (SCOR) within the canal at non-compressed sites was calculated and a SCOR $\geq$70% was used to identify congenital stenosis. The prevalence of these changes was separated into genders and the proportions were assessed using Chi-square analysis. A P value of $\leq$.05 was considered as statistically significant. Additionally, the proportion of degenerative changes present alongside other diagnoses was computed as well as the prevalence of pathologies per geographical region.**Results:** Globally, spondylosis was the most frequent cause of SCC (89.7%) and was frequently accompanied by enlargement of the ligamentum flavum (LF) (59.8%), Figure 1. OPLL was accompanied by spondylosis in 91.7%. Single level disc pathology, OPLL and spondylolisthesis had a prevalence of $\sim$10%. Associated abnormalities such as vertebrae fusion and congenital stenosis were observed in 2.8% and 8.4%, respectively. Single level disc pathology was less common in North America, congenital stenosis less common in Europe, and OPLL more common and spondylolisthesis less common in Asia-Pacific. Females presented more commonly with single level disc pathology ($P = .013$) and were less likely to have their maximum site of cord compression at C3-4 ($P = .007$). Males more commonly presented with spondylosis ($P = .017$) and enlargement of LF ($P = .012$). Globally, the C5-6 region was the most frequent maximum compressed site (39.7%) and region for T2WI hyperintensity (38.9%). T2WI hyperintensity more commonly presented in males ($P < .001$). **Conclusion:** DCM presents as a constellation of pathologies that most commonly includes multilevel disc and bone pathologies, as well as enlargement of the LF. These findings support that pathological features, including OPLL, are highly interrelated with one another and rarely present in isolation. There appears to be a number of differences in the frequency and constellation of pathologies between genders. Overall, females presented with milder degenerative changes and correspondingly a lower frequency of T2WI hyperintensity of the spinal cord on MRI. There are also variances in the spectrum and prevalence of pathologies between geographical regions and these may be due to a multitude of causes that likely span beyond ethnic factors.

A223: Kinematic MRI in the Identification of Occult Cervical Spine Pathology

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Introduction: Magnetic Resonance Imaging (MRI) is the imaging technique that provides the greater amount of information about the cervical spine, as it constitutes the most sensitive technique to show soft tissues and, at the same time, delineate bone structures with great accuracy. Kinematic MRI (k-MRI) adds to these advantages the possibility of studying the cervical spine with motion, as spine disorders are dependent on the patient's posture. This way k-MRI allows imaging in flexion/extension and with lateral movements, which allows the identification of otherwise occult pathology, mainly instabilities caused by positional changes, as well as the understanding of atypical symptomatology that might misguide a correct diagnosis. **Material and Methods:** Three clinical cases which have performed kMRI in the Department of Imaging of Centro Hospitalar de Vila Nova de Gaia/Espinho were selected in order to illustrate the benefits of this technique not only in diagnosis, but also in therapeutical decision guidance. kMRI has been added to the ordinary cervical spine MRI protocol and has been adapted to each patient, including T2 TSE sequences or volumetric T2 SPACE in the sagittal plane in neutral, flexion and extension positions and/or with lateral movements. **Results:** Case 1: Seventy-two-year-old female with complaints of neck pain and paresthesia in the territory of the median nerve. Clinically she showed a positive Hoffman test. Due to the suspicion of a cervical myelopathy, a cervical kMRI was obtained, showing a C3-C4 anterolisthesis which aggravated with flexion, a C4-C5 retrolisthesis and an increased conflict at C3-C4 due to the prominence of the hypertrophic yellow ligaments. The patient has been proposed for a C4-C5 corpectomy and anterior arthrodesis. Case 2: Thirty-three-year-old female with pseudoxanthoma elasticum, diagnosed with eye and skin examinations, previously proposed for bilateral carpal syndrome surgery, with complaints of upper limb paresthesia and night pain, upper limb edema and asthenia. A kMRI was obtained, showing inversion of the lordosis with flexion, centered in C4/C5. Additionally, discal protusions in C4-C5 and C5-C6 have been described, showing no variation with the dynamic study. The patient was then treated with glucocorticoids with clinical success. Case 3: Fifty-one-year-old male submitted to C1-C2 fixation due to cervical myelopathy. Two years after the surgery the patient kept complaints of severe neck pain, upper limb paresthesia and tetraparesis. A kMRI was obtained and confirmed the suspected instability of the complex dens-anterior arch of C1. The patient was then re-operated with significant muscular strength improvement. It must be noted that imaging quality is slightly undermined by addiction of dynamic studies. Nevertheless, this does not compromise the interpretation of the acquired images and adds the possibility of understanding cervical spine changes with movement. **Conclusions:** In conclusion, K-MRI adds the benefits of MRI to those of a dynamic study, allowing the diagnosis of otherwise unidentifiable situations, gaining a more and more important role in cervical spine pathology characterization. It is actually a valuable tool in the identification of otherwise unrecognized instabilities and, as already described in literature, increases the surgical indication rate in patients with varied pathologies.

A224: Morphological Characteristics of Diffuse Idiopathic Skeletal Hyperostosis in the Cervical Spine on Computed Tomography Images

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Introduction: Diffuse idiopathic skeletal hyperostosis (DISH) is characterized by anterior ossification of the spine with or without peripheral ossifying entheses. In the cervical area, the presence of DISH can lead to dysphagia and airway obstruction. The configuration of the hyperostosis in the cervical spine is markedly different compared with the thoracic or lumbar spine. The reason for this dissimilarity could be the difference in vascular anatomy between the neck and chest/abdominal region since vascular structures may act as a natural barrier against DISH. The aim of this study was to evaluate the relation between the location of the main arterial vessels and the location of the hyperostosis in DISH of the cervical spine. Furthermore, the relation between the cervical hyperostosis and dysphagia was examined. **Material and Methods:** Five patients with complaints of dysphagia (1 female, 4 males; 65-79 years old) were scanned by CT and diagnosed with DISH according to the Resnick criteria. For comparison, ten control CT scans were collected from patients that were scanned at the emergency department to exclude cerebral vascular injuries (4 females, 6 males; 57-90 years old). At nine levels (3 levels

per vertebral body, levels C4, C5 and C6) the locations of the vertebral and carotid arteries were assessed and the surface area of the hyperostosis was measured. A mid-sagittal line and two parallel lateral lines, which intersected the lateral borders of the spinal canal, were used for location determination. The distance between the center of the vertebral body and the trachea and esophagus was measured in C5 just above the endplate on the mid-sagittal line to determine if the trachea and/or esophagus were displaced by the hyperostosis. **Results:** At all levels the vertebral and carotid arteries were located lateral of the two parallel lateral lines. The area between the two parallel lines contained significantly more hyperostosis compared to the area outside these lines. The size of the bone surface area left of the mid-sagittal line was equivalent to the right surface area and the hyperostosis was thus symmetrically arranged. The ossification was not flowing but more solid in the sagittal view due to the lack of segmental vessels. The distance between the center of the vertebral body and the trachea/esophagus was statistically larger in the DISH group compared to the controls. **Conclusion:** The new bone in DISH at the cervical level was symmetrically formed ventrally of the vertebral body largely within the two parallel lateral lines, most likely defined by the major arteries that were located lateral of the parallel lines. New bone formation in the cervical spine resulted in ventral displacement of the trachea and esophagus which could explain the development of dysphagia and airway obstruction. In conclusion, the outcomes of this study are consistent with the concept of vascular structures being a natural border for the hyperostosis in DISH.

A225: High Resolution Diffusion Tensor Imaging in Cervical Spondylotic Myelopathy: A Preliminary Follow-up Study

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Introduction: Diffusion imaging is a promising technique as it can provide microstructural tissue information and thus potentially show viable change in spinal cords. However, it is limited by various image artifacts. In order to determine an accurate assessment method, instead of using traditional single-shot imaging method, we used newly developed multi-shot high resolution diffusion tensor imaging (DTI) to investigate diffusion metric changes and compare with T2 weighted images before and after decompressive surgery for cervical spondylotic myelopathy (CSM) patients. **Methods:** T2 W imaging, single-shot DTI, and multi-shot DTI were employed to scan 7 CSM patients before decompressive surgery and 3 months after the surgery. High signal intensity (HSI) was scored in the T2 W images. DTI metrics including fractional anisotropy (FA), axial diffusivity (AD), radial diffusivity (RD) and mean diffusivity (MD) were quantified and compared pre- and post-surgery. In addition, the relationship between imaging metrics and neurologic assessments was examined. **Results:** The mean grade of cervical canal stenosis recovered to normal from grade 3 three months after the surgery. Compared with low resolution DTI, high resolution DTI provided better images with lower artifact levels, especially following the surgery, due to reduced artifacts from metal implants. Both FA and RD values showed significant differences post-surgery (FA: $P = .026$, RD: $P = .048$). Their changes correlated strongly with neurologic assessments. In contrast, T2 W images did not show significant changes before and after the surgery. **Conclusion:** Multi-shot diffusion imaging showed improve image quality than single shot DWI, and presented superior performance in diagnosis and recovery monitoring for CSM patients than T2 W imaging. DTI metrics can reflect the pathologic conditions of spondylotic spinal cord quantitatively, and might serve as a sensitive biomarker for potential CSM management.

Thoracolumbar Trauma

A226: Efficacy and Safety of Riluzole in Acute Spinal Cord Injury (SCI): Rationale and Design of AOSpine Phase III Multi-center Double Blinded Randomized Controlled Trial (RISCIS)

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Introduction: There is convincing evidence from the preclinical realm that the pharmacologic agent riluzole attenuates certain aspects of the secondary injury cascade leading to diminished neurological tissue destruction in animal SCI models. The safety and pharmacokinetic profile of riluzole have been studied in a multicenter pilot study in 36 patients. Efficacy of riluzole in acute human SCI has not been established. **Material and Methods:** This ongoing multi-center, international double-blinded phase III RCT will enroll 351 patients with acute C4—C8 SCI and ASIA Impairment Grade A, B or C randomized 1:1 to riluzole and placebo. Primary outcome is the change in ASIA Motor Score (AMS) between baseline and 180 days. Other outcomes include ASIA Upper and Lower Extremity MS; ASIA Sensory Score; ASIA grade; SCIM); SF-36v2; EQ-5D and GRASSP. Two-stage sequential adaptive trial statistical design has 90% power to detect 9 points difference in the ASIA Motor Score at one-sided alpha = .025. **Results:** A matched cohort analysis performed in the Phase I study showed that riluzole treated cervical SCI patients experienced an additional 15.5 points in AMS recovery at 90 days post injury. Although the phase I study was underpowered to investigate efficacy the current phase III study is poised to definitive address this question. Subject enrollment for this trial began on October 1, 2013. To date, 57 subjects have been enrolled. Average age of the enrolled subjects is 49.7

(SD 16.3); 78% males. ASIA at arrival and Pre-Injury status, ASIA Grade A (50%), B (26%), C (24%). GRASSP 67.1 (SD 62.0), SF35v2 PCS 53.1 (SD 9.2) SF36v2 MCS 54.8 (SD 11.2). **Conclusion:** This is a Phase III study of riluzole in acute SCI.

A227: Natural History, Mortality, Complications and Impact of Early Surgical Decompression in Thoracic Spinal Cord Injury: A Multicenter Prospective Study from the North American Clinical Trials Network and AOSpine Spinal Cord Injury Knowledge Forum

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Introduction: Although less frequent than cervical injuries, thoracic spinal cord injury (SCI) remains an important cause of disability amongst the young; further, many studies, particularly those investigating cellular transplantation, have focused investigation on this clinical subgroup. Using a modern prospective multicenter SCI registry, our objective was to quantify mortality, complications and long-term neurological recovery in thoracic SCI. In addition, we aimed to investigate how treatment related variables, including surgical timing and administration of high-dose steroids, impact these outcomes. **Methods**: All analyses were based on prospective data from the North American Clinical Trials Network for SCI (NACTN), collected over a 10-year period (2005-2016) from 8 North American centers. We included surgically treated adult patients with an International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) exam performed within the first week and a neurological level of injury (NLI) between T1 and T12. Outcomes of interest included change in ASIA Motor Score (AMS) and ASIA Impairment Scale (AIS) grade at 1, 3, 6 and >12 months follow-up, as well as the incidence of acute in-patient pulmonary complications and mortality. The effects of surgical timing (before or after 24-hours post SCI) as well as intravenous Methylprednisolone (NASCIS II 24 hour protocol) on these outcomes were investigated through use of bivariable and multivariable statistics. **Results:** Of the 93 patients meeting eligibility (mean age 40.4 $\pm$16.2), 58 (62.4%) were AIS A, 12 (12.9%) AIS B, 14 (15.1%) AIS C and 9 (9.7%) AIS D; 48 patients (51.6%) had a NLI between T1-4, 15 (16.1%) between T5-8 and 30 (32.3) between T9-12. Although there were no acute inpatient mortalities, 53 pulmonary complications were recorded during acute hospitalization (incidence 57.0%), with pleural effusion, pneumothorax and pneumonia the three most commonly observed. Table 1 depicts neurological recovery at patients' last available follow-up (mean 5 months). For AIS grade A patients, while 15% converted at least one AIS grade at follow-up, improvement in motor function was low (mean 2.2 points), consistent with previous reports. The mean time to surgery was 57.2 hours with 48 patients (64.9%) undergoing surgical decompression/fusion within 24 hours post SCI. Multivariable analysis, adjusting for baseline AIS grade associated surgery before 24 hours with an additional 7 points of AMS recovery as compared to late surgery (Estimate = 7.14, $P = .03$). Further, late surgical decompression was associated with increased risk of inpatient respiratory complications (IRR = 2.50, $P = .04$). There was no association between Methylprednisolone administration and neurological or complication outcomes. **Conclusion:** Consistent with historical reports, thoracic AIS grade A patients experienced little motor recovery, with prognosis for incomplete patients substantially better. Although administration of high-dose IV Methylprednisolone had no effect on clinical outcomes, early surgical decompression was independently associated with improved motor recovery and reduced incidence of pulmonary complications.

Table 1. AIS Conversion and AMS change at last available follow-up.

AIS at presentation	AIS-A	AIS-B	AIS-C	AIS-D	AIS-E	AMS Improvement
AIS-A(N=46)	39	3	3	1	0	2.2 ($\pm$6.4)
AIS-B(N=12)	2	3	3	3	1	19.6 ($\pm$18.0)
AIS-C(N=9)	0	0	2	3	4	19.7 ($\pm$11.9)
AIS-D(N=8)	0	0	0	7	1	11.7 ($\pm$11.4)

A228: How Far Can We Go with Percutaneous Fixation of Spinal Fractures? A Comparative Study with Open Fixation in 110 Patients with Fractures of the Thoracolumbar Transition (T12-L1)

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Introduction: Fractures of the thoracolumbar spine usually result from high energy trauma and have a higher incidence in the thoracolumbar transition. The surgical treatment aims to stabilize the spine and correct its alignment. The transpedicular fixation can be performed by a minimally invasive approach or by open surgery. The aim of this study is to analyze patients with vertebral body fractures of T12 or L1 and to compare outcomes of transpedicular percutaneous fixation and open fixation. **Material and Methods:** Retrospective study of patients with vertebral body fractures of T12 or L1 without neurological signs who underwent percutaneous transpedicular fixation or open transpedicular fixation between January 2013 and April 2015. The sample CT scans were analyzed and the fractures grouped according to the AO classification. The segmental kyphosis angle and the degree of vertebral collapse before and after surgery were also saved in the database. Patients with less than 12 months of follow-up were excluded. The data obtained was analyzed with the software "STATA". **Results:** A total of 110 patients with vertebral body fractures of T12 or L1 were identified. Of this sample, 63 (57%) patients underwent percutaneous fixation and 47 (43%) open fixation. In the group of patients undergoing percutaneous fixation 35 (56%) were male and 28 (44%) female, with an average age of 55 years (18-82). There were 44 (70%) patients with isolated fractures of L1 and 19 (30%) with isolated fractures of T12; percutaneous fixation allowed the treatment of fractures of AO types A1 (14%), A2 (11%), A3 (16%), A4 (22%), B1 (34%) and B3 (3%); the average operative time was 60.3 minutes (30-105) and mean postoperative hospital stay was 4.2 days (2-9). In the group of patients undergoing open fixation 23 (49%) were male and 24 (51%) female, with an average age of 53 years (18-74). There were 30 (64%) patients with isolated fractures of L1 and 17 (36%) with isolated fractures of T12; open fixation was used to treat fractures of AO types A1 (11%), A2 (2%), A3 (21%), A4 (19%), B1 (9%), B2 (23%) and B3 (15%); the average operative time was 89 minutes (39-190) and mean postoperative hospital stay was 5.8 days (2 -17). The postoperative complications were: infection (1 case in a patient who underwent open fixation) and mechanical failure of the surgical implants (8 cases in patients undergoing percutaneous fixation). The average postoperative follow-up period of the 110 patients was 25 months (12-39). **Conclusion:** The majority (57%) of the patients with fractures of T12 or L1 was treated by percutaneous fixation; this procedure allowed a shorter operative time and an earlier discharge and was used predominantly in the treatment of AO B1 fractures. However, it resulted in postoperative mechanical complications. On the other hand, open fixation allowed the surgical treatment of more severe fractures, although it resulted in longer operative and hospitalization times. Mechanical failure associated with percutaneous fixation suggests that these patients are candidates for removal of surgical implants as soon as the fracture is consolidated.

A229: Early versus Late Surgery for Traumatic Spinal Cord Injury in the Thoracic or Thoracolumbar Area: Secondary Results of a Randomized Controlled Trial at One-Year Follow-up

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Introduction: Our aim was to conduct a randomized controlled trial (RCT) evaluating the efficacy of early (less than 24 hours) versus late (24-72 hours) decompressive surgery in patients with T1-L1 traumatic spinal cord injury (TSCI). **Material and Methods:** An RCT was conducted using blocked-sample-randomization in the neurosurgery department of Shahid Rajaee Hospital, Shiraz University of Medical Sciences from September 2010 to September 2016. Pre- and postoperative American Spinal Injury Association (ASIA) Impairment Scale (AIS) was assessed, as were ASIA motor/sensory scores, length of hospitalization and mortality. Independent t-test analysis was used to compare ASIA sensory and motor progress at 1, 3, 6 and 12-months follow-up between the early and late groups. To compare the complete and incomplete groups, the repeated measures ANOVA with covariate analysis was utilized. $P < .05$ was assumed for evaluation of significant differences. **Results:** Sixty-nine patients met the inclusion/exclusion criteria and consisted of early (n = 31) and late (n = 38) surgery groups. There were 1 deaths in the early and 2 deaths in the late group at 1-year follow up. Twenty-two cases (31.8%) had complete TSCI with no upgrading in AIS scale. For cases with incomplete TSCI, 4, 14, 8 and 1 patients had no, one, two and three level upgrading in AIS scale, respectively, and one patient died. At 1-year follow up, the mean ASIA motor score improved from 66 $\pm$ 20.8 to 78 $\pm$ 23 in the early group ($P = .001$), and from 58 $\pm$ 14.5 to 67 $\pm$ 20.6 in the late group ($P = .001$). The mean ASIA sensory score improvements were 5 $\pm$ 11.7 and 7 $\pm$ 12.7 for the early and late groups, respectively. Both ASIA sensory ($P < .001$) and motor scores ($P < .001$) had significant improvement from baseline time to 1-year follow-up. In the complete group, a significant improvement in ASIA sensory score was observed at the 12-month follow-up visit (95%CI = 1.8-11.4; $P = .009$) although there was no significant difference in ASIA motor score (95%CI = -0.5-2.7; $P = .186$). In the incomplete group, both ASIA

sensory (95%CI = 1-11.7; $P = .020$) and motor scores (95%CI = 12.7-23.5; $P < .001$) had significant improvements at 12_months follow-up. However, there was no statistically significant difference in ASIA motor ($P = .93$) and sensory ($P = .20$) score between early and late groups. On the contrary, there was a significant difference between complete and incomplete groups in motor improvement scale after decompression surgery at one-year follow-up ($F(1.32) = 8.208, P = .007$). Although there was no statistically significant difference in ASIA motor and sensory score between the two groups, one patient experienced a three-grade AIS scale improvement in the early group. There were 3 and 5 patients with two-grade improvement in AIS scale in the early and late groups, respectively. **Conclusion:** These results demonstrate overall AIS and motor score improvements in both the early and late surgical intervention groups after traumatic spinal cord injury in the thoracolumbar region. No motor improvements were observed in complete TSCI. There were no significant differences between the early and late groups in ASIA sensory and motor scale at 1, 3, 6, and 12-month follow-ups.

A230: Quality of Life following Thoracoscopic Stabilization of Traumatic Thoracolumbar Fractures with a Distractable Cage

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Introduction: While anterior column support for thoracolumbar fractures involves constantly evolving surgical procedures and materials, not much patient related outcomes have been reported. Expandable titanium cages are now considered a safe and effective treatment option compared to bone strut grafts to support the anterior spine. In combination with minimal invasive thoracoscopy, surgical damage can be minimized and functional outcomes can be maximally improved after surgery. This is the first study to report on long-term quality of life (QOL) and radiologic outcomes after thoracoscopic anterior stabilization of thoracolumbar fractures with an expandable cage. **Material and Methods:** Between 2004 and 2012 75 patients with unstable traumatic thoracolumbar fractures had a combined antero-posterior stabilization in our university level 1 trauma center. After posterior stabilization, an expandable titanium cage with additional anterolateral plating was implanted thoracoscopically. At follow-up forty-nine patients without neurologic injury completed the SF36 and EQ5D questionnaires. QOL scores were stratified for ISS ($<$ and ≥ 16), and compared to a cohort of patients that had solely posterior stabilization and to a general population from the Netherlands. In addition, correlation of QOL with kyphosis and fusion was checked. **Results:** From the patients that filled in the questionnaires, 44 valid scores could be calculated and questionnaires were filled in at median 48 months (IQR 14 – 84) after anterior surgery. Mean age at accident was 42 years (16-65), fractures consisted of AO type A to C and were located from T6 to L2 and 82% of the fractures were located at T11 to L2. Complications were present in 4 (8%) patients of which one (2%) required a re-operation because of an infection, there was one cage dislocation which remained stable at follow up. Compared to a general population, QOL as reported on the EQ5D was significantly lower on all domains, on the SF36 five out of eight domains scored lower. When compared to a cohort of patients that underwent solely posterior fixation, no differences in QOL were found. QOL scores of patients that filled in the EQ5D and SF36 at consecutive times (n = 14, median 13 months, IQR 12-23) did not improve or worsen significantly. After one year, bony fusion was completed on CT in 98%. While kyphosis (Cobb-angle) from injury to postoperative values decreased significantly, some re-kyphosing occurred at follow up. No correlation was found between final cobb-angles and QOL. Posterior implants were removed in 57% of patients. Patients that had a posterior implant removed showed more kyphosing after posterior implant removal to final follow up compared to patients that had no implant removal. **Conclusion:** Patients with a thoracolumbar fracture that require a thoracoscopically combined antero-posterior stabilization do not have a worsened quality of life compared to patients with a fracture that only require posterior stabilization. Kyphosis is significantly corrected directly after surgery, but there is some correction loss over time. QOL does not correlate with radiographic outcomes. Compared to a general population, overall quality of life is lower.

A231: The Change of Adjacent Segment after Thoracolumbar Posterior Instrumentation and Fusion Surgery in Thoracolumbar Fractures

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Introduction: The incidence of adjacent segment degeneration or disease is increasing as the spine surgeries increase. There have been many articles on risk factors causing adjacent segment change after lumbar fusion surgery, but few articles have been released on the topic in thoracolumbar spine. Therefore, we intended to evaluate the change of adjacent segment after posterior instrumentation and fusion in thoracolumbar spine. **Material and Methods:** From 2000 to 2013, fifty patients were reviewed retrospectively. The patients underwent posterior instrumentation and fusion due to thoracolumbar fracture and were able to follow up more than 2 years. To evaluate the change of adjacent segment, postoperative sagittal angle, disc height and disc angle of adjacent segment were compared with those at the last follow up. We divided the patients into two

groups according to age (more or less than 50 years), laminectomy, fusion levels (2 levels or more than 3 levels) and compared the radiologic parameters between groups. **Results:** The male patients were 36 and the female patients were 14. The average age of the patients was 45.6 years and the mean follow up was 4.3 years. There were no cases of adjacent segment disease. The mean kyphotic sagittal angle progression was 6.8° ($P < .05$), but the angle of adjacent segment disc did not show significant change between preoperative and last followup. The change of disc height of proximal adjacent segment was 0.3 mm and 0.5 mm of disc height in distal adjacent segment ($P < .05$). Laminectomy did not make significant difference on the change of adjacent segment, but in the group age less than 50 years, the angle of adjacent disc decreased significantly, 0.8° in proximal adjacent disc and 0.5° in distal adjacent disc ($P < .05$). There were no significant radiologic changes as the fusion levels is increased. **Conclusions:** Adjacent segment degeneration or disease after lumbar fusion surgery is not applied to the adjacent segment of thoracolumbar spine. These results are attributed to proximal level of fixation. Mobile segment of lumbar spine may make this difference rather than the instrumentation and fusion procedure itself.

A232: Minimally Invasive Stabilisation of the Fractured Ankylosed Spine: A Comparative Case Series Study

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Fractures in the ankylosed spine, secondary to ankylosing spondylitis or diffuse idiopathic skeletal hypersotosis (DISH), are often unstable and require surgical stabilization. Standard open pedicle screw and rod fixation with long constructs have good results but are associated with high levels of morbidity. Whilst technically demanding, minimally invasive surgery can potentially reduce the risks of open surgery. This study aims to compare the results of minimally invasive surgical (MIS) techniques, to traditional open surgery. **Method:** A prospective, ethics-approved database (Spine Tango) at a tertiary referral centre was retrospectively reviewed for results of surgery on fractures of the ankylosed thoracolumbar spine. These were then split into two cohorts: MIS stabilization and fixation or standard open surgery. **Results:** We identified 17 patients who had presented with ankylosed spines with associated fractures since 2010 with 10 undergoing MIS stabilization and 7 open surgeries. Average age in the MIS was 72 years compared to 56 in the traditional cohort ($P < .05$). An average of 6.7 levels was stabilized in the MIS group which was comparable with the traditional group. There was a significant difference in the operative time and blood loss in favour of MIS ($P < .05$) although this did not result in a significantly higher transfusion rate. Radiation exposure time and dose was significantly higher in the MIS group. There were no cases of non-union, significant implant malposition or failure in either group. 2 significant complications including 1 death occurred in the MIS group, and 1 significant complication in the open group. **Conclusion:** The MIS technique for fractures of the ankylosed spine has shown an acceptable complication rate and good results comparable to open surgery for a high-risk patient population.

A233: Percutaneous Fluoroscopic-Guided versus Percutaneous 3D Navigation-Guided versus Open Pedicle Screw Fixation for Treatment of Thoracolumbar Fractures without Neurologic Deficits

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Introduction: The main goals of the treatment of thoracolumbar fractures are stabilization and promotion of vertebral healing or fusion of the affected segment. Recently, as an alternative for the Open Pedicle Screw Fixation (OPSF) of Thoraco -Lumbar Fractures (TLF), Percutaneous Pedicle Screw Fixation (PPSF) has evolved to minimize soft tissue injury and perioperative morbidity. The purpose of this study was to prospectively compare the clinical and radiological outcomes of three different methods of neurologically intact TLF treatment: OPSF, minimally invasive two-plane conventional fluoroscopy – guided (F-PPSF) and navigation-guided (N-PPSF). **Material and Methods:** A total of 137 patients underwent either OPSF (n = 50) or F-PPSF (n = 39) or N-PPSF (n = 48) for stabilization of TLF between 2014 and 2016 in two Departments (Orthopaedics and Neurosurgery). Radiographs were obtained before surgery, immediately after surgery, and at the final follow-up for assessment of the restoration of the spinal column. For radiologic parameters, Cobb angle, vertebral wedge angle, and vertebral body compression ratio were evaluated on lateral thoracolumbar radiographs. As a method of clinical evaluation, the intraoperative blood loss, operation time, radiation dose, postoperative hospital stay, the postoperative scar size and perioprative complications. For patient's pain and functional evaluation, the visual analogue scale (VAS) and the Oswestry Disability Index (ODI) were evaluated. **Results:** There were significant differences between open and both percutaneous methods of treatment in surgical blood loss and postoperative hospital stay in favour of percutaneous and without significant difference between F-PPSF and N-PPSF. The time of the surgery was the shortest in OPSF. The

radiation dose was both the highest for the patient and the lowest (none) for the operative team in N-PPSF. The length of the postoperative scar was equal for all groups. There were two infections and one implant loosening in OPSF group without any significant complication in both percutaneous groups. Postoperative VAS decreased significantly in all groups and there was a significant difference between both percutaneous and OPSF groups at the time of discharge and after 6 weeks postoperatively. There were no statistical differences in VAS between all groups at the final follow-up. For both F-PPSF and N-PPSF ODI was significantly better 6 weeks after the surgery than for OPSF without any difference between all groups at the final follow-up. The regional sagittal Cobb angle, vertebral wedge angle and anterior height of the fractured vertebra all significantly improved in each group immediately after the surgery and at the final follow-up. There were no signifficant differences in the postoperative radiographic improvement between F-PPSF and N-PPSF groups but there was a significant difference in favour of OPSF in the immediate postoperative radiographic parameters in comparison to both percutaneous groups. **Conclusion:** Both percutaneous pedicle screw fixation techniques were comparable except the radiation dose for the operative team, which was the lowest in N-PPSF group. Although all three groups showed favorable outcomes at the final follow-up, F-PPSF and N-PPSF provided earlier pain relief, better functional improvement, less perioperative complications but worse postoperative radiological outcome in comparison with OPSF.

A234: Sacral Fractures with Spondylopelvic Dissociation

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Introduction: Spondylopelvic dissociation is a rare pattern characterized by a transverse sacral fracture in conjunction with bilateral dissociation between the sacrum the pelvis. Severe neurological complications due to the damage of lumbosacral plexus may also occur. Spondylopelvic dissociations are usually misdiagnosed or underestimated, thus potentially leading to chronic low back pain and progressive deformity. **Material and Methods:** From 2013 to 2016 11 patients (7 females, 4 males) underwent surgery for traumatic spondylopelvic dissociation. Patients averaged 41.2 (15-66) at the index procedure. Nine of them followed a precipitation from height, while the remnant 2 followed a crash. Fractures have been classified according to the system described by Denis. **Results:** There were 8 "U-shaped" and 3 "Lambda-shaped" fractures; the S1-S2 levels were involved in 5 cases, and the S2-S3 in 6 cases. A concomitant open book pelvic fracture occurred in one case. One patient reported a concomitant bilateral proximal femoral fracture and underwent early surgery. One patient was surgically treated for a fibula fracture and a wrist fracture. One patient underwent an early L1-L3 percutaneous screw fixation for an amyelic L2 fracture and, following a complete diagnosis of spondylopelvic dissociation, a L1-iliac stabilization thereafter. Surgeries were meanly performed 8.4 days after the injury. In all but one patient a posterior spondylopelvic screw fixation was performed; one patient underwent also a S1 laminectomy. At the last available examination 12 (1-34) months postoperatively, no complications were recorded. **Conclusion:** Spondylopelvic dissociation are rare high-energy injury fractures, and the true nature of the injury is easily missed and diagnosis is delayed. Hence, a comprehensive imaging assessment including CT scan reconstructions needs to provide optimal understanding of the fracture pattern. Early and proper diagnosis and classification will lead to an adequate surgical treatment. A comprehensive assessment of possible associated neurological deficits is also mandatory. This challenging disease can be satisfactory treated with a posterior screw fixation, with or without and associated laminectomy, thus minimizing the risk of neurological deficits, residual instability, deformities and chronic low-back pain. In our experience such a surgical is safe and effective.

Spine Biologics

A235: Human Intervertebral Disc Cells Hinder Primary Human Osteoblasts and Stromal Cells to Undergo Osteogenesis

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Introduction: Today's standard treatment strategy for intervertebral disc (IVD) degeneration is surgical intervention, like discectomy followed by spinal fusion. During spinal fusion the damaged disc is removed, the empty space is filled up with bone substitute or an autograft and the two adjacent vertebral bodies are immobilised. However, clinical observation showed that partial IVD tissue removal could lead to a failure of spinal ossification (1). Recently, it could be shown that human mesenchymal stem cells (MSC) co-cultured with human IVD cells show an inhibition in bone formation (2). In this study we hypothesised that mature human primary osteoblasts (OB) co-cultured with IVD cells would also show inhibitory effects in ossification as previously demonstrated for MSC. **Material and Methods:** OB were seeded at a density of 13'000 cells / cm2. IVD cells (ie, NPC, AFC and EPC) were encapsulated in 1.2% alginate beads ($\sim$30 µm in Ø at 4 M cells/mL, $\sim$75'000 cells/bead) and co-cultured via inserts (PET Ø 0.4 µm pore size)

with OB in the lower part as monolayer. The experiment was performed under hypoxic conditions. Dose response of inhibition was investigated by co-culturing six, nine and twelve NPC, AFC or EPC beads. The experimental groups were stimulated with osteogenic medium. Additionally, three controls were cultured: OB monolayer with osteogenic medium ($\pm$empty beads) and with control medium (-MEM + 10% FCS). To quantify ossification, matrix mineralization of OB was measured after 21 days by Alizarin red (ALZR) staining and was quantified by absorbance and normalised to cell activity (Resazurin assay). Furthermore, the alkaline phosphatase (ALP) activity of OB was determined after 21 days and normalised by total protein content (Bradford assay). **Results:** After 21 days, the OB culture in osteogenic medium $\pm$ empty beads (positive control) showed a strong ALZR staining. However, no deposition of mineralised matrix in OB monolayer cultured in control medium could be observed. OB cultured with NPC, AFC and EPC showed a decreased calcium deposition compared to the positive control (N = 2). The ALP activity measured after 21 days (N = 2) was reduced in OB co-cultured with IVD cells compared to positive control. The lowest amount was detected in OB cultured with NP cells (ALP activity / protein content $\pm$ SEM, 904.0 $\pm$ 262.6 mU/mg), compared to positive control (1975.7 $\pm$ 1793.714 mU/mg). **Conclusion:** In this study we could show a trend that mineralization of primary OB could be inhibited by direct exposure to IVD cells. Like observed in clinics, IVD cells seem to directly influence OB, by apparent inhibition of ossification. Particularly NPC in 3D alginate beads indirectly co-cultured with OB demonstrated inhibitory effects, such as low matrix mineralization in OB monolayer. However, these data need to be further confirmed using more donor repeats.

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A236: Comparison of Outcomes Between Artificial Disc Replacements and Bone Marrow Concentrate Injections for Chronic Discogenic Low Back Pain: 2 Year Follow up

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Introduction: Surgical interventions remain a controversial option for the treatment of chronic discogenic low back pain. Intervertebral disc arthroplasty has become more common due to the potential to minimize adjacent level issues and similar outcomes to the previous standard of fusion surgery. Recent advances in understanding biologic/cell therapies have allowed for the development of minimally invasive procedures to treat discogenic pain and probably degeneration. In this study, the results of an FDA, IDE trial for two lumbar total disc replacement systems were compared to the results of a study assessing safety and efficacy of intradiscal bone-marrow concentrate (BMC) injections as an alternative to surgical procedures. **Materials and Methods:** Patients from each trial who were screened using very similar inclusion/exclusion criteria were selected from each study to be compared. Patients from both groups were treated by the same physician at the same clinic. Criteria included: 6+ months failed conservative therapy for low back pain, visual analog scale (VAS) pain score of greater than 50mm/100 mm, Oswestry Disability Index (ODI) score of > 40%, absence of abnormal neurological exam, and absence of significant stenosis, herniation, or other compressive pathologies. Statistical comparison of outcomes and adverse events were performed for baseline and all follow-up points between studies (3, 6, 12, and 24 months). Methodological characteristics were virtually identical between studies. Results from each patient were individually obtained and statistically compared. **Results:** Chi squared distribution analysis was used to assess homogeneity between the studies. Significance testing showed no significant differences between Kineflex™ disc systems and BMC at any time point. Improvements were statistically significantly better in the BMC study group at 3 and 24 months compared to Maverick™ disc replacements (P = .024, 0.038 respectively). Adverse events were more common in both disc replacement systems compared to BMC injection (there were no serious adverse events reported in the BMC study). Maverick patients had baseline ODI/VAS scores of 57.77/82.28 and improved to 22.20/37.73 at 24 months. Kineflex patients had baseline ODI/VAS scores of 62.00/84.01 and improved to 23.75/28.05 at 24 months. BMC patients had baseline ODI/VAS scores of 56.80/82.05, and improved to 16.45/20.25 at 24 months. **Conclusion:** Previous meta-analyses and systematic reviews have demonstrated fusion and total disc replacement to have near equal efficacy regarding pain and disability and some evidence of lower rates of adjacent segment degeneration in disc replacements. Bone marrow concentrate injections, based on the comparisons in this study, show equal efficacy at resolving discogenic back pain and disability compared to disc replacement surgery. This indirect comparison shows preliminarily that BMC injections may be a viable alternative to surgical procedures, and provides justification for further studies involving direct comparison between the two interventions and/or studies of each intervention with standard conservative treatment control groups.

A237: Destiny of Allogeneic Tie2+ Cells from Isolation to Injection into Intervertebral Discs in Organ Explant Culture

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Introduction: An angiopoietin-1 receptor (Tie2) positive subpopulation of nucleus pulposus (NP) cells was recently described as NP progenitor cells (NPPC), which possess multipotency.[1,2] Hence, NPPC could represent an outstanding source of cells for intervertebral disc (IVD) regeneration. However, culture conditions to maintain NPPC *in vitro* are yet unknown. As is the cell number required for successful restoration of mildly degenerated discs. Thus, we aimed to test different isolation methods for Tie2 cells and to observe their survival when injected into IVDs and their regenerative potential. **Material and Methods:** IVDs were isolated from fresh bovine tails as described previously.[3] Degeneration of IVD was induced by injection of $\sim 100\,\mu l$ of 60U/mL papain solution and incubation for eight days.[4] In parallel on day 7, cells were isolated from allogeneic NP tissue using sequential digestion protocol with 0.19% pronase and 64.5 U/mL collagenase type 2. On day 8, Tie2+ cells and Tie2− cells were sorted using antibody against Tie2 by fluorescence-activated cell sorting (FACS, Facsaria, BD) or magnetic-activated cell sorting (MACS, Miltenyi Biotec). Subsequently, 20'000 Tie2+ and 200'000 Tie2− cells (control) were labeled with DiL (red fluorescence dye, Thermo-Scientific). Cells were mixed with fibrin hydrogel (Tisseel, Baxter) or PBS and injected into the cavity of the degenerative group (DG) and non-degenerated control discs. Followed by seven days of culture in free swelling conditions (absence of loading). On day 15, organ cultures were stopped, and after removal of the cartilage endplates the NP was separated from the annulus fibrosus (AF). Outcome measurements were cell viability (CV) of injected and native cells by cLSM and semi-automated cell counting and GAG/DNA ratio.[5] All cells were stained with green fluorescence calcein-AM staining and DAPI, which allowed to distinguish living and dead exogenous and native cells. **Results:** FACS ($n = 9$) showed a nearly 10-fold higher Tie2+ cell yield than MACS ($n = 2$). The 3D cLSM stacks taken from the healthy discs injected with Tie2+ showed a cluster and spheroid-like arrangement of the NPPC in the NP region in contrast to the autochthonous IVD cells. NPPC survival was considerably reduced after seven days of culture embedded in fibrin hydrogel. Whereas CV in PBS was very good with NPPC clustered in the native IVD environment. In the NP-region of non-degenerated discs, CV of exogenous Tie2+ cells in PBS ($n = 3$) was estimated to be $71 \pm 29.2\%$ and $64.5 \pm 46.12\%$ for the AF ($n = 2$), respectively. Tie2− cell's CV was considerably lower in PBS ($\sim 13\%$ for NP, $n = 1$). In the DG discs with fibrin hydrogel, CV of Tie2+ in NP ($n = 3$) dropped from $\sim 90\%$ down to $\sim 33\%$. **Conclusion:** Problems with nutrition diffusion through fibrin hydrogel or the particular IVD degeneration model could be factors for reduced CV. Also, NPPC can be isolated from bovine NP tissue with a higher yield using FACS and show differentiation into osteo- and adipogenesis. Future studies should focus on which factors maintain the NPPC phenotype *in vitro* and *in vivo* and to identify a suitable carrier for NPPC for both, *in vitro* cell expansion and delivery by injection.

Acknowledgement

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A238: Intervertebral Disc Repair by Combining Genipin-Enhanced Fibrin Hydrogel and Engineered Silk-Fleece

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Introduction: Low back pain is mainly caused by trauma or disc degeneration. We aim for an "inside-out" approach repair for herniated intervertebral discs (IVD) or injuries of the outer annulus fibrosus by using hydrogel in combination with modified silk. The silk's fibroin contains the human growth and differentiation factor 6 (GDF6), directly produced by baculovirus transduced *Bombyx mori* larvae in culture. GDF6 was shown to drive mesenchymal stem cells (MSC) towards an IVD-like phenotype.[1] Within this study, we investigated the feasibility of a genipin cross-linked fibrin hydrogel using an

ex vivo organ culture approach.[2] Furthermore, cytotoxicity and proliferation potential of human MSC within the silk material were assessed. **Material and Methods:** Bovine IVDs were harvested under aseptic conditions.[3] After inducing an IVD injury (2 mm biopsy punch), the cavity was filled with a human-based fibrin hydrogel enhanced with genipin. A GMP-compliant silk membrane-fleece composite was placed on the hydrogel to close the injury. Subsequently, IVDs were subjected to *in vitro* organ culture for 14 days using three loading regimes: 1) complex (0.2 MPa compression and $0 \pm 2^{\circ}$ torsion at 0.2 Hz for 8h/day), 2) static diurnal (0.2 MPa) and 3) no loading. For complex loading a custom built two-degree of freedom bioreactor was used.[4] At the end of culture, the discs were controlled for seal failure, height, metabolic activity, cell death (necrosis and apoptosis), DNA, GAG and collagen (hydroxyproline) contents. qPCR of ECM production and inflammation was performed. Histologies for collagen, proteoglycan and cytoplasm/nuclei were performed on plastic and cryo-sections. Proliferation potential of GDF6-silk was investigated by seeding MSC (P2) on silk fleece-membrane composite for 21 days. Metabolic activity, DNA and GAG content as well as qPCR (*aggrecan*, *collagen 2*, and others) were measured on day 0, 7, 14 and 21. All experiments were performed with $N = 5$ repeats. **Results:** Macroscopic inspection revealed that the silk seal was not displaced throughout the culture period. Metabolic activity, DNA and GAG content and disc height of the repaired discs did not differ significantly from the injured IVDs. Except for a higher DNA content under static loading for the repaired discs compared to the injured IVDs (P value $\leq .004$). Examination of histological sections indicated that the injury created a cavity. Whereas in the repaired discs the induced injury was closed and the cavity was filled with tissue. *In vitro* experiments on the cellular level attributed a good cell compatibility within the silk and GDF6 silk. Also proliferation, DNA and GAG content did not reveal significant differences among the different silks. qPCR of MSC revealed a trend towards a higher *aggrecan* to *collagen 2* ratio. This ratio indicated a differentiation of MSC towards a nucleus pulposus phenotype. **Conclusion:** Strikingly, discs responded equally to the injury on opposite sides, suggesting exchange of cytokines either throughout the disc or the culture media. The *in vitro* experiments attributed the silk a good biocompatibility. Further, GDF6 silk thrives MSC towards a NP-like phenotype. The silk and the hydrogel offer a promising approach to repair and regenerate the IVD after nucleotomy upon disc herniation.

Acknowledgements

We thank Eva Roth for her help in IVD isolation and biomechanical assays. Microscopy was performed on equipment supported by the Microscopy Imaging Center (MIC), University of Bern, Switzerland. This project was supported by the Gebert Rüf Foundation project # GRS-X028/13.

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A239: Effects of Systemic PEGylated NELL-1 on Bone Healing and Density in a Mouse Model

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Introduction: NEL-like molecule-1 (NELL-1) is a potent pro-osteogenic cytokine that has been demonstrated to enhance bone formation when applied locally. PEGylation is a biocompatible process in which polyethylene glycol (PEG) is attached to a protein to prolong its half-life. The primary objective of this study is to investigate the effects of systemic administration of PEG-NELL-1 on fracture repair in an open fracture model in the mouse radius; the secondary objective is to investigate effects on bone mineral density in uninjured bones. **Methods:** A total of twelve CD-1 mice aged 10 weeks were subjected to 0.15 mm transverse open osteotomies of the bilateral radii. They were treated with weekly tail vein injections of PEG-NELL-1 ($n = 5$) or PEG phosphate buffered saline (PBS) ($n = 7$). Animals were sacrificed at week 4. Fracture healing was evaluated by micro-CT and microPET. For the microPET, F-18, is substituted for hydroxyl groups and binds to new bone; therefore uptake is higher in newly formed bone. Bone density was evaluated by Dual-energy X-ray absorptiometry (DXA) and performed on humeri and femurs. Statistical analyses were performed using a Student's t test. A P value of $<.05$ was considered significant. **Results:** At 4 weeks of treatment, bone volume of the fracture site in the PEG-NELL-1 group was 22% greater compared with control across three different threshold values. There were no significant differences in trabecular density. MicroPET demonstrated 34% more uptake of F-18 in the PEG-NELL-1 group compared with control. On DXA, the PEG-NELL-1 group demonstrated significantly higher BMD than control in the mid femur, distal femur, proximal humerus, and distal humerus. There was no difference in BMD in the mid humerus. **Conclusion:** Weekly systemic administration of PEG-NELL-1 increased bone formation in this radial defect fracture model as verified by bone volume on micro-CT and F18 uptake on microPET. Furthermore, systemically injected PEG-NELL-1 induced bone formation as measured by DXA in uninjured long bones in mice. These exciting results warrant further investigation of PEG-NELL-1 as an injectable therapeutic agent to induce bone formation in both fractured and uninjured bones. This discovery is novel as the first

demonstration of a systemically administered anabolic cytokine to enhance bone formation in fractured and uninjured long bones.

A240: The Effect of the Extra Dural Compression on The Intraspinal Pressure, In Vitro Study

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Introduction: Previous animal models for spinal cord injury required laminectomy and exposure of the spinal cord to create direct trauma. Imaging studies were not always possible during these experiments. Furthermore, previous studies did not permit a correlation of extent of cord compression with cord injury. The purpose of our study is to determine the relationship between extent of cord compression and the increase in cord pressure in an in-vitro burst fracture model of graded cord compression. **Methods:** 12 Porcine spinal sections, six thoracic, and six lumbar were harvested from 30 kg pigs. Each spine segment consisted of 7 vertebrae. With the cord exposed and tied off at each end. A hole was drilled in the middle of the most central vertebra of the segment that was carefully created from the most anterior portion of the vertebral body through the posterior wall of the vertebral body without damaging the underlying cord. A 12.5 mm diameter DHS hip screw with 3 mm thread pitch was then inserted into this hole and advanced in a graded fashion. Pressure at the cord was monitored by means of the central hole running longitudinally down the DHS screw toward the cord. As the DHS screw was advanced, pressure was measured at the tip of the screw where it contacted the spinal cord. A radiolucent dye was administered in the subdural space to create a myelogram during the procedure. All the segments were observed under fluoroscopy to monitor the advance of the DHS screw. **Results:** Accurate measurement of the time averaged pressure showed no significant difference ($P < .05$) in the pressure/compression curves before and after radiopaque dye injection. Cord Pressures increase dramatically at approximately 65% to full compression. **Conclusions:** Cord Compression can be obtained in a systematic and controlled manner. Cord Pressures increase dramatically when cord compression reaches approximately 65% to full compression. Our samples exhibited Creep Phenomenon- the tendency of a material to slowly move or deform permanently under the influence of stresses, as repeated measurements at same percentage of compression showed substantially decreased pressures.

A241: The Effects of Combined High-Dose Parathyroid Hormone (PTH 1-34) and Low Dose Bone Morphogenetic Protein 2 (BMP-2) Treatment in a Rabbit Model of Lumbar Spinal Fusion

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Introduction: Intermittent treatment with parathyroid hormone (1–34) (PTH) has been shown to increase bone mass and reduce fracture risk in osteoporotic patients. Previously, we established that low-dose (10 μg/kg) PTH (1–34) treatment resulted in increased fusion mass volume in a rabbit model. However, it did not improve biomechanical stiffness over the use of autograft alone, and did not improve fusion when combined with BMP-2 treatment (Lina et al, Spine [Phila Pa 1976]. 2014; 39(5):347). Studies in rodent models have shown that the effects of PTH (1–34) on spinal fusion may be dose-dependent (Ming et al, Spine [Phila. Pa. 1976]. 2012; 37(15): 1275; Abe et al, Bone.2007; 41(5): 775). We thus aim to evaluate whether increasing the administered dosage of PTH (1–34) increases both the volume and biomechanical stiffness of the resulting fusion masses and/or exhibits synergistic effects with low-dose BMP-2 treatment. **Materials and Methods**: Posterolateral intertransverse process lumbar spinal fusion surgery was performed on 60 male, New Zealand White rabbits. Six experimental groups were evaluated: [1] iliac crest autograft alone (n = 10); [2] autograft + 20 μg/kg PTH (1–34) (n = 10); [3] autograft + 40 μg/kg PTH(1–34) (n = 10); [4] BMP-2 alone (n = 10); [5] BMP-2 + 20 μg/kg PTH (1–34); and, [6] BMP-2 +40 μg/kg PTH (1–34). Fusion was assessed using manual palpation and volumetric CT analysis. Four-point bending non-destructive biomechanical testing was utilized to evaluate the fusion mass stiffness. **Results**: In the autograft groups, rabbits receiving PTH (1-34) displayed an increased rate of fusion via manual palpation. Increasing doses of PTH (1–34) were found to lead to increased fusion mass volume as assessed via CT. However, increased mechanical stiffness was only observed in the 20 μg/kg group via four-point bending tests. All groups treated with BMP-2 were observed to fuse via manual palpation and CT analysis. The highest dose of PTH (1–34) in combination with BMP-2 was found to lead to significantly increased fusion mass volume compared to treatment with BMP-2 alone, however, no significant differences in mechanical stiffness were observed. **Conclusions**: Treatment with PTH (1-34) alone increases fusion rate and fusion mass volume in a dose dependent manner. However, significant increases in mechanical

stiffness were only observed in the autograft group at a dosage of 20 μg/kg, thus suggesting there may be an optimal dose of PTH(1-34) in the rabbit model. When combined with low-dose BMP-2 treatment, the effects of BMP-2 on fusion dominate. A significant increase in fusion mass volume at a dosage of 40 μg/kg over BMP-2, however, suggests some synergistic effects.

A242: Mesenchymal Progenitor Cells Primed with Pentosan Polysulfate Mediate Disc Repair following Microdiscectomy in an Ovine Model

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Introduction: Lumbar microdiscectomy is a commonly performed surgical procedure for the relief of chronic radicular symptoms. However, the procedure targets neural decompression but does not repair the underlying disc pathology. As a consequence, 10 – 20% of patients re-present with debilitating back pain and approximately 15% undergo further surgical intervention.[1,2] In-vitro studies have demonstrated that pre-incubation of mesenchymal progenitor cells (MPCs) with the sulphated polysaccharide, pentosan polysulfate (PPS), for 24 hours, increased their viability and enhanced chondrogenic differentiation. The objective of the present study was to determine if primed MPCs (pMPCs), embedded in a gelatin/fibrin scaffold and inserted into the lesion produced by microdiscectomy, could facilitate disc repair in the ovine model. **Material and Methods:** Eighteen adult ewes underwent pre-operative 3 T MRI at baseline. Microdiscectomy was performed via a lateral surgical approach at two lumbar disc levels. Adjacent non-operated lumbar discs served as normal controls. The microdiscectomy procedure consisted of a standardized 3 x 5 mm annulotomy which removed approximately 200 mg of annulus fibrosus (AF) plus some nucleous pulposus (NP) tissues. Post microdiscectomy sheep were randomized into 3 groups (n = 6). Group 1, received no further treatment (injured control group); Group 2 were implanted with non-primed MPC (500,000 cells) + scaffold; Group 3 received the pMPC (500,000 cells) + scaffold. Necropsies were performed at six months and lumbar spines were scanned using 3 T and 9.4 T MRI and radiographic imaging. Spinal columns were dissected, individual discs sectioned and NP and AF regions scored using gross morphological and histological assessments. Following subdivision of the discs into 6 regional segments, NP and AF tissues were analysed biochemically for their proteoglycans (PGs) (as S-GAGs), collagen and DNA content. **Results**: The MPC and pMPC groups (Groups 2 & 3) demonstrated significantly less reduction in disc height relative to the injury group (Group 1) ($p < 0.05$). Pfirrmann 3 T degeneration scores failed to show a significant difference between the three groups. Gross morphological scoring revealed significantly reduced degeneration scores in Group 3 disc segments overall compared to Group 1 for the NP and AF. The PG content of the contralateral NP for the pMPC group (Group 3) was significantly higher than for Group 1 ($P < .01$) and not statistically different to the normal control disc values. The PG content of Group 3 discs at the site of injury were greater than Group 1 discs ($P < .02$). The PG content of the contralateral AF of Group 3 was not significantly different to normal controls discs and greater than Groups 2 discs ($P < .04$). Histological scoring of the respective groups reflected the gross morphology scores with degeneration scores in Group 3 being lower than in Group 1. **Conclusion:** Local administration of pMPCs (Group 3), embedded in the gelatin/fibrin carrier, post microdiscectomy reduced disc degeneration and improved disc height relative to microdiscectomy alone (Group1). These findings suggest a potential therapeutic role of pMPCs in limiting the extent of spontaneous disc degeneration in patients post lumbar microdiscectomy and, consequently, the recurrence of low back pain and radiculopathy.

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A243: Effect of RNA Interference (RNAi)-Mediated Suppression of Fas Gene on Viability of Rat Intervertebral Disc Cells

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Introduction: RNA interference (RNAi) enables inhibition of specific genes by sequence-specific gene silencing by double-stranded RNA (dsRNA). It involves post-transcriptional gene silencing via a process by which dsRNA inhibits gene expression through degradation of a specific, targeted mRNA. Small

interfering RNA (siRNA), a type of RNAi, is a hybrid consisting of a sense and antisense strand homologous in sequence to the suppressed gene. Therefore, synthetic siRNA can trigger an RNAi response in mammalian cells and induce inhibition of specific gene expression. Fas death receptor is reported to cause apoptosis of intervertebral disc cells, which results on disc degeneration. We performed the current study to investigate the effect of siRNA on Fas gene expression, apoptosis, and proliferation in rat disc cells treated with serum deprivation. **Material and Methods:** Disc cells were isolated from nucleus pulposus tissues of 4-week old rats, cultured, and placed in either 10% (normal control) or 0% (apoptosis-promoting condition) fetal bovine serum (FBS) for 48 hours. The expression of Fas and viability (apoptosis and proliferation) of the cells were determined. To suppress Fas gene expressions, siRNA against Fas (Fas siRNA) was synthesized and transfected into the cells using oligonucleotides. The suppression of Fas gene expression was investigated by RT-PCR and densitometry. The effect of Fas siRNA on apoptosis and proliferation of the cells was determined. Negative siRNA and MOCK (transfection agent alone) were used as control. **Results:** Serum deprivation increased apoptosis by 40.3% and decreased proliferation by 45.3% in disc cells (both, $P < .001$), and upregulated Fas expression. Fas siRNA suppressed Fas expression in 0% FBS. The rate of suppression by Fas siRNA was 68.5% at the mRNA level ($P < .001$). Suppression of Fas expression by siRNA significantly inhibited apoptosis by 9.3% and increased proliferation by 21% in 0% FBS (both, $P < .05$). **Conclusion:** RNAi-mediated suppression of Fas gene results in significant inhibition of apoptosis and increased proliferation of rat disc cells under serum deprivation. This dual positive effect of RNAi might be a powerful therapeutic approach for disc degeneration by suppression of harmful gene expression. RNAi can also be used in gene function studies for the process of disc degeneration control.

Minimally Invasive Surgery Lateral Lumbar Fusion

A244: Comparative Study at Difference of Perioperative Complication, Cage Location and Sagittal Alignment: MIS-OLIF (Minimally Invasive Oblique Lateral Lumbar Interbody Fusion) vs. MIS-DLIF (Direct Lateral Lumbar Interbody Fusion)

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Introduction: MIS-DLIF using tubular retractor has been used for the treatment of lumbar degenerative diseases. Although addition of electrophysiological monitoring potentially decreased the perioperative neurological complications, blunt retroperitoneal and transpsoas dissection poses a risk of injury to the lumbar plexus, especially at lower lumbar level. As an alternative, MIS-OLIF uses a window between the prevertebral venous structures and psoas muscle, and gets an access to the target disc obliquely. Theoretically, MIS-OLIF preserves psoas muscle and lumbosacral plexus with reducing the complication of direct lateral approach, and by orthogonal maneuver (oblique to vertical way), the position of cage would be easily controlled. The purpose of this study was to compare the incidence of perioperative complication, difference of cage location and sagittal alignment between MIS-OLIF and MIS-DLIF in the cases of single level surgery at L4-5. **Material and Methods:** A total of 31 consecutive patients who underwent MIS-DLIF or MIS-OLIF for various L4/5 level pathologies between November 2011 and April 2014 by a single surgeon were retrospectively reviewed. A complication classification based on the relation to surgical procedure and effect duration was used. Perioperative complications until 3 month postoperatively were reviewed for the patients. Radiologic results including the cage location and sagittal alignment were also assessed with plain radiography. **Results:** The study group comprised 16 patients in DLIF group (M: F = 1:1.7, mean age = 67.8 (range 54∼82)) and 15 patients in OLIF group (M: F = 1:2, mean age = 63.5 (range 49∼75)). There were no significant statistical differences in perioperative parameters (operation time, intraoperative blood loss and hospital stay) and early clinical outcome between two groups. Overall, there were 8 (50.0%) approach-related complications in DLIF group (4 leg paresthesia, 2 leg weakness, 1 wound infection and 1 local hematoma) and 2 (13.3%) in OLIF group. (1 leg paresthesia and 1 local hematoma; $p < 0.05$) Of all approach-related complications in DLIF group, 2 (12.5%) were classified as persistent, and 6 (37.5%) were classified as transient complications. However, there was no persistent complication in OLIF group. The overall incidence of approach-unrelated complication accounted for 12.4% in DLIF group and 13.3% in OLIF group respectively. The most common non-approach related complication in OLIF group was abdominal ileus. (6.2% vs 13.3%, $P < .00$). In OLIF group, cage is located mostly in the middle 1/3 of vertebral body, significantly increasing posterior disc space height (38.1% vs 21.2%, $P < .05$) and foraminal height compared to DLIF group (21.1% vs 12.7%, $P < .05$), where cage is placed more anteriorly. Global and segmental lumbar lordosis was greater in DLIF group ($45.6 \pm 11.6^\circ$ vs $36.5 \pm 6.9^\circ$, $15.8 \pm 4.7^\circ$ vs $9.5 \pm 6.1^\circ$) due to anterior cage position without statistical significance. **Conclusion:** In our report of L4/5 level diseases, the OLIF technique may decrease approach-related perioperative morbidities by eliminating the risk of unwanted muscle and nerve manipulations. Using orthogonal maneuver, cage could be safely placed more posteriorly, resulting better disc and foraminal height restoration. Longer-term follow-up is warranted.

A245: Does a Preoperative Pain Free Posture Predict Success of Indirect Decompression by Extreme Lateral Interbody Fusion (XLIF) in Degenerative Lumbar Spinal Conditions?

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Introduction: Extreme lateral interbody fusion (XLIF) is a minimally invasive technique that can be used to relieve radicular pain and neurogenic claudication in patients with degenerative spondylolisthesis, scoliosis and foraminal stenosis. It relies upon indirect decompression, in contradistinction to traditional surgical treatment by direct posterior decompression and fusion procedures. Preoperative prediction of the success of indirect decompression is currently based mainly on radiological criteria.[1,2] This study evaluates the reliability of a clinical algorithm that is simply based on the ability for a patient to achieve a pain free posture preoperatively (typically sitting or lying). If this was achievable, our hypothesis was that an indirect decompression would be successful. **Materials and Methods:** A prospective consecutive series of patients who underwent XLIF by a single surgeon was conducted from October 2014 to June 2016. All patients who were able to achieve a pain-free position underwent XLIF alone. Patients with constant radicular pain underwent XLIF and supplemental direct decompression. The patients' demographic, clinical data, Oswestry Disability Index (ODI) and visual analogue scale (VAS) for leg pain were collected preoperatively and at 1, 3, 6, and 12 months post-operatively. **Results:** 26 consecutive patients were recruited into the study with a mean age of 67.4 (range 36-84) and were treated with XLIF at 36 levels (range 1- 4). The most common levels treated were L4/L5 level in 18 patients and L3/L4 in 13 patients. Six patients had supplemental posterior decompressions during the index procedure. Fixation was performed in 24 patients (21 pedicle screws, 3 lateral plate). At 1 month postoperative follow up, leg pain for both groups (XLIF alone and XLIF with direct decompression group) showed significant improvement with reduction of mean VAS score by 5.9 (95% CI 4.3 – 7.5, $P <$ .0001) and reduction of mean ODI by 13.9% (95% CI 3.8% - 24.0%, $P = .0115$). In XLIF alone group, patients also demonstrated significant improvement, with reduction of mean VAS score by 6.2 (95% CI 4.2 – 8.2, $P <$ .0001) and reduction of mean ODI by 13.3% (95% CI 0.9% - 25.8%, $P = .038$). There was no significant difference in the treatment effect (mean reduction in VAS and ODI) between the XLIF alone group and the group receiving XLIF with supplemental decompression. No patients required reoperation. Complications included urinary retention in one patient, contralateral leg pain in one patient that resolved at 14 days, cerebrospinal fluid leak in one patient who had decompression, resulting in a remote cerebellar haemorrhage that resolved without further intervention. **Conclusion:** A single clinical criterion of achieving a pain-free position at rest preoperatively can be used as an aid in selecting patients that may benefit from indirect decompression using XLIF alone. Longer follow up and a larger series is required to assess durability of this algorithm.

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A246: Saggital Alignment Parameters in Patients Submitted to Extreme-Lateral Interbody Fusion (XLIFR) versus Minimally Invasive Transforaminal Lumbar Interbody Fusion (MIS-TLIF)

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Introduction: The aim of this study was to assess current spinopelvic parameters measured after extreme-lateral interbody fusion (XLIF^R) *versus* minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF), in order to compare postoperative results. **Material and Methods:** Eighty consecutive patients undergoing single to three level lumbar interbody fusion surgery for common spine degenerative disorders at a single center were recruited to two different groups, according to the surgical technique applied: XLIF^R (n = 36) x MIS-TLIF (n = 44). Postoperative (PO) standing lateral films including all lumbar segments and femoral heads were obtained from all included patients and analysed using Nuvamap^R software by a single experienced spine surgeon. XLIF and MIS-TLIF patients were compared in terms of the following parameters: age, gender, operated levels (number and location), pelvic incidence (PI), lumbar lordosis (LL), segmental lordosis (SL), L4S1 lordosis, pelvic tilt (PT), sacral slope (SS), and mismatch (PI-LL). Data were registered in a specific database created for

the study. **Results:** XLIF^R and MIS-TLIF groups were similar in terms of age and gender. In XLIF^R group (n = 36), the following spinopelvic parameters were obtained in average: PI 56.1; LL 53.2; PT 16.7; SS 39.5; mismatch (PI-LL) -2.2. For MIS-TLIF group (n = 44): PI 52.6; LL 45.9; PT 19; SS 34.3; mismatch -5.9. A mismatch (PI-LL) greater than 20 degrees was observed in only 7 (8.75%) patients (XLIF^R- n = 2; MIS-TLIF– n = 5). Considering single level interbody fusion and excluding L5S1 level, spinopelvic parameters obtained for XLIF^R (n = 18) group were: PI 58.3; LL 57.1; PT 16.7; SS 41.8; mismatch -0.61; and for MIS-TLIF (n = 19) group were: PI 57.5; LL 46.6; PT 24.1; SS 33.6; mismatch -9.1. LL, PT, SS and mismatch showed statistically significant different values between XLIF^R and MIS-TLIF groups. **Conclusion:** XLIF^R and MIS-TLIF are both adequate surgical techniques for treatment of common spine degenerative disorders, with low risk of decompensation in saggital profile. In this study, XLIF^R showed superior efficacy to preserve spinopelvic alignment compared to MIS-TLIF.

A247: Mini-Open Approach to Lateral Transpsoatic Interbody Fusion of the Lumbar Spine: A Technical Perspective Comprising > 5,000 Levels

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Introduction: Lateral transpsoatic interbody fusion (LTIF) permits discectomy and insertion of a wide cage resting on the apophyseal ring, while preserving the anterior and posterior annular/ligamentous structures. Commercially available systems employ a series of tube shaped dilators to traverse the psoas muscle and expose the target disc. These systems rely upon a hand held depolarizing device to detect and avoid damage to the exiting nerve roots and lumbar plexus. Despite this methodology, injury to the neural elements has been reported, as has injury to the viscera and vascular structures. We hypothesized that a mini-open technique, permitting direct visualization of retroperitoneal and neural structures, would result in a lower incidence of such injuries. **Materials and Methods:** From 2007 through 2016, a patient registry accrued >2,000 patients undergoing LTIF. At an average of 2.5 levels/patient, >5,000 levels were done using a mini-open muscle splitting approach, permitting visualization of the retroperitoneal space and digital palpation of the target disc. A transpsoatic dissection plane ventral to the exiting nerve roots and lumbar plexus was established via direct visualization and palpation. Retraction was maintained by table mounted Altus®, DePuy® or Nuvasive® self-retaining systems, or by hand held renal vein retractors. Coronal deformities were approached through the concavity of the curve. In cases involving the L4-5 disc space, coronal angulation of the L4-5 disc was the principal factor determining choice of operative side. **Results:** There were no instances of peritoneal violation or permanent motor deficit. Incidence of minor sensory deficit at one year was <5%. Segmental vessel injury was easily handled, as were various venous anomalies. A single aortic injury was repaired following conversion to midline laparotomy. **Conclusions:** Vision and palpation are familiar skills to the operating surgeon. Mini-open approach to LTIF of the lumbar spine permits the use of these skills, facilitating safe localization of the target disc, thus avoiding injury to the viscera and minimizing damage to the neural elements and vascular structures.

Surgical Complications

A248: Emergent Reintubation in Spine Patients

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Introduction: General anesthesia and airway management is the cornerstone of safe care and passage through spine surgery. Emergent reintubation after extubation is a important and potentially dangerous event. Reintubation as a Medicare or Joint Commission metric is likely to come under increasing scrutiny in the changing and cost conscious healthcare environment. These healthcare metrics will be increasingly important to outcomes conscious reimbursement and quality assessment models. The purpose of the present study is to identify those factors that contributed to the need for emergent reintubation amongst a cohort of spine patients, accounting for indication for surgery (trauma, degenerative, deformity, tumor) as well as temporal indications (elective vs emergent surgery), type of surgery (cervical, thoracic, lumbar) and surgical site (anterior, posterior, combined). **Materials and Methods:** All patients undergoing spine surgery at the University of Washington and Harborview Medical Center were identified from a prospectively collected data base from July 1, 2008 to December 31, 2012. **Results:** During the collection period, 4995 patients underwent spine surgery requiring intubation. Sixty-six (1.3%) required an un-planned re-intubation. Baseline demographics are as follows: sex: male 49, 17 female; diagnosis: (63.6%) trauma, (21.2%) degenerative, (6.1%) deformity, (6.1%) infections, (3.0%) tumors; surgical site: (62.1%) cervical, (30.3%) thoracic, (7.6%) lumbar; surgical procedure: (16.7%) anterior cervical, (9.1%) a/p cervical, (37.9%) posterior cervical, (28.8%) posterior thoracic, (7.6%) posterior lumbar; position: (16.7%) anterior, 6 (9.1%) anterior/posterior, (74.2%) posterior; index extubation location:

(42.4%) in OR/PACU, (57.6%) delayed in ICU; time to re-intubation from extubation: 30 < 24 hours, 8 < 48 hours, 9 < 72 hours, 14 > 72 hours; location of re-intubation: 13 acute care floor, 4 in OR, 49 in ICU; reason for re-intubation: 59 respiratory failure, 3 cardiac, 1 hematoma, 1 sepsis, 1 reduced mentation, 1 hypotension. Of the 66 patients re-intubated, 52 (78.8%) occurred within the first 72 hours and the other 14 occurred more than 3 days post-extubation. The most common cause for re-intubation was respiratory failure in 59 patients with 7 re-intubations related to other causes. Only one re-intubation was felt to be due to a post-operative hematoma in an anterior cervical case. Interestingly, 42 (63.6%) of the 66 patients requiring re-intubation had a spinal traumatic lesion as the surgical indication. **Conclusion:** The greatest percentage of reintubation events occurred within the first 72 hours and trauma is a risk facture especially in those requiring cervical surgery, either anterior or posterior. Length of surgery or operative variable did not seem to be predictive. Overall the rate of emergent reintubations is very low and therefore one should not guide treatment decisions to aggressively to avoid an otherwise rare event. And finally, patients destined for acute care (ICU etc) have a higher risk and this likely reflects their overall status and injuries However, despite a large patient sample, prospective database and important clinical question we do not feel that large retrospective databases such as these, even collected prospectively are sufficiently strong to use in the construction of healthcare quality metrics for review, CQI and especially reimbursement outcomes models.

A249: Airway Adverse Events after Posterior Occipitocervical Fusion

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Introduction: Airway management can be very challenging in patients undergoing posterior occipitocervical fusion (OCF). Limited data exist pertaining to the incidence, risk factors for, severity of and types of airway adverse events following OCF. The purpose of this retrospective cohort study was to quantify the rate of postoperative airway adverse events (AE), describe the types of AE and examine potential risk factors for AE in patients undergoing posterior OCF. **Material and Methods:** After obtaining IRB approval at our institution a retrospective review of adult patients undergoing OCF at a single tertiary academic spine center was performed. Subjects with a history of spine surgery or with an endotracheal tube or tracheostomy at the time of the OCF were excluded. Chart review was performed to collect data pertaining to patient demographics, airway management strategy, anesthesia, surgical intervention and adverse events. Airway adverse events were classified into three types: Type 1) immediate airway complications (ie, need for reintubation within the first hour following extubation of the patient in the operating room), Type 2) failed extubation in the intensive care unit (ICU) or Type 3) delay of extubation at emergence from anesthesia with transfer of the patient intubated to the ICU. Preoperative and postoperative radiologic studies were used to measure the occipitocervical angle (OC2A) and the change in each patient's OC2A (dOC2A) was calculated. Descriptive statistics were summarized and differences between patients without an airway AE (Group 1) and with an airway AE (group 2) were examined. **Results:** Between 2005 and 2013 a total of 59 patients undergoing posterior OCF and meeting study inclusion criteria were identified. No airway AE occurred in 47 (73%) of our patients (Group 1). Of the 16 patients (27%) who experienced an airway AE, four (25%) were Type 1 requiring reintubation, 12 (75%) were transferred to the ICU intubated (Type 3) and 2 of those patients eventually failed extubation in the ICU (Type 2; 16.7% rate of failed ICU extubation). Those patients who experienced airway AE (Group 2) were more likely to have had a surgery lasting greater than 5 hours ($P = .009$), had surgery of 6 or more lev ($P = .012$) and were more likely to have been identified as being a difficult intubation ($P = .002$). Mean dOC2A was not significantly different between Groups 1 and 2 (-1.1 degrees versus -4.4 respectively, $P = .127$). **Conclusion:** The incidence of airway AE in our population was 27% indicating that airway management in patients undergoing posterior OCF is challenging and high risk. Decisions regarding timing of extubation must be individualized and factors such as difficult intubation, number of vertebral levels fused and surgical duration must be considered. While surgical attendance to fusion position is important dOC2A was not related to postoperative airway AEs in our cohort. Risk factors for postoperative airway AEs following posterior OCF are multifactorial and require prospective evaluation.

A250: The Effect of Pre-Operative Smoking on Short-Term Outcomes after Anterior Cervical Discectomy and Fusion

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Introduction: There is conflicting information about the relationship between tobacco smoking and risk of postoperative

complications among anterior cervical discectomy and fusion (ACDF) procedures. With the availability of databases such as the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database, it is now possible to identify perioperative outcomes associated with ACDF surgery within a large, nationally representative sample. To our knowledge, no studies have been performed among ACDF patients that evaluate the association of preoperative smoking status with the development of perioperative complications using a national database. We sought to compare the postoperative complications following ACDF surgery among non-smokers to complications among current or ever-smokers. **Material and Methods:** Patients over the age of 18 undergoing ACDF between 2005-2014, excluding emergency cases, were identified. The following baseline admission data were collected: age, gender, race, height, weight, American Society of Anesthesiologists status, revision status, osteotomy status, presence of at least one comorbidity, and number or anterior instrumented levels. ACS-NSQIP defines "smokers" as patients who have smoked cigarettes in the year before admission for surgery. The number of pack-years of smoking (defined as the product of the number of packs of cigarettes smoked daily and the years the patient has smoked) is also reflected for both previous and current smokers. Outcomes analyzed included development of at least one complication, development of a major complication, in-hospital mortality, and length of stay. **Results:** A total of 25,869 patients undergoing ACDF were identified; 7,847 (30.3%) current smokers, 18,022 (69.7%) not currently smoking, and 8542 (33.0%) ever-smokers. Logistic regression analysis revealed that current smoking status was not significantly associated with the occurrence of any one complication (OR, 1.054; 95% CI, 0.874 -1.271; $P = .584$) or any major complication (OR, 1.233; 95% CI, 0.935 -1.627; $P = .138$). An ever-smoker status was not significantly associated with greater odds of developing any one complication (OR, 1.035; 95% CI, 0.858 -1.249); $P = .718$) compared to non-smokers. However, ever-smoker status was significantly associated with a higher risk of any major complication (OR, 1.333; 95% CI 1.007 -1.764; $P = .044$) than for non-smokers. Using the number of pack-years as the primary independent variable, multivariate logistic regression analysis revealed that pack-years was not significantly associated with greater odds of developing any one complication (OR, 0.992; 95% CI, 0.978 -1.006; $P = .276$) or any major complication (OR, 0.991; 95% CI, 0.972 -1.010; $P = .334$). **Conclusion:** Although a positive ever-smoker status was associated with increased odds of developing morbidities compared to never-smokers, there was no relationship between the number of pack-years and the odds of developing any one complication or any major complication. Given the potential deleterious effects of a positive ever-smoker status, as well as the continued debate in the spine literature over the effect of smoking on long-term fusion success, smoking cessation should still be endorsed for ACDF surgery candidates.

A251: Renal Dysfunction in Lumbar Fusion Patients: Short-Term Complications in a Nationwide Sample

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Introduction: Chronic kidney disease (CKD) remains a worldwide public health problem, with a rising incidence and prevalence of kidney failure. Existing research on CKD and lumbar surgery using the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database has been limited to single years of data, non-specific lumbar procedures, and sole use of glomerular filtration rate (GFR) as an indicator of renal dysfunction. The objective of this study was to compare post-lumbar decompression and fusion complication rates and mortality for 1) patients with and without preoperative hemodialysis (HD) use and 2) non-preoperative HD patients with and without renal dysfunction as estimated by GFR and creatinine levels. **Material and Methods:** Patients over the age of 18 undergoing lumbar fusion between 2005 to 2014, excluding emergency cases, were identified. The following baseline admission data were collected: age, gender, race, American Society of Anesthesiologists status, osteotomy status, height, weight, revision status, and whether the procedure involved multiple levels. The preoperative use of HD was noted for all patients. To estimate preoperative kidney function in patients without HD, the most recent lab values for creatinine collected within 90 days prior the operation were evaluated. GFR was then estimated using the CKD-Epi formula that accounts for race, gender, and age. Outcomes considered included the development of at least one complication, development of a major complication, in-hospital mortality, and length of stay. **Results:** A total of 29,136 patients undergoing lumbar fusion were identified; 55 (0.19%) with preoperative HD, and 29,081 (99.81%) with no preoperative HD. Logistic regression analysis revealed that preoperative utilization of HD was not significantly associated with the occurrence of any one complication (OR, 1.900; 95% CI, 0.880-4.103; $P = 0.102$) or any major complication (OR, 2.019; 95% CI, 0.710-5.737; $P = .187$). Non-HD patients with severe preoperative kidney function impairment demonstrated increased likelihood of any complication (GFR = 15-30 ml/min/1.73m^2; OR, 3.82; 95% CI, 2.061-7.082; $P = <.0001$ and GFR = 30-45 ml/min/1.73m^2; OR, 2.124; 95% CI, 1.506-2.996; $P < .0001$). Compared to patients with normal preoperative creatinine levels (given by Cr = 0.75 -1.0 mg/dL), patients with more severely impaired function did demonstrate a significantly higher likelihood of complications (Cr = 2.0-3.0 mg/dL; OR, 2.291; 95% CI, 1.312-4.002; $P = .004$ and Cr = 1.5-2.0 mg/dL; OR, 1.871; 95% CI, 1.363-2.569; $P < .0001$). **Conclusion:** Although patients undergoing preoperative HD

did not have higher rates of developing complications than non-HD users, those non-HD users with impaired kidney function as measured by low estimated GFR and elevated creatinine levels were more likely to have perioperative complications. Our results suggest that lumbar surgery candidates who are not on HD prior to surgery but who demonstrate impaired kidney function should be counseled about the increased risks of complications following surgery. Special measures should be taken to account for perioperative morbidity among this patient population.

Tumor 2

A252: Unilateral Laminectomy Approach for the Removal of Spinal Meningiomas and Schwannomas: Impact on Clinical Outcomes and Foraminal Extension

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Introduction: Total single-level or multilevel laminectomy/laminotomy has been widely used in neurosurgery for the removal of spinal intradural-extramedullary (ID-EM) tumors at last decades. In recent years, minimally invasive surgery (MIS) approaches have become increasingly popular for treatment of spinal pathology. There have been prior reports of MIS for ID-EM tumors; however, these have been limited to case reports or small series. Sufficient surgical indications have not yet been thoroughly evaluated. Some controversy has existed concerning the use of unilateral approach for the spinal tumors with foraminal extension or multi-level. **Material and Methods:** A retrospective analysis of medical records and radiologic data was performed on patients who undergone unilateral laminectomy approaches for the removal of spinal meningiomas and schwannomas by one surgeon in a single center from January 2010 to June 2016. Extradural spinal mass and other ID-EM tumors and patients who followed up loss are excluded. 71 patients were enrolled finally in this study. Schwannomas were 55 cases. Meningiomas were 16 cases. Foraminal extension was found at 20 cases. We investigated the neurologic outcomes, complication rate, gross total removal rate, estimated blood loss (EBL), operation time, hospitalization, recurrence or progression with or without foraminal extension and multi-level. Japanese orthopedic association (JOAS) score, Visual analogue scale (VAS) and McCormick grade were used for the evaluation of postoperative neurologic outcomes. **Results:** The difference of preoperative and postoperative VAS, JOA score and McCormick grade was 4.3 ± 2.9, 1.8 ± 1.3 and 0.4 ± 0.7. These were statistical significance ($P = .000$). Complication rate was 12 patients; orthostatic headache was detected in 6 patients, wound dehiscence was observed 1 patient, wound infection was found 2 patients and myelopathy was detected 3 patients. Gross total resection was 66.2%, near total resection was 11.3%, subtotal resection was 16.9% and partial decompression was 5.6%. EBL was 235 ± 157.2 cc. Operation time was 210.4 ± 63 mins. Hospitalization was 13.8 ± 7.5 days. Recurrence or progression rate was 4.2%. In subgroup analysis, EBL with foraminal extension ($P = .03$), operation time with more 2 levels ($P = .04$) and the difference of preoperative and postoperative VAS with schwannoma ($P = .05$) was increased significantly. The present study showed significant improvement of VAS in lumbar level and McCormick grade in cervical level more than other levels. There was no severe kyphotic degeneration after laminectomy. **Conclusion:** Clinical outcomes of unilateral laminectomy approach for the spinal ID- EM tumors were excellent even in foraminal extension and multi-level cases. The minimal approach does not preclude a low recurrence rate. Unilateral laminectomy approach for patients with relatively short life expectancy would be the good option of surgical approach. That might be also selective option for good general condition and young age patients.

A253: The Management of Spinal Metastases from Renal Cell Carcinoma

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Introduction: Metastatic spine disease accounts for 10% to 30% of new cancer diagnoses annually. Surgical intervention is indicated in patients with spinal instability, spinal compression, progressive neurologic deterioration. For the management of spinal metastases two different approaches can be chosen. There are radical resection and palliative resection of the tumor. Surgical decompression and stabilization, along with targeted therapy and bisphosphonates, may provide the most promising treatment. In this research the frequency of local recurrences, quality of life and survival were studied depending on the surgical approach. **Material and Methods:** Between 2009 and 2015, 99 patients with histologically verified renal cell cancer metastasis were retrospectively reviewed. There were 66% males. Mean age of 55 years (range 35-71). Mean follow-up of 12 months. All patients were treated with targeted therapy and bisphosphonates. The patients were divided into two groups depending on the surgical approach. In

the first group 46 patients underwent radical tumor resection. In the second group 53 - palliative tumor resection. Local recurrences of the tumor were evaluated. Overall survival was calculated using the Kaplan-Meier method. Quality of life was evaluated using a questionnaire SF-36 3, 6 months postoperative follow-up. **Results:** In the I group a local recurrence occurred in 24.0% (11/46) of patients, in the II group - in 24 cases (45%) during 1 year follow-up. Local recurrences were significantly ($P < .001$) less frequent in patients with radical tumor resection. The difference in survival between groups wasn't statistically significant ($P < .001$). In the first group approach has been shown to be associated with greater blood loss and operative time; in the second group surgery was less invasive. And in the first group were taken more complications such as dural tears, neurological deficit. Consequently, quality of life 3 months after more aggressive surgical approach as radical tumor resection has low rates results. But then 6 months follow up quality of life parameters in both groups were improved. **Conclusions:** Analysis finds comparable results of survival rates and quality of life 6 months follow-up with both approaches. More aggressive surgical approach as radical tumor resection has fewer frequency of local recurrence, but longer time postoperative recovery. Palliative resection of the tumor is an acceptable approach especially for the patients with comorbidities, because of less invasive and has fewer complications.

A254: Metastatic Spinal Cord Compression: Effects of Tumour Type on Survival

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Introduction: Metastatic spinal cord compression is defined radiographically as an epidural metastatic lesion causing true displacement of the spinal cord from its normal position in the spinal canal. Spinal metastasis is common in patients with malignancy. The spine is the third commonest site for metastasis after lung and liver. Approximately 70% of cancer patients have metastatic disease at death. The spine is involved in up to 40% of those patients. Spinal cord compression may develop in 5% - 10% of cancer patients and up to 40% of patients with pre-existing non-spinal bone metastasis. The management of patients with metastatic spinal cord compression is individualised and can include surgery, radiotherapy or chemotherapy. The role of surgical decompression is expanding with the increase in survival times. **Material and Methods:** Prospective data collection of consecutive 192 patients referred with suspected metastatic spinal cord compression of whom 151 constituted the most common tumour types were included. Record of surgical intervention and survival times were collected over a 2 year period. **Results:** A total of 151 patients were identified in the study, 64% were males (96/151) and 36% were females (55/151). Tumours included were breast, prostate, lung, myeloma, renal cell carcinoma and malignancy of unknown origin. The mean age was 67.4 (Median 69 and Range 32-94 years). Breast, prostate and lung primaries represented 15, 34 and 23% respectively. Eighty-seven percent of patients (131/151) were treated non-operatively with an overall mortality rate of 84.7%. The mortality rate at 6 months was 73% (n = 95), range 0-5.7 and median of 1.5 months ($P = .0001$). The mortality rates at 6 months for breast, prostate and lung primary patients were 50% (mean 2.9, median 3 months), 67% (mean 1.7, median 1.7 months) and 93% (mean 1.7, median 1.5months) respectively ($P < .0001$). Surgical intervention was performed in 13% of patients (20/151). The overall mortality was 45%. The mortality at 6 months was 30% (n = 6), range 0-4.6 and median 1.6 months ($P = .0056$). The mortality rates at 6 months for breast, prostate and lung primary patients were 12.5% (mean 4.6 months), 33% (mean 1.3 months) and 100% (mean 1.6 months) respectively ($P < .0001$). **Conclusion:** Operative intervention certainly has a role in the management of patients with metastatic spinal cord compression, however, the natural history of the primary tumour should be taken into account when deciding whether or not to intervene surgically. The cost effectiveness of surgical intervention versus palliative care should considered carefully, especially in the current economic climate with ongoing financial pressures on the National Health Service.

A255: Chromosomal Deletion (22q13) May be Associated with Sacral Chordoma Recurrence

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Introduction: Chordoma is characterized with a high rate of recurrence and questionable response to radiotherapy. Adjuvant chemotherapeutic possibilities are limited because the molecular genetic pathogenesis of the tumor is still not known. The goal of the authors was to find new chromosomal aberrations and gene expression variations of the tumor by using next generation total RNA sequencing, with the possibility of identifying novel molecular targets in chordoma. **Material and Methods:** Next generation sequencing of total RNA was performed on 8 fresh frozen sacral chordoma samples and 8 nucleus pulposus cell culture samples. Data was analyzed with standard bioinformatic tools available on the Galaxy server (Galaxy Main), to identify fusion transcripts and evaluate differential gene expression. The results were validated by using polymerase chain reaction from the reverse transcripted RNA

samples (RT-PCR). **Results:** A new in-frame gene fusion was observed between the SAMM50 and TBC1D22A genes in the sample of a patient with multiple sacrum chordoma recurrences. Both genes are localized on chromosome 22, and the fusion transcript appears to be the result of a large interstitial deletion in the 22q13 region (over 2.7 Mbp), which is known to be a fragile genomic region. Many of the genes localized within the deleted region (GTSE1, PPARA, WNT7B, CELSR1, FBLN1) have a role in oncogenesis, and PPARA expression was suppressed in all chordoma samples compared to normal cells. **Conclusion:** This work demonstrates the first successful next generation total RNA sequencing from chordoma. A chromosomal deletion was detected by identifying a fusion transcript of the SAMM50-TBC1D22A genes in a case characterized by several recurrences. The deleted chromosomal region can be associated with oncogenesis, as well as with the susceptibility of recurrence of chordoma. These molecular genetic findings can help to develop general and individualized adjuvant therapeutic options for chordoma patients.

Biomechanics

A256: The Effect of an Interspinous Spacer on the Pars Interarticularis after Minimally Invasive Lumbar Decompression: A Finite Element Analysis

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Introduction: Minimally invasive (MI) lumbar decompression is a common procedure for spinal stenosis disease. These dorsal decompression procedures can benefit so many patient by reducing pain and recovering the function. Resections of posterior bony structure of lamina and partial or total disc in decompression procedure are often performed, but they are also associated with potential postoperative spinal instability on posterior neural arch. Recently, a number of interspinous spacers (ISS) have been combined with MI decompression for surgery of degenerative lumbar disc disease as a concept of dynamic stabilization. The ISS is designed to restrict segmental motion and theoretically did some potential beneficial effect and avoid the development of adjacent level complications. A current study has been done to evaluate the biomechanical influence of MI decompression plus the DIAM on the pars interarticularis area. **Material and Methods:** The MI decompression procedures are simulated to including the laminotomy over mainly part of L3 and less part of L4 and discectomy over L3/L4 levels. Finite element models were developed for the intact spine (INT), the DIAM was implanted at L3/4 (DIAM), the unilateral MI decompression procedures with DIAM (DIAM+uni), and the bilateral MI decompression procedures with DIAM (DIAM+bil). The models were subjected to axial loads and pure moments and evaluated by a hybrid method on range of motion (ROM)s, disc stresses, pars interarticularis stresses, and facet joint contact forces. **Results:** The investigation revealed that it is similar to the disc stresses including adjacent levels after DIAM insertion with uni- or bilateral MI decompression procedures but a considerable increase in stresses over pars interarticularis at L3 in both flexion and extension and decrease in stresses at L4 in extension. In contrast to L4, the amplitude of increasing stresses distribution across L3 pars interarticularis in extension were likely to be observes significantly larger. **Conclusion:** The MI decompressions are broadly being performed for lumbar spinal stenosis. Surgeon always concerns the risk of stress fracture for remaining posterior neural arch. The ISS did alter the biomechanical behavior in various indications. The effects of ISS combined with MI decompression is still unclear and no previous studies was known or done to study the changes of posterior neural arch with MI decompression procedures plus ISS. The results demonstrate the DIAM apply a distraction force and unload the facet force in posterior element after MI procedure, but this implantation may led to much greater stress concentrated in pars area, especially in upper level of implanted segment. The increased stresses at the pars interarticularis could still be a risk factor for a stress fracture. The surgeon should consider the possibilities for pars fracture in active patient group after these procedures with ISS.

A257: Optimal Cement Dosage and Configuration for Prophylactic Vertebroplasty Above Long Thoracolumbar Fusion Constructs to Reduce Proximal Junction Kyphosis (PJK): A Finite Element Model

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Introduction: PJK is not uncommon and can result in significant complication after spinal deformity surgery. Prophylactic vertebroplasty has been shown to reduce the rate of PJK, but optimal cement dosage and configuration has yet to be analyzed. Using a finite element (FE) model we analyzed various dosages and configurations of vertebral cement to see how it influences junctional endplate stress. **Material and Methods:** A validated FE T6-pelvis osteoporotic spinal model was modified with screws/rods from T10-S1 and various dosages (0 – 5ccs) and configurations (anterior, anterior/central, and central placement) of vertebral cement was simulated in T10 (UIV), T9 (UIV+1), and T8 (UIV+2). With the pelvis fixed, load was applied 10 mm anterior to the center of T6 to simulate a flexion moment. Endplate stresses were recorded from T7 to T9. **Results:** FEA identified the optimal cement dosage of 2.5 cc in T10, 2 cc in T9, and 1 cc in T8 resulted in the smallest change in stress observed at the inferior endplate of the

unadulterated T7 vertebra, relative to the superior endplate of cemented T8 at −7.6%. Larger volumes of cement (5 cc) resulted in larger changes in endplate stresses, including maximum changes of 37.3% and 61.1% with centrally and anteriorly placed cement, respectively. Using this dosage (2.5 cc, 2 cc, 1 cc), optimal cement configuration included anteriorly placed cement in the UIV (T10), anterior/central placement in the UIV+1 (T9), and centrally placed cement in the UIV+2 (T8). This resulted in the lowest endplate stresses in the both cemented (T10, T9, and T8) and more importantly in the unadulterated non-cemented (T7) vertebra. **Conclusion:** Prophylactic vertebroplasty has been advocated to reduce the rates of PJK and revision surgery, but the number of levels, cement dosage, and configuration has not been evaluated. In this osteoporotic T10-S1 instrumented spine FE model, placing 2.5 cc anteriorly in the UIV (T10), 2 cc anterior/central in the UIV+1 (T9), and 1 cc centrally in the UIV+2 (T8), reduced the endplate stresses in both the cemented (T10, T9, and T8) and more importantly in the supra-adjacent non-cemented T7 vertebra. Decreased endplate stresses may translate to vertebral bodies that are

A258: A Biomechanical Analysis of a Novel Growing Rod for Early Onset Scoliosis

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Introduction: Early onset scoliosis (EOS) is defined as the development of an abnormal spinal curve occurs in growing children before the age of 10. Invasive corrective surgeries are often required for the children ineffectively responding to conservative treatment and curves have rapidly progressed. Surgical implantation such as growing rod system is used to correct spine deformity. The forced growing rod system has been found to demonstrate effective spinal deformation correction; however, it has its shortcomings, such as requiring periodical revision surgeries. The purpose of this study has two aims: one is to design a novel self-adjusted growing rod that would control the spinal deformity and allow the growth of spinal column without repetitive invasive surgeries and secondly, to compare the biomechanical properties of the self-adjusted growing rods to the current clinical-used rods construct in different motions. **Material and Methods:** The design of the self-adjusted growing rod was center on the mechanism housed within a connector that allowed a unidirectional elongation of the pair of rods. Porcine thoracic spines with 8 vertebrae (n = 6) were used. Each specimen was tested following the grouping: 1) non-instrumented, 2) self-adjusted rods, and 3) rigid rods. Nondestructive bending moments of 5 Nm in the direction of flexion, extension, lateral bending were applied. Rods elongations were recorded and the vertebral motions were measured using a motion tracking system. The biomechanical analysis included the range of motion (ROM) of the instrumented as well as the adjacent levels. Furthermore, the force required for the elongation of the unit length for the self-adjusted rod was also determined. **Results:** The average pull force of 10.4 N was required for the self-adjusted rod to be lengthened by a single scaled unit. Irrespective of test conditions, all specimens with instrumentations demonstrated a significant decrease of ROM in instrumented levels compared to the specimens without the instrumentations (60.6% and 75.8% decrease in lateral bending and flexion-extension motion for self-adjusted rods; 86.3% and 89% decrease in lateral bending and flexion-extension motion for rigid rods, respectively) ($P < .05$). However, ROM of specimens of the self-adjusted rods were significantly higher than the rigid rods ($P < .05$). In terms of the adjacent levels, no significant difference was found among the three groups. Moreover, elongation of self-adjusted rods was observed in lateral bending and flexion motion. **Conclusion:** In the current study, a prototype of the novel self-adjusted rods construct was successfully designed and utilized in the biomechanical test. The results proved that the self-adjusted rods construct provided more stable instrumented segments than non-instrumented group; and furthermore, preserved more range of motion than rigid rods. It is anticipated that the design will be suitable for treating early onset scoliosis. Most of all, the length of the self-adjusted rods can be modulated by the patients themselves, and hence prevents the patients from repeated invasive lengthening procedures.

A259: Biomechanical Aspects of Non-rigidity in Lumbopelvic Reconstruction following Total Sacrectomy

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Introduction: En-bloc resection of a primary malignant sacral tumor with wide oncological margins impacts the biomechanics of the spinopelvic complex deteriorating postoperative morbidity and mortality. The closed loop technique (CLT) for spinopelvic fixation (SPF) uses one single U-shaped rod to connect all pedicle and iliac screws. The method applies the philosophy of non-rigid fixation to avoid the stress-shielding phenomenon and to promote the bony fusion between the lumbar vertebral body and the pelvis. Solid bony connections will be formed within the first 24 months after the surgery. Here, based on the 6 years follow up clinical data, we establish a method to measure the deformation in the hardware system, and to numerically determine the fusion process. **Materials and Methods:** Retrospectively post-operative CT scans were collected from a male patient who underwent total sacretomy at

the age of 42 due to chordoma. CLT technique was used to reconstruct the spinopelvic junction. From our database we collected 12 CT scans during the 6-year long follow up. We defined the 3D geometry of the implant construct and by using image registration algorithms. A common coordinate system for the CLT was used in order to measure and visualize the deformation of the hardware during the 6-year long follow up. We selected a region of interest (ROI) at the proximal level of the construct and the modulus of the displacement during the follow up period was determined. In order to investigate the fusion process we defined a single axial slice based voxel finite element (FE) mesh. The ROI determination was based on the second post-operative CT scan where we had solid bony fusion between the pelvis and the L.V. vertebral body. We determined the Gray scale values, and using linear empirical equation bone mineral density (BMD) values for every mesh element was assigned. For the BMD assignment we determine 10 categories with linearly increasing values and different color codes. **Results:** The developed method has allowed us to visualize the 3D deformation of the implant construct during the investigated period. The mean displacement value of the ROI during the 6 years was found to be 6.04 mm. We determined and visualized the element distribution over time in the different BMD categories and found in the highest BMD value category on the first post-operative CT was 9 FE mesh elements, at the 2 years FU was 64 FE elements and after 6 years it was 144 FE elements. **Conclusion:** The observed deformation occurred due to the shock/load absorber characteristics of the CLT providing strong lumbopelvic bony fusion within 2 years. The study results and the measurement method can be used for validation of complex patient specific FE models which can be useful for the individualized pre-operative surgical planning.

Adult Deformity 2

A260: A Retrospective Value Analysis of the Management of Primary Adult Spinal Deformity

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Introduction: Surgical management of spinal deformity is characterized by significant variability in the rates, costs and approaches to care. Such variability is clear evidence of the absence of an evidence-based approach to care. Areas of both high cost and high variability present potential targets for innovation, cost-saving and the promotion of consensus in clinical practice. The purpose of this study is to: (1) identify and document the range of direct costs for multi-level spinal fusions and reconstructions for ASD; (2) correlate surgical outcomes with administrative data to identify predictors of surgical and patient reported outcomes; (3) determine if there exists a correlation between dollars spent and outcomes achieved in ASD surgery. **Material and Methods:** Retrospective study of a consecutive series of patients treated with primary multilevel spine surgery for ASD. ASD patients who underwent multilevel spinal fusions from the upper thoracic spine (T3/T4) and lower thoracic spine (T10/T11) to pelvis met inclusion criteria. Patients with incomplete billing or Health Related Quality-of-Life (HRQoL) data were excluded from the study. Demographic, surgical, direct cost data and HRQoL data were collected directly from administrative and medical ontologies. All records were chart reviewed and source verified for accuracy. **Results:** The cohort included 83 patients. Mean lenght of follow up was 911 days. Direct costs ranged from \$26,936-\$140,777 (mean = \$78,751 +/− \$21,592). Cost variability was the highest in blood product utilization (80.64 fold variation for non-zero charges) and lowest for time related operating room costs (3.55 fold variation). Implant costs were the largest contributor to the direct cost of care (46.3%) Median implant direct cost was \$33,557. Median implant cost was significantly heigher in patients who experienced positive changes in health status ($P = .005$). Mean change in EQ-5D Utility score was 0.16 with 66% of patients experiencing an improvement in health status from their spine surgery. There was no statistical difference in health status change for upper vs. lower thoracic fusions ($P = .22$) or posterior vs. circumferential fusions ($P = .82$). Lower ASA scores were correlated with greater improvements in health status ($P = .009$). 34% of patients required revision surgery. Mean time until revision surgery was 382 days. Those who had revision surgery had an average of 1.47 additional surgeries in addition to their index surgery. 46% of obese patients (BMI > 30) had revision surgery, while the revision rate for patients in a healthy range (18.5 < BMI < 25) was 22%. Lower thoracic fusions (31%) were less likely to require revision surgery than fusions to the upper thoracic (48%) but did not reach statistical independence ($P = .14$). **Conclusion:** The costs and outcomes of spinal surgery are highly variable. Implants, operating room time, and length of stay were the most important drivers of cost for a hospital admission. Areas of high cost and high variability offer potential targets for cost savings and quality improvements. High BMI and ASA scores were predictors for revision surgery. Surgical approach and length of fusion did not significantly effect changes in health status.

A261: Development and Assessment of a Novel Adult Spinal Deformity (ASD) Frailty Index (ASD-FI) to Assist with Risk Stratification for ASD Surgery

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Introduction: The high complication rates currently associated with ASD surgery necessitates the development of accurate preoperative complication risk measurements. Frailty has been associated with complication incidence in trauma surgery. **Material and Methods:** 40 variables in an ASD database were selected to calculate a frailty score for each patient in the database and used to stratify them into 3 frailty cohorts: not frail (NF) <0.3, frail (F) 0.3-0.5, severely frail (SF) >0.5. We then performed a multivariate logistic regression to determine the relationship between frailty cohort and incidence of major complications. **Results:** Of 417 participants eligible for minimum 2-year follow-up the average ASD-FI score was 0.34 (range 0.0 – 0.8). Compared to NF patients (n = 171), F (n = 162) had a 2.6 day [0.95-4.3] ($P < .01$) longer and SF (n = 84) had a 6.4 day [4.2-8.7] ($P < .001$) longer LOS. The adjusted odds of incurring a major intraoperative or postoperative complication was 9.4 times greater for F and 14.5 times greater for SF than NF. Compared with NF, the odds of having a medical complication were 3.9 for F and 14.6 for SF and the odds of having a surgical complication were 1.8 for F and 2.1 for SF. The adjusted odds ratio of developing proximal junctional kyphosis was 4.4 and that of developing a wound infection was 5.1 for SF compared to NF patients. **Conclusion:** Increasing patient frailty, as measured by the ASD-FI, is associated with increased risk of major complications. The ASD-FI is a potential tool that spine surgeons may use to improve the accuracy of preoperative risk stratification and aid patient counseling.

A262: Despite Higher Risk Stratification Scores, Frail Patients Achieve Greater Two-year Health Related Quality of Life Improvement from Baseline Compared to Non-frail Patients Following Adult Spinal Deformity Surgery

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Introduction: The ASD-FI is a risk stratification tool which predicts major complications and prolonged hospital length of stay. The impact of frailty on postoperative improvement in HRQOL is unknown. **Material and Methods:** ASD patients who underwent ≥4 level instrumented fusion and had minimum 2-year follow-up were stratified by ASD-FI score into categories: not frail 0-3 (NF); frail 3-5 (F); and severely frail >5 (SF). We compared baseline demographic, HRQOL, and radiographic parameters. The primary outcome measure was reaching substantial clinical benefit SCB (SCB) in ODI, SF-36 PCS, back and leg pain. Secondary outcomes included: absolute and change in ODI, PCS, MCS, back and leg pain. SCB thresholds for outcome following lumbar fusion were utilized. **Results:** 332 patients were identified with 2-year follow-up: 135 NF, 175 F, and 22 SF. F and SF patients were significantly older, had more comorbidities, worse baseline HRQOL and pain scores (e.g. ODI 69.5, 52.5, 27.6 for SF, F, and NF; $P < .0001$), and worse radiographic deformity (e.g. SVA 130.5, 85.9, and 28.4 mm for SF, F, and NF; $P < .0001$). At 2-years, ODI, PCS, MCS, back and leg pain were all worse in F/SF than NF patients. More NF than F patients reached SCB for back pain (63.4 vs. 57.5%; $P = .045$) whereas more F than NF reached SCB for ODI (43.7 vs. 29.3%; $P = .025$), PCS (56.9 vs. 51.2%; $P = .03$), and leg pain (45.8 vs. 23.0%; $P = .003$). SF patients were least likely to achieve SCB for ODI (28.6%), PCS (18.2%), and back pain (28.6%). **Conclusion:** Despite higher preoperative risk stratification scores, worse baseline HRQOL scores, and greater complication rates, frail patients experience greater improvement in HRQOL and likelihood of reaching substantial clinical benefit compared to non-frail patients.

A263: Which Clinical Parameters of the Schwab-SRS Classification System for ASD Is Significant in Predicting Treatment Outcomes for Surgically Treated Patients?

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Introduction: Adult spinal deformity (ASD) is a complex group of conditions with a broad range of clinical and radiological characteristics. We had concernsthat the most widely used classification system may lack the ability to evaluate all these characteristics and provide guidance on treatment alternatives. Specifically, although having shown to be associated with outcomes, a multitude of (only) radiological parameters may demonstrate a substantial co-linearity and may not necessarily be useful for classification and guidance purposes.The Aim of this study is to evaluate the impact of Schwab-SRS classification parameters on the treatment outcomes for ASD. **Material and Methods**: Prospectively collected data from a multicentric adult deformity database of surgically treated ASD patients with a minimum of 1-year follow-up. Using MCID, patients were dichotomized into two groups of improved or unimproved. Chi-Square test analyzed the difference in baseline Schwab-SRS modifiers (Curve types, PI-LL, PT and SVA) of the two cohortsfor ODI, SF-36MCS, SF36-PCS and SRS22. A multivariate logistic regression model was then built when a relationship was found between these parameters and any of the outcome measures. **Results**: A total of 186 patients, (157 female, 29 male) were included (Figure 1). There were no significant differences inbaseline Schwab-SRS parametersbetween improved and un-improved cohortsforODI, SRS22 and SF36-MCS ($P < .05$). For SF36-PCS howevera significant difference in baselinePI-LL (0, +, ++) between the cohorts was seen. Multivariate regression analysis shows Odds Ratio of 4.584 to improvement for 3FS6-PCS if PI-LL is <10° (0) vs. PI-LL>20°(++) ($P = .001$). **Conclusion**: Baseline Schwab-SRS parameters PT, Curve type and SVA were not significant prognostic indicators of improvementat 1 year post surgery for all outcome measures. Baseline PI-LL is predictive of reaching MICD at one-year post surgery.These findings suggest that the present classification system may not be a very accurate tool for prognostication in surgically treated patients. In addition, not all radiological parameters included in this system may be neededeither; the usefulness of this classification system may be reduced down to lesser essential parameters.

Figure 1. Chi-square test analysis grey area for SF36PCS& multivariate logistic regression analysis. (PI_LL shows significance only with SF36PCS)

		PI-LL _Baseline			
P<0.001		<10° (0)	10°><20° (+)	>20° (++)	Total
SF36 PCS_MCID	Un-improved	48	16	13	77
	Improved	29	18	36	83
Total		77	34	49	160

Multivariate Logistic Regression Analysis

			95% C.I for OR	
SF36PCS	P-Value	Odds Ratio	**Lower**	**Upper**
PI_LL (0)	0,001			
PI_LL (+)	0,135	1,862	0,823	4,211
PI_LL (++)	0,000	4,584	2,093	10,039
Constant	0,032	0,604		

A264: Factors Associated with Prolonged Ventilation and Reintubation in Adult Spinal Deformity (ASD) Surgery

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Introduction: The scope and incidence of adult spinal deformity surgery has been pushed considerably over the last 10 years with more complex and longer reconstructions and corrections. This is to no small part due to the development of different approaches to the spine that allow for a more extensive realignment and reconstruction. However, with more extensive surgical procedures, the risk to the patient including the need for more extensive post-operative care increases. IN this study, we aimed to investigate the incidence and risk factors for prolonged ventilation and reintubation in adult spinal deformity (ASD) surgery. **Material and Methods:** The American College of Surgeons National Surgical Quality Improvement Program database (2007 – 2013) was reviewed. Inclusion criteria were adult patients over 21 years of age who underwent spinal fusion for ASD. The association between patient/operative characteristics and prolonged ventilation/reintubation was

investigated via multivariate analysis. Results are presented as odds ratios (OR) with 95% confidence intervals (CI). **Results:** There were 1,250 patients who underwent ASD surgery and met our inclusion criteria. Among these, there were 34 patients who required prolonged ventilation (2.7%) and 22 patients who underwent reintubation (1.8%). Factors associated with prolonged ventilation after multivariate analysis were history of bleeding disorder (OR 5.67; 95% CI, 1.01 – 31.83) and operative time over 6 hours (OR 3.72; 95% CI, 1.17 – 11.80). For reintubation, these included older age (OR 1.06; 95% CI, 1.01 – 1.12), history of bleeding disorder (OR 12.21; 95% CI, 2.03 – 73.42), and fusion of 13 or more spinal levels (OR 9.14; 95% CI, 1.53 – 54.63). **Conclusion:** Prolonged ventilation and reintubation in ASD surgery are uncommon events. Older patients, patients with bleeding disorders, and those undergoing long operations and fusion of 13 more spinal segments may be at an increased risk for these occurrences.

A265: Adult Spinal Deformity Patients with Previous Fusions Have an Equal Chance of Reaching Substantial Clinical Benefit Thresholds in Health-Related Quality of Life Measures but Do Not Reach the Same Absolute Level of Improvement

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Introduction: Substantial clinical benefit (SCB) represents a threshold above which a patient recognizes substantial benefit and may therefore be a desirable target outcome. We investigated the impact of prior spinal fusion on the likelihood of reaching SCB thresholds for 2-year health-related quality of life (HRQOL) after adult spinal deformity (ASD) surgery. **Methods:** We included ASD patients who achieved minimum 2-year follow-up. We compared baseline demographic, HRQOL, and radiographic features for patients undergoing primary versus revision procedures. The primary outcome measure was reaching SCB threshold in Oswestry Disability Index (ODI), SF-36 physical component summary (PCS), back and leg pain (numeric rating scale; NRS). Secondary outcomes included absolute and change scores in ODI, PCS, back and leg pain. We used SCB thresholds previously reported for outcome following lumbar fusion. **Results:** 332 patients achieved 2-year follow-up, including 228 primary and 104 revision cases. Those undergoing revision surgery had similar demographic features (age 58.3/55.9, female 80.8/82.9%, Charlson Comorbidity Index (1.9/1.6) to primary surgery patients. Revision surgery patients had worse baseline HRQOL (ODI 48.5/41.2, PCS 29.5/33.4, back 7.5/7.0, and leg pain 4.9/4.3; $P < .001$) and radiographic deformity (sagittal vertical axis 111.4/45.1, pelvic incidence to lumbar lordosis mismatch 26.7/11.0, pelvic tilt 29.5/21.0; $P < .0001$). Nevertheless, the number of patients who reached SCB for ODI (38.3/36.3%), PCS (48.5/53.4%), back (53.1/60.5%) and leg pain NRS (28.6/36.9%) did not significantly differ between revision and primary operations. Despite similar magnitudes of improvement of outcomes measures, revision patients had worse 2-year HRQOL for all measures compared with primary surgery patients. **Conclusions:** Patients undergoing revision ASD surgery have worse baseline HRQOL and radiographic deformity. Although they do not achieve the same absolute level of 2-year HRQOL outcome scores as patients undergoing primary surgeries, they have a similar likelihood of reaching SCB threshold for improvement in 2-year HRQOL.

Cervical Surgery Complications

A266: Risk Factors and Clinical Outcomes of Dysphagia after Anterior Cervical Surgery in Patients with Degenerative Cervical Myelopathy: Results from the Prospective AOSpine Studies

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Introduction: Although dysphagia is a common complication after anterior cervical decompression and fusion (ACDF),

important risk factors have not been rigorously evaluated. Furthermore, the impact of dysphagia on neurological and quality of life (QOL) outcomes is not fully understood. This study aim is to determine the incidence and risk factors of postoperative dysphagia and evaluate short- and long-term clinical outcomes in patients with this complication. **Material and Methods:** Four hundred and seventy patients undergoing an ACDF or a 2-stage surgery were enrolled in the prospective AOSpine CSM-North America and International studies at 26 global sites. Logistic regression analyses were conducted to determine important clinical and surgical predictors of dysphagia. Preoperatively and at each follow-up, patients were evaluated using the modified Japanese Orthopedic Association scale (mJOA), Nurick score, Neck Disability Index (NDI), and the Short- Form 36 (SF-36) Health Survey. A two-way repeated analysis of co-variance was used to evaluate differences in outcomes at 6- and 24-months between patients with and without dysphagia, while controlling for relevant baseline characteristics and surgical factors. **Results:** The overall incidence of dysphagia was 6.2%. Univariately, the major risk factors for perioperative dysphagia were a higher co-morbidity score, the presence of cardiovascular and endocrine disorders, a 2-stage surgery and a greater number of decompressed levels. Based on multivariable analysis, patients were at an increased risk of perioperative dysphagia if they had diabetes, a greater number of decompressed segments, and a 2-stage surgery. Functional, disability and quality of life (QOL) improvements were comparable between patients with and without dysphagia at both short- and long-term follow-up. **Conclusion:** The most important predictors of dysphagia are endocrine disorders, a greater number of decompressed levels and a 2-stage surgery. Patients with postoperative dysphagia exhibit similar improvements in functional impairment, disability and QOL as patients without dysphagia in both the short- and long-term.

A267: A New Scoring System for Evaluation Early Dysphagia after Anterior Cervical Spine Surgery: A Prospective Study

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Introduction: Dysphagia is a common complication following anterior cervical spine surgery (ACSS). The majority of them occurred in the early postoperative period. The incidences of dysphagia were variable and controversial. The purpose of this study was to determine the incidence of early dysphagia after ACSS with a new scoring system, and to identify the risk factors for it. **Materials and Methods:** A prospective study was performed and patients who underwent ACSS from March 2014 to August 2014 in our hospital were included in this study. A dysphagia questionnaire was delivered to all of the patients from the first day to the fifth day after ACSS. Patients' age, gender, body mass index (BMI), operation time, blood loss, hardware use, preoperative JOA score were recorded, and the dC2-C7 angles (postoperative C2-C7 angle minus preoperative C2-C7 angle) were calculated on the plain film. The incidences of dysphagia were analyzed and the risk factors were evaluated. **Results:** A total of 104 patients who underwent ACSS were included in this study. The incidences of dysphagia from the first to the fifth day after ACSS was 87.5%, 79.81%, 62.14%, 50% and 44.23%, respectively. And there was a good correlation between the new dysphagia scoring system and Bazaz scoring system ($P < 0.05$). Patients who got early dysphagia after surgery had similar age, gender, blood loss, hardware use and preoperative JOA score comparing with those with no dysphagia. Operative time and BMI were the risk factors for dysphagia during the first to the second day postoperatively. However, the dC2-C7angle was the main risk factor for dysphagia from the third to the fifth day after surgery. **Conclusions:** There were comparatively high incidences of early dysphagia after ACSS, which were ascribed to operating time, BMI and the dC2-C7 angle. Spine surgeon should consider the degree of dC2-C7 angle when performing the surgery.

A268: Preoperative Radiographic Parameters to Predict a Higher Pseudarthrosis Rate following Anterior Cervical Discectomy and Fusion

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Introduction: Various factors, including type of bone graft, number of fusion levels, and duration of follow-up, have been reported to influence occurrence of pseudarthrosis after anterior cervical discectomy and fusion (ACDF). However, to our knowledge, there has been no report on the relationships between preoperative radiographic parameters and postoperative pseudarthrosis. The purpose of this study was to determine whether postoperative pseudarthrosis could be predicted according to specific parameters on preoperative plain radiographs, including segmental and global cervical motion and T1 sagittal slope. **Material and Methods:** We retrospectively analyzed 84 consecutive patients (male: female = 45:39; mean age, 58.9 ± 11.2 years) who underwent ACDF and were followed for more than 2 years. In all patients, allografts filled with local chip bone were inserted after discectomy and anterior plating was performed. On preoperative plain radiographs, various parameters were measured and analyzed; C2-C7 sagittal vertical axis (SVA), T1 sagittal slope, segmental motion, global cervical (C2-C7) motion, segmental interspinous motion, and location of fusion segments. Pseudarthrosis was diagnosed as interspinous motion >1 mm with superjacent interspinous motion ≥4 mm on the magnified plain dynamic

lateral radiographs at final follow-up. Multiple logistic regression was performed to analyze the risk factors of pseudarthrosis, and the receiver operating characteristic (ROC) curve was used to define a cutoff value. **Results:** Eighty-four patients (1 level in 49, 2 levels in 29, and 3 levels in 6) and 125 segments (4 at C3–4, 31 at C4–5, 55 at C5–6, and 35 at C6–7) were included. The pseudarthrosis rate was 29% based on number of patients (24/84) and 20% based on number of segments (25/125). Multilevel surgery and the lowest cervical fusion level showed a higher pseudarthrosis rate ($p = 0.01$). In multiple logistic regression analysis, C6–7 segment, greater T1 sagittal slope, and greater segmental motion were associated with a higher risk of pseudarthrosis ($P < 0.05$, respectively). A cutoff value of segmental motion of 12° demonstrated.pseudarthrosis with a sensitivity of 87%, specificity of 84%, and area under the curve of 0.899, indicating moderate accuracy**.** **Conclusion:** Greater preoperative segmental motion, greater T1 sagittal slope, and the lowest fusion level (especially C6-7 segment) could be risk factors of pseudarthrosis following ACDF. According to the ROC curve, a preoperative segmental motion >12° is likely to be a clue to predict the development of pseudarthrosis. Surgeons need to be aware of these risk factors which could be detected on preoperative plain radiographs and should consider various supportive procedures to enhance the fusion rate in those cases.

A269: Risk Factors for Dysphagia after Anterior Cervical Surgery: Preliminary Results from a Prospective Multicenter Study of the AOSLA Group

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Introduction: The objective is to determine the degree of dysphagia and predict factors associated with it. **Materials and Methods:** Prospective and multicenter observational cohorts of patients with spinal degenerative pathologies undergoing anterior cervical surgery were the target of this investigation, while patients undergoing posterior lumbar surgery were enrolled as a control group to determine the effect of the intubation itself on postoperative dysphagia. The exclusion criteria were trauma, tumors, and infectious diseases, previous history of head and neck surgery, gastroesophageal reflux disease, prolonged use of endotracheal tube or neurological disorders associated with dysphagia. The evaluation was made in the preoperative period and on postoperative days: 1, 7, 21, and 180. The factors analyzed were related to pathology (type (disc herniation, cervical stenosis, level of the disease, and anterior osteophytes)), patient (ASA score, age, BMI, sex, history of hypertension, diabetes mellitus, pulmonary disease, coronary artery disease, cancer, anxiety, depression, and smoking) and surgery (intubation attempts, right or left-sided approach, deep retractors used, release of endotracheal tube cuff pressure, number of fused levels, length of the surgery, and bleeding. The dysphagia was assessed by swallowing satisfaction index and swallowing questionnaires. Patients who refer to having dysphagia after 6 months will undergo an OTL examination. **Results:** the preliminary results comprise 85 consecutive patients who underwent anterior cervical approach and 105 consecutive cases in which a posterior lumbar approach was performed. The baseline characteristics of the cervical and lumbar cases had no significant difference except regarding length of surgery that was longer in cervical cases and volume of bleeding that was higher in lumbar cases. The satisfaction index and the severity of dysphagia (mild, moderate, and severe) were similar between the cervical and lumbar cases at the preoperative evaluation. The patients who underwent cervical approach had a lower satisfaction index on days 1, 7, and 21 after surgery when compared with the lumbar patients. Patients who underwent anterior approach had a major incidence of dysphagia on day 1 (49.4%, 42/85). Complaints about swallowing are progressively lower on day 7 (25.9%, 22/85) and day 21 (11.8%, 10/85). At 6 months, no swallowing complains was reported. The only variable that showed significance for dysphagia in cervical patients on the day 1 assessment was 2 or more orotracheal intubation attempts ($P = .05$). **Conclusions:** the prospective observational multicenter study in Latin America showed that the incidence of dysphagia after anterior cervical approach was 49.4%, 25.9%, 11.8% and 0.0% on 1, 7, 21, and 180 days after surgery. The severity of dysphagia was usually mild or after eating solid food. The only variable that showed significance for dysphagia in cervical patients on the day 1 assessment was 2 or more orotracheal intubation attempts ($P = .05$).

A270: The Effect of Uncinate Process Resection on the Subsidence in Anterior Cervical Discectomy and Fusion

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Introduction: The effects of uncinate process resection (UPR) on cervical spine instability have a controversy according to

study type; in vivo, in vitro. To estimate in vivo effects of UPR in the case of anterior cervical discectomy and fusion (ACDF), we evaluated clinical and radiological outcome after ACDF with bilateral UPR. **Methods**: We collected a clinical and radiological data from January 2011 to June 2015, retrospectively. A total of 29 patients 41 segments were included in this study. All procedure includes bilateral UPR and anterior plate fixation by single surgeon. Coronal reformatted-CT images were used to evaluate the resection rate of uncinate processes. To reduce level induced bias, we converted the area of UPR to proportion of UPR to pre-operative vertebral body (UPR/VB) or pre-operative uncinate process (pUPR). **Results:** The sum of bilateral pUPR ($P = .006$) is closely correlated to subsidence. By simple regression analysis, the subsidence could be estimated by following formula; subsidence = 0.896 + 3.980 * sum of pUPR. The subsidence rate was 34%. Comparative analysis revealed no significant difference on clinical outcomes, and fusion rate between subsidence group and non-subsidence group. **Conclusion**: We performed quantitative analysis of UPR, and correlation analysis with subsidence. Our finding suggests that if the sum of pUPR were more than 52.9%, the possibility of subsidence would increase significantly. ($R^2 = 0.178$, $P = .006$)

A271: Predictors of Clinical Outcome in Cervical Arthrodesis: Evaluation of Physical, Mental and Social factors

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Introduction: The influence of psychological and social factors has only recently been acknowledged to impact clinical outcome following spine surgery. Some studies demonstrated that preoperative affective disorders predicts poor outcome after spinal surgery. We aimed to identify potential risk factor for unfavourable outcome following cervical spine surgery for degenerative disc disease. **Methods:** In a prospective observational study the authors determined quantitative measurements of pain (visual analog scale [VAS]), health related quality of life (HRQL: SF-36 and EuroQOL-5D), disease-specific disability (ODI), metal status (anxiety [STAI-T, STAI-S and ASI-3] and Depression [ASD-K]) and social status (Berliner Social Support Scale [BSSS] and education level). Uni- and multivariate analyses were performed to assess associations between the various preoperative factors and the health related quality of life (HRQL) at 12 months follow up. **Results:** 51 patients met all inclusion criteria. 34 patients were male (66.7%); mean age was 58.6 years. Most patients were married or in a steady relationship (78.4%). Preoperatively high values in education ($r = 0.293$; $P = .07$), SF-36 PCS ($r = 0.405$; $P = .022$) and low scores of depression (ASD-K: $r = -0.363$; $P = .011$) and anxiety (ASI-3: $r = -0.354$; $P = .013$) and ODI ($r = -0.343$; $P = .038$) correlated with better HRQL at 1 year postoperatively. **Conclusion:** Clinical outcome one year after surgery is influenced by pre-operative physical, mental and social status. A screening instrument allowing the identification of such patients is feasible.

Lumbar Surgery 2

A272: Is There Clinical Evidence of Galvanic Corrosion in Constructs with CoCr Rods and Titanium Screws?

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Introduction: Combining Cobalt Chrome (CoCr) rods with Titanium (Ti) fixtures in cases of adult scoliosis is common because CoCr rods better support the increased correctional forces in these cases compared to Ti rods. However, research in other orthopaedic implants has raised concerns about galvanically accelerated corrosion on the interfaces between the two different materials, leading to early failure of the implants and patient reactions, including metallosis. Here we present the first spine retrieval study of comparing CoCr/Ti constructs with Ti/Ti constructs. **Material and Methods:** We have received spine instrumentation from 8 patients; 3 patients with CoCr/Ti constructs and 5 patients with Ti/Ti constructs. All patients gave consent for research on their implants. Implants were revised for infection, persistent pain, fractured components, to correct kyphosis and to prevent adjacent segment degeneration. In the case of the persistent pain, metallosis was discovered intraoperatively. All components were macroscopically inspected and documented using DSLR photography, following by microscopic inspection using an optical microscope to identify the contact areas between components and patterns of corrosion and wear. Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDX) were performed to identify the surface changes and the elemental composition of foreign debris. We then classified the different types and patterns on the rod junctions to develop a visual grading score for corrosion and wear. All junctions were scored by two researchers, expert in corrosion of orthopaedic implants, and then statistical analysis was performed to test the reliability of the proposed score. **Results:** Macroscopic and microscopic analysis revealed fretting and pitting on most of the junctions, while in 43% of the rod junctions black debris were found. EDX revealed that in the case of CoCr rods, that was Ti transfer from the fixtures to the rods, while in the case of Ti the origin was biological. Using the corrosion score, only 5% of the

junctions in CoCr rods showed no signs of damage, while all junctions in Ti rods showed at least some degree of wear. Most of the junctions on CoCr rods and all junctions on Ti rods were moderately damaged, while 7% of the CoCr junctions were severely damaged. K-analysis of the scores from the individual scoring of the junctions showed that the corrosion score is reliable (kappa > 0.7). Using this score, the components which were found with metallosis in the surrounding tissue had one of the lowest overall score. There was no correlation between time of implantation and corrosion score ($P = .2968$). However, we found that the scores between CoCr and Ti rods are significantly different ($P = .0107$), with CoCr being more severely damaged. **Conclusion:** There is evidence in corrosion in all implants with increased scores in the cases of CoCr rods. Corrosion is linked with reasons for revision including fracture of components, however from this study there was no clear link between increased scores and reaction to metal debris, suggesting that patient susceptibility might play a large role to implants failure.

A273: A Radiological Evaluation of Insertion S2 Alar-Iliac Screw in the Japanese Population

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Introduction: S2 alar-iliac screw (S2AIS) for lumbosacral fixation is becoming common procedure for deformity surgeries because of inline rod placement, low profile, less complication, and easy to harvest bone graft from iliac bone. Although it is useful surgical technique, there are few reports of comparison regarding optimal entry point of S2AIS so far. The purpose of this study was to determine optimal entry point for S2AIS from the normal Japanese population data. **Material and Methods:** We used 30 CT scans of pelvis in this study. All the pelvis scanned were free from bony diseases or deformity. These were from 15 males and 15 females CT scans of pelvis. We took 4 mm margin (accounting for half the diameter of a 8.0 mm pedicle screw) for S2AIS from inner ilium cortex, outer ilium cortex, and posterior cortex of the sacrum. We selected two entry points from previous papers. One was 1 mm inferior and 1 mm lateral to the S1 dorsal foramen (A group) and the other was midpoint between S1 and S2 dorsal foramen (B group). We compared between A group and B group regarding all of parameters. We measured (1) screw length, (2) angle in the axial plane, (3) angle in the sagittal plane, (4) angle range in the axial plane, (5) distance from entry point to sacroiliac joint, (6) distance from S2AIS to acetabular roof, (7) distance from S2AIS to sciatic notch, (8) insertion difficulty of S2AIS. Finally we compared each parameter between two groups. **Results:** In group A, (3) angle in the sagittal plane was significantly smaller and (7) distance from S2AIS to sciatic notch was significantly longer than B. In B group, there were statistically significantly longer regarding (1) screw length, (5) distance from entry point to sacroiliac joint, and (6) distance from S2AIS to acetabular roof than A. The rate of (8) insertion difficulty of S2AIS was much higher in A group. There were no significant differences between two groups regarding other parameters, (2) and (4). **Conclusion:** Regarding insertion from midpoint between S1 and S2 dorsal foramen, we can use longer screw than A group because of inner entry point. Regarding insertion from 1 mm inferior and 1 mm lateral to the S1 dorsal foramen, we found the number of insertion difficulty cases was much higher than the other entry point. It was because A group was very likely to perforate posterior cortex of the sacrum because of outer entry point. Based on our data, we recommend the insertion from midpoint between S1 and S2 dorsal foramen for S2AIS.

A274: Autologous Disc Chondrocyte Transplantation in Lumbar Spine Disc Degeneration Disease: A Prospective, Controlled, Randomized Study

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Introduction: Morphological restoration of degenerated intervertebral discs through the use of Autologous disc chondrocyte transplantation (ADCT) represents a strategy that offers a potential to accentuate disc metabolism that will achieve mechanic function. This could be demonstrate in a preclinical animal study and was translated into the clinical prospective, controlled, randomized study. **Materials and Methods:** 78 patients with single level intervertebral disc herniation with acute neurological symptoms or after conservative treatment failure were enrolled from January 2002 to November 2006 in a single institution. Operative procedure was done as a minimal invasive open sequestrectomy done by an experienced neurosurgeon. Cells are transplanted approximately 12 weeks following sequestrectomy to assure that the annulus has healed and will contain the cells. Therefore a single puncture was used. Oswestry low back pain disability questionnaire (OPDQ), Prolo and VAS scores were used for the evaluation. Disc height and water content were assessed by MRI. Demographic data, neurological status and BMI were collected from the patients 6, 12 and 24 months postoperatively. **Results:** 36 patients were randomized into the Autologous disc chondrocyte transplantation group and 43 patients into the control group. The mean age of the patients was 31.4 years; the mean BMI 23.9. 23 patients from the ADCT group were transplanted in level L5/S1 and 12 patients at level L4/5. There were 7 drop out patients by private reasons. After 24 Months the patients of the treatment group scored an average of 16.4 in the Oswestry questionnaire and 20.4 on the VAS, while the controls got 21.1 in the Oswestry

and 22.6 on the VAS. Regarding the Prolo scale, transplanted patients were able to reach a 4.7 and 4.5 in working situation and functional status in comparison to 4.6 and 4.4 in the non-treatment group. The differences between the two groups were much higher by comparison the changes in all scores after the operative treatment and in the 24 month follow up. Reherniation rate was reduced by 52%. No neurological or inflammatory complications were reported. **Conclusions:** For once, we were able to prove that no harm was done with the transplantation, that is at least as good as the standard procedure and that there is no common adverse effect. Furthermore, even though that there was no statistical difference between the two groups big enough to prove the benefit of the Autologous disc chondrocyte transplantation, we were still able to show that there is a tendency towards that 24 month after transplantation. Indeed, having such small differences may only shows how good our standard procedures already are. Knowing the degeneration process in younger patients is going on over more than 2 years we might just need to oversee the results over a longer period of time.

A275: Factors Influencing Lumbar Paraspinal Fatty Infiltration on MRI

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Introduction: factors influencing paraspinal muscle degeneration are still not well understood. Fatty infiltration (FI) is known to be one main feature of the degeneration cascade. The aim of this study was to illustrate the cluster of paraspinal lumbar muscle degeneration on MRI. **Material and Methods:** Mono-, Pluri- and Multi-segmental lumbar muscles groups were segmented on T2-weighted MR sequences using a novel semiautomatic technique for quantitative muscle/fat discrimination. The degree of fatty infiltration of t3 predefined muscle groups was compared on a 3-dimensional basis, with regard to segment involvement, age and disc degeneration. General linear models were utilized for statistical comparison. **Results:** N = 78 segments (age: 52.7; range 16 - 87years) could be included. The average fatty infiltration of the mono-segmental muscles (21.1 $\pm$ 14.5%) was significantly higher compared to the multi- (16.0 $\pm$ 8.8%) and pluri-segmental (8.5 $\pm$ 8.0%) muscles. Muscles on the levels L4/5 ($P = .09$) and L5/S1 ($P = .016$) showed a significant higher amount of fat compared to the levels L2/3 and L3/4 if degeneration was present. Higher age ($P = .039$) and disc degeneration (0.025) were co-variables associated with increased fatty infiltration. **Conclusion:** The complexity of the problematic issue of lower back pain is likely to be beyond the horizon of a simple bony disease. Muscle affection which was shown to correlate will to the degree of degeneration, may truly play a more important role than yet perceived by the general spinal community and would necessitate increased attention in the future.

A276: Failed Back Surgery Syndrome: Is This Patient Created Problem or Surgeon Created Problem?

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Introduction: Failed back surgery is a nonspecific term that implies that the final outcome of surgery did not meet the expectation of both the patient and the surgeon as it was established before surgery. Expected outcome varies according to the type of structural problems, the number and types of prior surgeries and the psychological health of the patient. These patients have some of the psychosocial problems and multiple operation on them lead to more severe pain and further detonation of their neurology. **Materials and Methods:** We present 12 cases of failed back surgery. All of them underwent multiple operations on the lumber spine, ie multiple discectomy, laminectomy and/or fusion. The etiology in 6 patients was recurrent disc herniation above the level of fusion. Two patients had nonunion of fusion mass; two had neuropathic pain and iatrogenic instability. In addition 2 patients had facet and sacroiliac joint pain. The number of previous spinal operations varied from 3 to 21. The time lapse of symptoms ranged from 3 months to 5 years. All of these patients had negative x-rays that could not explain the cause of their symptoms, and either CT scan / CT myelogram or MRI scans was done to identify the problem. **Result:** In all of these patients, the first line of treatment was conservative, namely with analgesia, antidepressants, physiotherapy, caudal and facet joint block. Four patients underwent revision surgery for removal of implant and discectomy just above the fusion level. In Three patients, pain could not be controlled, and these patients had implantation of spinal cord stimulator. This ultimately gave them relief. **Conclusion:** Failed back surgery syndrome is unfortunately common problem with enormous cost to patient, insurer and society. With a careful history, examination, imaging studies, psychological evaluation and diagnostic injection, a diagnosis can be made in over 90% of the cases. These patients should be treated conservatively with good team work, which include surgeon, psychiatrist, physiotherapist and the pain specialist. Our conclusion come to the fact that more the surgery these patient has more miserable these patients become.

A277: Multiple Anterior Cages vs Osteotomies in Sagittal Imbalance Management

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Introduction: The principles of lumbar lordosis restoration and sagittal balance are of primary importance in spinal deformity surgery. Biomechanical, clinical and radiological studies suggest that an amount of 75% of the total lumbar lordosis should be in the lower lumbar spine (between L4-S1) to improve outcome of surgical procedures. The most common techniques used to get this target are osteotomies. Smith Petersen Osteotomy (SPO) and Pedicle Subtraction Osteotomy (PSO) are the two most employed techniques. We describe our experience using multiple hyperlordotic cages (HLCs) in degenerative deformity surgery for lumbar lordosis restoration and sagittal imbalance management. **Materials and Methods:** we report a series of patients underwent multilevel anterior lumbar interbody fusions (ALIF) with HLCs to restore lower lumbar lordosis and sagittal balance realignment. The ALIF procedures were associated to posterior pedicle screw fixation and fusion to increase segmental lordosis and put in compression all the cages. All patients were examined with a standard X-Ray of the whole spine pre- and post- operatively (EOS), with measurement of spinopelvic parameters. We did use titanium HLCs filled with hydroxyapatite or bone graft, with 24°, 20° or 16° degrees of lordosis, on at least 2 levels (L4-L5 and L5-S1). **Results:** We show that the mean increase in lumbar lordosis was comparable or superior to huge posterior Osteotomy (SPO or PSO). **Conclusion:** Multiple ALIF with HLC provides a satisfactory increase in lower lumbar lordosis (L4-S1 lordosis). The use of those devices could decrease the need of posterior osteotomies (PSO and SPO) to restore lumbar lordosis and sagittal balance. Posterior major osteotomies have an high rate (up to 40%) of general (especially neurologic and mechanical) complications. However, a good knowledge of the anterior approaches to the lumbar spine and, mostly, pitfalls avoidance and management, is needed to perform this kind of surgery with good results and a low rate of associated complications.

Trauma Cervical 2

A278: The Impact of Translation and Stenosis on Spinal Cord Injuries in Traumatic Jumped Facet Injuries

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Introduction: Although facet dislocations are relatively rare among patients with cervical spine trauma, accounting for about 5% of all cervical trauma, the consequences are often devastating. Approximately a third of patients with unilateral jumped facets are diagnosed with SCI at presentation but there is large variability in the literature with respect to SCI in patients with bilateral jumped facets. The goal of our study was to assess a consecutive series of patients with jumped facet injuries to assess rates of SCI and the impact of sagittal diameter and translation on SCI. **Material and Methods:** Between 2004 and 2014, a retrospective review at a level I trauma center identified patients with unilateral or bilateral dislocated facets. Demographic data, initial neurological exams, and radiographic findings were reviewed with a detailed assessment of the injury computed tomography (CT) films. We assessed sagittal diameter at the level of the injury as well as the level above and below the injury. We also assessed the amount of translation at the level of injury. **Results:** Ninety-seven patients were identified as having unilateral or bilateral jumped - 39 were unilateral and 58 bilateral. Of the 97 patients, 61% had a SCI with 38 ASIA A, 4 ASIA B, 4 ASIA C, 13 ASIA D, and 38 ASIA E on admission. When assessing canal diameter at the level of injury, those with ASIA A SCI had an average diameter of 8.00 mm (95% CI 7.50 - 8.50) versus those with ASIA E with an average of 12.63 mm (95% CI 11.83 – 13.44) ($P < .001$). When assessing translation at the level of injury, those with ASIA A SCI measured 8.03 mm (95% CI 7.19 – 8.86) and those with ASIA E measured 4.22 mm (95% CI 3.48 – 4.95) ($P < .001$). Due to the small sample size of those with ASIA B (4), C (4) and D (13), we combined those with ASIA A-C and compared them to ASIA D-E with the assumption of significant difference in a general ability to function independently with this separation. Canal diameter at the level of injury for those with ASIA A-C SCI averaged 8.40 mm (SD 1.94 mm) and those with ASIA D-E averaged 12.32 mm (SD 2.46 mm) which was significantly different ($P < .001$). Translation in patients with ASIA A-C measured 7.72 mm (SD 2.55 mm) compared to those with ASIA D-E which measured 4.39 mm (SD 2.18 mm) which also was significantly different ($P < .001$). When plotted on a Receiver Operating Characteristic (ROC) curve, translation was a good predictor of ASIA A-C SCI and canal diameter was an almost perfect predictor of ASIA D-E SCI. **Conclusion:** Patients with greater translation and/or smaller diameter have a higher rate of SCI. We found an average canal diameter of 8.40 mm and translation of 7.72 mm in those with ASIA A-C injuries compared to a diameter of 12.32 mm and translation of 4.39 mm in those with ASIA D-E injuries. Translation was a better predictor of ASIA A-C and diameter was a better predictor of ASIA D-E.

A279: Prospective Clinical and Radiographic Assessment of the Cervical Spine in Professional Rodeo Riders After Exposure to Greater than 10G Linear Acceleration

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Introduction: Whiplash Associated Disorder (WAD) remains a controversial clinical diagnosis. Few models exist to comprehensively assess the clinical effects of rotational and linear acceleration on the cervical spine. As professional rodeo riders are subjected to repeated flexion/extension events during their rides, they represent an ideal population to assess the clinical and radiographic effects of massive acceleration and deceleration on the cervical spine. The purpose of this study was to evaluate the clinical and radiographic effect of a measurable acceleration / deceleration event on the cervical spine in professional rodeo riders using objective clinical data and validated health related quality of life (HRQoL) scores. **Material and Methods:** The following outcome measures were evaluated: Pre- and post-ride physical examination; Visual Analogue Score (VAS) for Neck, Arm, and Back; Neck Disability Index (NDI); Short Form-36 (SF-36); EuroQuol (EQ-5D); pre- and post-ride MRI of the cervical spine. After informed consent, subjects underwent focused physical examination by a licensed physician and completed the aforementioned validated questionnaires before each ride. Six riders also underwent pre- and post-event MRIs of the cervical-spine. VAS neck and arm pain scores were assessed post-ride. Peak linear accelerometer data were recorded by a mouth-guard accelerometer. Descriptive statistics were performed and pre- and post-ride data were compared using Student's T-tests with α set at $P \leq .05$. **Results:** Twenty-one male professional roughstock riders (bareback-8, saddle bronc-7, bull riders-6; average age 24.3 $\pm$ 5.6 years) were enrolled. They reported to have competed in an average of 55 $\pm$ 25 rodeos per year. The minority reported a prior neck injury (5/21) and missing rodeos due to neck injuries (4/21). No riders reported prior neck surgery. Baseline NDI (4.9 $\pm$ 6.5), EQ-5D (0.89 $\pm$ 0.15), and SF-36 (PCS 51.9 $\pm$ 6.2, MCS 55.1 $\pm$ 4) were recorded. Seventeen riders' mouth-guards recorded events >10 g. Mean linear acceleration was 23.8 $\pm$ 13.9 g. Peak linear acceleration was 62.8 g. Post-ride VAS for neck pain trended towards higher scores although the difference was not significant (pre: 0.48 *v.* post: 1.0; $P = .10$). Post-ride VAS scores for arm pain were not significantly different from pre-ride scores ($P > .25$). There were no differences in post-ride VAS scores between the bareback, saddle bronc, and bull riding groups ($P > .20$). Mild disk bulging adjacent to pre-existing disease was noted in 2/6 post-ride MRI scans but no clinically significant changes were identified. **Conclusion:** Repeated high G-forces did not significantly impact the clinical incidence of neck or back pain in professional rodeo riders, nor did they produce any significant MRI changes. In this population, the extreme G-forces experienced by the cervical spine did not produce any acute cervical symptoms or new neurological deficits. As the G-forces experienced by these riders are significantly greater than most activities of daily living and low-speed rear-end automobile collisions, these data provide a clinically useful context for evaluating patients with whiplash injuries.

A280: Glasgow Coma Scale Score, Age and Intramedullary Lesion Length on MRI Are Independent Predictors of Mortality in Traumatic Upper Cervical Spinal Cord Injuries

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Introduction: Evidence from forensic necropsy studies indicates that more than 77% of patients in a motor vehicle accident who died at the scene had radiographic proof of upper cervical spine injuries (C1-C3). Almost one half of patients with traumatic upper cervical spine fracture dislocations and spinal cord injury (SCI) do not survive following admission to a trauma center. Sporadic case reports have shown that in these patients admission MRI indicated SCI at the epicenter of fracture dislocation and extension of spinal cord edema into the lower medulla oblongata. In patients with complete SCI there is abrupt interruption of supra-segmental impulses supplying diaphragmatic motor neurons, loss of sympathetic outflow into the intermediolateral cell columns of spinal cord (T1-L2 segments), and unopposed vagal parasympathetic impulses into the sino-atrial node. The resultant catastrophic tetraplegia, loss of diaphragmatic function, neurogenic shock, and cardiac bradyarrhythmias result in instantaneous death at the scene of accident. With today's rapid response offered by the emergency medical systems, there is a chance for immediate resuscitation and transfer of these victims into Level 1 trauma centers. The mean transfer time from injury to the resuscitation unit at this Level 1 trauma center is 59 minutes. High mortality rate is one of the reasons we find almost no clinical case series of patients with upper cervical spine traumatic SCI and detailed studies such as MRI. We sought to analyze factors that predicted mortality in upper cervical fracture dislocations and SCI. **Material and Methods:** We investigated relevant independent variables including presence of cardiorespiratory arrest, computed tomography, and MRI characteristics from 73 patients with traumatic upper cervical SCI in order to determine predictors of mortality. Analysis was by multiple logistic regressions. **Results:** Mean age was 60.2 years (SD = 19.1) and Glasgow Coma Scale (GCS) score was 9.7 (SD = 5.0). Morphology was Anderson D' Alonzo II/III fractures in 46 (63%), C2 vertebral body fractures (Benzel 1-3) in 14 (19%), and vertical or extension distraction in 6 (8%). Seven patients had no visible fracture dislocation. Injury epicenter was at the C2

vertebral body level in 46 of these patients, odontoid process in 16, C2/3 junction in 3, foramen magnum in 1, and C3 vertebral body in 1 patient. Forty of the total 73 (54.8%) patients died in this series; 29 of the 40 (72.5%) died within 1 month after trauma. Cardiorespiratory arrest was encountered in 42 patients, 30 of whom went on to die ($P < .001$). The overall intramedullary lesion length (IMLL) on admission MRI was 34.6 millimeters ([mm], SD = 24): in survivors, 24.7 mm (SD = 16.3); in those who died, 41.7 mm (SD = 27.7); and in the 5 patients who had diaphragmatic pacing, 70 mm (SD = 54). Logistic regression analysis indicated that lower admission GCS score ($P < .001$), older age ($P < .01$) and longer IMLL ($P < .01$) were independent predictors of mortality. **Conclusion:** In traumatic upper cervical SCI, lower GCS score at admission older age, and IMLL were independent predictors of mortality.

A281: Cervical Facet Dislocations in the Adolescent Population: A Report of 21 Cases at a Level 1 Trauma Center from 2004-2014

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Introduction: The purpose of this study is to present a series of adolescent patients with cervical facet dislocations to identify the mechanism of injury, severity of neurological injury and rate of neurological recovery. **Material and Methods:** Between 2004 and 2014, a retrospective review at a level I trauma center identified patients with unilateral or bilateral dislocated facet(s). Demographic data, initial neurological exams, surgical data, radiographic findings, and follow-up records were reviewed. **Results:** Of the 21 adolescent facet dislocations, 7 were unilateral and 14 bilateral. Mean age was 14.9 years; (range, 12 to 17). Male female ratio was 15:6. All patients presented as a result of a high-energy injury. C6-7 was the most common level of dislocation. 1 of 18 (5.5%) patients with an MRI had a cervical disc herniation. Nine (43%) patients had an associated facet fracture (8 unilateral, 1 bilateral). None of the 12 patients who presented as a complete spinal cord injury (SCI) (AISA A) had any neurological recovery. Only one of the three patients who presented as an incomplete SCI (ASIA B, C, D) had an ASIA grade improvement at final follow-up. Only six patients who presented were neurologically intact (ASIA E). **Conclusion:** Over half of children with this injury in our study had a complete SCI with no recovery. We believe that the adolescent spine is more resilient to injury, thus requiring a high-energy injury to cause a dislocation but resulting in a high rate of SCI with a low rate of neurological recovery, and a low rate cervical disc herniation.

A282: Odontoid Synchondrosis Fracture in Children: Report of 6 Cases with Special Reference to Posterior Partial Odontoidectomy in an Irreducible Atlantoaxial Dislocation

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Introduction: Fractures of the odontoid process are among the most common cervical injuries in preschool children, occurring at an average age of 4 years. However, these injuries are infrequently reported in the literature. The reports are mostly confined to one or two cases. These are actually physeal injuries of the basilar synchondrosis between the odontoid process and the body of the axis. However, the odontoid process is angulated anteriorly in majority. Reduction by hyperextension or by cranial traction followed by rigid immobilization results in a high rate of union, in a minority, either suffering irreducible atlantoaxial dislocation, in those with severely angulated odontoid malunion, and in missed cases surgery is warranted. Herein we want to report 6 new cases of synchondrosis odontoid fracture with displacement where four were diagnosed early and two with delay. The fracture could be reduced with hyperextension with traction in four and open reduction in the other two. **Material and Methods:** 3 boys and three girls at the age of 3 to 6 years with odontoid synchondrosis fracture are presented. Four were admitted shortly after injury and the other two, around 4 months after injury. Three of the acute cases were managed with immobilization in halo after reduction. The other acute one, a non-compliant child, underwent primary C1-C2 fixation. Both neglected ones were associated with irreducible atlantoaxial dislocation. One of these two, with odontoid non-union was reduced with facet releasing followed by a new reduction maneuver with polyester bands. The last one with malunited odontoid fracture could be reduced only after partial odontoidectomy via posterior only approach followed by C1-C2 fixation. **Results:** All 6 patients recovered and fusion could be achieved. **Conclusion:** Where majority of acute synchondrosis odontoid fractures heal with external immobilization. Primary surgery has been advocated by some to obviate the need for long-term immobilization. The real challenge is in neglected one with account a small proportion of the fractures with fracture angulation more than 30 degree or significant odontoid displacement which require posterior C1-C2 fixation after alignment .In addition, neglected ones with chronic IAAD require more challenging surgery. From facet release, odontoidectomy and atlantoaxial stabilization. We will describe a new formulation protocol for management of irreducible atlantoaxial dislocation which will facilitate decision making. Furthermore, we will show demonstrative odontoidectomy via posterior only approach which is not done before.

A283: A Retrospective Review of Patients Receiving Cervical Spine Stabilization While Being Actively Anticoagulated with Heparin in the Immediate Perioperative Period

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Introduction: Trauma patients presenting with a cervical spine injury are often evaluated for associated cerebrovascular injuries. The presence of a vascular injury may lead to the initiation of heparin anticoagulation treatment prior to necessary surgical stabilization. Literature regarding the safety and efficacy of these procedures while a patient is on active anticoagulation is limited requiring further investigation. **Materials and Methods:** Between May 2013 and November 2015 the authors identified 14 cervical spine trauma patients who underwent spinal stabilization surgery while on heparin anticoagulation treatment. A retrospective examination was completed in an attempt to report outcomes and associated complications in these cases. This patient cohort was compared to 49 cervical spine trauma patients who received cervical stabilization from the same surgeon over the same period without the necessity of anticoagulation therapy. **Results:** Out of the 14 patients, 11 had successful operations that healed without incident. Although two postoperative complications (a case of pneumonia and a fixation failure requiring reoperation) and one incident of elevated PTT were reported, there were no anticoagulation related complications. Described complications matched those found in our non-anticoagulated cohort. **Conclusions:** While it would be preferable to avoid undertaking spine procedures on patients actively being anticoagulated, this retrospective review reveals that when necessary, patients on heparin anticoagulation can undergo successful spine stabilization procedures, but close monitoring is required.

Deformity Cervical

A284: Comparison of Frailty Based on Cervical and Global SVA Classification

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Introduction: The SRS-Schwab thoracolumbar classification (gSVA) was developed to group patients into three deformity cohorts from mild to severe. The ISSG-Ames cervical deformity classification has a C2-C7 SVA grade (cSVA) on a comparable three cohort scale. The lack of ability to maintain a level gaze has devastating impacts on functional quality of life scores, which could increase frailty scores. Patients with global sagittal imbalance, on the other hand, must exert more energy to maintain truncal alignment, which could also impact frailty status. **Material and Methods:** Patients' cSVA and gSVA scores were classified using the classifications proposed by Ames and Schwab, respectively. Frailty was assessed using the ASD-FI and ACD-FI and split into three cohorts: not frail (NF), frail (F), and severely frail (SF). Association of the cSVA and gSVA classifications with frailty were assessed. **Results:** Of 736 patients in a multi-center global deformity database, the mean frailty score was 0.35. 371 had a gSVA of 0, 140 +, and 276 ++. The Goodman Gamma correlation coefficient for gSVA was 0.51 (ASE 0.04). When adjusted for important operative and preoperative covariates, the odds ratios of increased gSVA were 2.2 [1.5-3.3] ($P < .001$) times higher for F and 6.1 [3.5-10.5] ($P < .001$) for SF than NF. In a designated cervical deformity multi-center database with 123 patients, the mean frailty score was 0.26. 30 had a cSVA of 0, 49 +, and 9 ++. The Goodman Gamma correlation coefficient for cSVA and ASD-FI was 0.28 (ASE 0.17). After adjusting, the odds ratios were 4.1 [1.0-16.7] ($P < .05$) and 14.0 [1.1-171.7] ($P < .05$) for F and SF compared to NF, respectively. Age is also significantly associated with gSVA (gamma 0.49 ASE 0.05), but not with cSVA. **Conclusion:** While the odds of a patient being frail trended up with increasing gSVA and cSVA, there was a greater correlation between gSVA and frailty. However, the lower overall frailty in the cervical database may be attributed to multiple factors like surgeon selection bias or the theory that cervical deformity patients might to present earlier due to increased functional burden. More study is needed to distinguish these results.

A285: The Health Impact of Symptomatic Adult Cervical Deformity: Comparison to United States Population Norms and Chronic Disease States Based on the EQ-5D

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Introduction: Although adult cervical deformity (ACD) has been empirically associated with significant pain and disability, the magnitude of this negative impact has not been objectively quantified. Our objective was to assess whether symptomatic ACD patients have substantial negative health impact based on the EQ-5D compared with United States (U.S.) normative and chronic disease state values. **Materials and Methods:** ACD patients presenting for surgical evaluation and treatment were identified from a prospectively collected multicenter database. Baseline demographics, deformity characteristics, and EQ-5D scores were collected. EQ-5D scores were compared with age- and gender-matched U.S. normative and chronic disease state values. **Results:** Of 121 ACD patients, 115 (95%) completed the EQ-5D (61% women, mean age 61 years, previous cervical surgery in 46%). Diagnoses included: cervical sagittal malalignment (63%), cervical kyphosis (60%), proximal junctional kyphosis (9%) and coronal deformity (8%). The mean EQ-5D index was 0.511, which is 35% below the bottom 25th percentile score (0.790) for a similar age- and gender-weighted normative population and worse than the bottom 25th percentile for several other chronic disease states (diabetes [0.708], ischemic heart disease [0.708], and myocardial infarction [0.575]). The EQ-5D index of 0.511 seen in this ACD cohort is comparable to the bottom 25th percentile for blindness (0.543), emphysema (0.508) and heart failure (0.437). Based on EQ-5D subscores, patients reported impact on mobility (87%), daily self-care (47%), daily activities (91%), pain/discomfort (98%), and anxiety/depression (67%). **Conclusions:** The health impact of symptomatic ACD is substantial, with an EQ-5D index that is 35% below the bottom 25th percentile for an age- and gender-matched normative U.S. population. The markedly negative health impact of ACD was demonstrated across all domains of the EQ-5D. The overall mean EQ-5D index for ACD patients was worse than the bottom 25th percentile for several other chronic disease states, including chronic ischemic heart disease, malignant breast cancer, and malignant prostate cancer, and was comparable to the bottom 25th percentile values for blindness/low vision, emphysema, renal failure, and stroke.

A286: Surgical Treatment for Kyphotic Deformities of the Cervical Spine: A Review of the Surgical Approaches and Clinical Outcomes

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Introduction: Cervical kyphosis in general is undesirable and places the cervical musculature at a significant biomechanical disadvantage with resultant morbidity and cord compression. Several surgical techniques are described in the treatment of cervical kyphosis but few reports exist analysing the outcomes of treatment. The aim of our study was to evaluate the clinical and radiological outcomes of a consecutive group of patients with kyphotic deformity of the cervical spine treated at our department with a further emphasis on the surgical approach used (anterior, posterior or combined). **Materials and methods:** We conducted a prospective cohort study of 121 consecutive patients undergoing surgical correction for kyphotic deformity of the cervical spine. 107 patients were available for analysis with a minimum 24 months follow-up. Mean age was 54 years degenerative disease was the commonest cause of kyphosis. Patients with acute injuries, tumors, infections and congenital anomalies were excluded. A stand-alone anterior surgery was performed in 73 patients, a stand-alone posterior surgery in 14 patients and combined two or three step procedures in 20 patients. **Results:** The Neck Disability Index (NDI) improved from a mean of 26.2 preoperatively to 14.4 at two years post- surgery. In 92.5% of cases the value improved or remained un-changed. The mean value in the Nurick system 107 was 0.7 preoperatively and 0.5 at two years after surgery. The VAS mean value for neck and radicular pain changed from 5.9 preoperatively to 2.5 post-operative. If asked whether the patients would undergo the surgery again, 88.2% answered yes, indicating a good patient satisfaction. Of the total number of 107 patients 104 (97.2%) fused at 24 months after surgery. **Conclusions:** Surgical correction of the kyphotic deformity

resulted in marked improvement of the patients' quality of life, improvement of the neurological condition and of the spine alignment, as documented by radiological examination of the cervical spine. The best correction was achieved by anterior or combined surgery, although the type of surgery had no impact on clinical outcomes of the patients.

A287: Assessment of a Novel Adult Cervical Deformity (CD) Frailty Index (FI) as a Component of Preoperative Risk Stratification

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Introduction: While patient age has been shown to be a risk factor for complications, patients age at different rates, leading to a discrepancy between biological age, or frailty, and chronological age. As patients become increasingly frail, they have been shown to be more vulnerable to adverse outcomes. **Material and Methods:** The CD-FI was constructed using variables recorded in a multicenter adult cervical deformity database using a validated method. The CD-FI was calculated and used to stratify patients into 3 frailty severities: <0.2 = not frail (NF), 0.2-0.4 = frail (F), >0.41 = severely frail (SF). We then performed a multivariate logistic regression to determine the relationship between CD-FI severity, incidence of major complications and hospital length of stay (LOS). **Results:** Of 61 patients with ≥ one year follow-up, the average CD-FI was 0.26 (range 0.25-0.59). 17 patients were NF, 34 F, and 10 SF. The incidence of major complications increased with increasing frailty with a gamma correlation coefficient of 0.25 (ASE 0.22). The unadjusted odds ratio of having a major complication was 1.13 [Confidence Interval 0.34-3.8] and 2.75 [0.55-13.7] times higher for F and SF compared to NF patients ($P > .05$). After adjusting for several covariates, the odds ratio of having a major complication was 4.67 [0.51-42.39] ($P = .171$) for F and 56.00 [2.37-1324.33] ($P < .02$) for SF compared to NF patients. The incidence of medical complications correlated with frailty and had a gamma correlation coefficient of 0.30 (ASE 0.26). **Conclusion:** Increasing frailty was associated with increased risk of major complications for CD patients undergoing surgery. This indicates the value of the CD-FI to improve the accuracy of preoperative risk stratification and allow for adequate patient counseling.

A288: Iatrogenic Cervical Subaxial Kyphotic Deformity following C1/C2 Fixation: Post-traumatic Epiphenomenon or Iatrogenic Reciprocal Change: A Series of 20 Cases

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Introduction: Reciprocal changes in spinal alignment are observed to occur in mobile segments of the spine following fusion. This has been described most frequently in the thoracolumbar spine, and is thought to be a compensatory mechanism. The majority of cervical flexion and extension occur at the craniovertebral junction with observed combined range of range of approximately 45°. With surgical fusion of one or both of these joints, compensatory flexion and extension and maintainance of horizontal gaze can lead to reciprocal changes in the adjacent subaxial spine. We examine our experience of 102 cases of craniovertebral junction fusion over 10 years to look at the incidence of this reciprocal change and its clinical Sequelae. **Material and Methods:** Retrospective chart review of all patients who underwent a craniovertebral junction fusion procedure from 2004 to 2014 at the university hospital of Lausanne (CHUV). A total of 102 records were found. A total of 15 patients developed radiological subaxial kyphosis during the follow- up period. Of these, 12 underwent C1-C2 fixation and 3 underwent C0-C2 fixation. Trauma was the most common pathology (12 patients), followed by degenerative (2 patients) and tumor (1 patient). Only 1 patient has standing cervical X rays prior to surgery confirming the absence of cervical kyphosis in the preoperative period. The remaining 14 all had preoperative imaging in the supine position. None of these patients displayed any pre-existing kyphosis, and were assumed to have no kyphosis in the upright position. The mean follow up period was 27 months. Upright lateral cervical spine X rays at the most recent follow up were used to measure C0-C1 and C1-C2 angles, and the degree of subaxial kyphosis. **Results:** All patients had documented subaxial kyphosis on upright cervical spine X rays, measured from the endplate of C2 to the end plate of C7 or the lowest visible endplate. The range of kyphosis was from 1° to 49° (mean 15.6°). All patients were hyperlordotic at the C0-C1 (range 11°-40°, mean 22.14°) and the C1-C2 (range 22°-44°, mean 31.9°) segments. Two patients were symptomatic with mechanical neck pain without neurological deficit attributable to the kyphosis. Both had marked kyphosis (29° & 49°). The first being an elderly male with an odontoid fracture, the second a middleaged female following a severe brain injury and traumatic atlanto-axial rotatory subluxation. **Conclusion:** Subaxial kyphotic deformity following

C1-C2 fixation has been described in both rheumatoid and in non-rheumatoid patients. However, the precise mechanism is not clear. This is seen in 14.7% of our patients following C1-C2 fixation. All patients were fixed with the C1-C2 segment in a lordotic position. The C0-C1 segment is spontaneously in a hyperlordotic position and it appears that the main compensatory mechanism is in the subaxial spine and not at C0-C1. Attention should be paid to the C1-C2 angle when performing a C1-C2 fusion. Upright Xrays are needed to accurately assess these reciprocal changes related to horizontal gaze.

A289: The Application of One Stage Combined Approach with Circumferential Osteotomy in the Treatment of Congenital Cervical Scoliosis

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Introduction: One stage circumferential osteotomy was applied to treat the congenital cervical scoliosis (also called as osteogenic torticollis). The feasibility, safety and early clinical outcomes were evaluated. **Material and Method**: Retrospective investigation of 13 cases who received surgical correction procedure due to congenital cervical scoliosis with hemivertebra deformity of cervical spine. The clinical outcomes were evaluated. The severe complication such as the injury of nerve root, spinal cord, vertebral artery and dural sac were collected and recorded. The Cobb angle of structural curve and compensation curve were recorded and compared on CT scan coronal plane reconstruction images. **Results**: 13 patients with average age of 9.2 $\pm$ 3.4 years old (5-15) were treated. There were 8 male and 5 female. Two cases had anterior-posterior osteotomy with Halo-vest immobilization for three months. 11 cases had anterior-posterior-anterior osteotomy with soft collar for 6 weeks. The average operating time was 324 $\pm$ 91.9 min with average blood loss 585 $\pm$ 319 ml. Five cases had convex side nerve root symptoms postoperatively. Four cases fully recovered 6 months after the operation. One case remained triceps power reduction (grade 3) 24 months after the operation. No other complications. The average follow-up period was 30.0 $\pm$ 12.4 months (24-60). The Cobb angle of structural curve was 28.3 $\pm$ 11.0°(9 ~ 45°) preoperatively and 6.9 $\pm$ 7.8°(0 ~ 25°) post-operatively. The correction ratio was 78 $\pm$ 24%. The Cobb angle of compensation curve was 21.8 $\pm$ 5.8° (0 ~ 25°) pre-operatively and 5.5 $\pm$ 4.3°(3 ~ 23°) post-operatively. The correction ratio was 37 $\pm$ 33%. The patient's appearance improved significantly after the surgery. **Conclusion**: The one stage circumferential osteotomy for the treatment of the congenital cervical scoliosis is feasible and safe procedure. The clinical and radiological outcomes were satisfactory

A290: Significance of Multimodal Intraoperative Monitoring (MIOM) for the Patients with Craniovertebral Junction Pathology

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Introduction: Cervical myelopathy is the most commonly acquired cause of spinal cord dysfunction and surgery is usually the treatment of choice for those patients. At present, there have been lots of studies concerning the application of multimodal intraoperative monitoring to cervical spine surgery, including the value of predicting postoperative neurological deficits. However, the relation of the craniovertebral junction (CVJ) myelopathy and multimodal intraoperative monitoring (MIOM) change remains unclear. The objective of the study was to seek a relationship between multimodal intraoperative monitoring and corresponding cervical cord myelopathy in high cervical spinal surgery. **Materials and Methods:** We reviewed multimodal intraoperative monitoring (MIOM) records of 107 (39 males and 68 females, average age was 54.49 ¡¾ 16.78) consecutive patients with high cervical spinal pathology, who underwent posterior fusion with instrumentation surgery from December 2009 to March 2016. We classified patients into a cervical myelopathy group (26 patients) or a non-myelopathy group (81 patients), based on the cord compression with myelopathy in MRI and analyzed MIOM change in both group respectively. Risk factor analysis of MIOM change was performed in both groups. **Results:** Our results showed that the 11 patients showed MIOM changes in cervical myelopathy group, 7 patients showed MIOM change in non-myelopathy group. Cervical myelopathy group showed significantly higher incidence of MIOM change than non-myelopathy group ($p < 0.01$). MIOM change group showed significantly narrower in spinal cord diameter (P 0.01). There is no difference between two groups in sex (P 0.35) and age (P 0.83). There is a relationship between cervical myelopathy and MIOM change. However, there were two cases of false negative MIOM response in cervical myelopathy group. **Conclusion:** MIOM change might be more common in cervical myelopathy and be correlated with spinal cord diameter. MIOM monitoring could be more useful in the case with myelopathy and canal stenosis.

A291: The Impact of Cervical Sagittal Alignment on Post-operative Outcome after Anterior Cervical Fusion in Patients without Evident Deformity: A New Method to Evaluate the Right Amount of Cervical Lordosis

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Introduction: A detailed understanding of the cervical spine biomechanics and sagittal alignment parameters is essential during the planning of surgery. Approximately 70-80% of the load in the cervical spine is supported by the posterior column. Cobb angle C2-C7 sagittal vertical axis (SVA) and T1 Slope (SL) are the main parameters to take into account in case of cervical degenerative pathology. The literature shows that cervical kyphosis contributes to the development of myelopathy by different mechanisms. The aims of the study were to evaluate the relationship between the cervical sagittal alignment parameters and surgical clinical outcomes after anterior cervical fusion; determine the role of T1 Slope, C7 Slope, cervical lordosis (CL), C2-C7 plumb line, the ratio CL/C7SL and CL/T1SL in surgical outcome; describe an innovative method to calculate the correct cervical lordosis necessary for every single patient. **Materials and Methods:** Retrospective study of 70 patients treated with an anterior approach in our center between 2013 and 2014. Great deformities were excluded. The following parameters were calculated by upright x-ray: C7 slope, T1 slope, cervical lordosis, C2-C7 SVA; we calculated the ratio CL/C7SL and CL/T1SL. We analyzed the obtained data with Pearson correlation coefficient and Student t-test. The clinical post-operative outcome was evaluated at 1 year by Neck disability index and VAS score. **Results:** We founded a significant correlation between C2-C7 SVA, C7 slope, T1 slope and CL / C7 SL with NDI and VAS. There is no correlation between cervical lordosis and clinical outcome. Statistically significant differences were found between group 1 (NDI 0 and VAS 0) and group 3 (NDI > 17 and VAS > 5): C2-C7 SVA (p 0.0026), C7 SL (p 0.0014) T1 SL (0.0095), CL / C7SL (p 0.0012). No significant differences about cervical lordosis (p 0:32) and CL / SL T1 (p 0.29) were found. A value of C2-C7 SVA <25 mm correlates with good outcomes. C7 slope proved to be related with the neck disability index (NDI) and visual analogue scale (VAS) (p 0.0014). Cervical lordosis isn't related with surgical outcome. The CL/C7 slope ratio showed to be significantly correlated with the NDI and VAS (r: −0.52, p 0.0012). Patients with a CL/C7 SL > 0.7 had a better clinical outcome. **Conclusions:** Sagittal parameters correlate with clinical outcome. Values C2-C7 SVA <25 mm correlate with a better surgical outcome. The increase of the C7 slope needs an higher cervical lordosis to obtain a positive outcome. We suggest that CL/C7 SL (0.7) multiplied by C7 slope can be used in the pre-operative planning to calculate the ideal lordosis value for that patient. Larger and prospective studies are required to define a better and stronger relationship between sagittal alignment parameters and clinical post-operative outcome.

A292: Correlation Between Cervical Alignment and Neck Disability

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Introduction: The importance of sagittal cervical alignment has recently been linked with clinical outcomes in spinal deformity surgery. Despite of the increasing number of studies showing the relationship of these radiographic parameters with postoperative clinical outcome, there is a lack of data correlating sagittal cervical alignment with health related quality of life (HRQOL) considering patients in nonsurgical treatment for cervical spondylosis. The aim of the present study is to evaluate the impact of the sagittal cervical alignment on neck pain and disability in patients in nonsurgical treatment for cervical spondylosis. **Material and Methods:** This is a transversal study considering patients with symptomatic cervical spondylosis, including only patients with no prior spine procedures. The patients were divided into three groups: axial pain, radiculopathy and myelopathy. Sagittal upright full spine radiographs were obtained and the cervical radiographic parameters considered were: CSVA, CL, TS and TS minus CL (TS-CL). The radiographic parameters were correlated with the HRQOL, assessed by the neck disability index (NDI) score and the visual analogue scale (VAS) for neck pain, using ANOVA. **Results:** Fifty-two patients were included. There was no significant difference in the cervical sagittal parameters between the three groups. The mean of the radiographic parameters in the total sample was: CL, 22.4° (±8.8°); TS, 29.3° (±6.6°); CSVA, 17.8 mm (±8.3 mm); TS-CL, 7.0° (±7.4°). There was a significant inverse correlation between CL and NDI ($r = 0.3$, $P = .039$), but there was not significant correlation between CL and VAS ($r = 0.0$, $P = .989$). CSVA ($r = 0.1$, $P = .541$), TS ($r = -0.2$, $P = .287$) and TS-CL ($r = 0.2$, $P = .287$) did not significantly correlated with NDI and VAS. **Conclusion:** Considering patients in nonsurgical treatment for cervical spondylosis, increasing CL is correlated with worst neck disability, but not with pain. There was not correlation between CSVA, TS and TS-CL with neck disability and pain in those patients.

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A293: Endoscopic Lumbar Foraminal Decompression: Myth? Or Trustworthy?

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Introduction: There is borad spectrum of surgical options to treat foraminal stenosis from simple decompressive microscopic foraminotomy to lumbar interbody fusion for foraminal height reduction. Nowadays, several trials of endoscopic foraminal decompression have been reported. But, its' usefulness and durability was not proved to the extent to satisfy most spine surgeons. Objective of study is to evaluate the clinical efficacy and safety of endoscopic foraminal decompression in lumbar foraminal stenosis. **Materials and Methods:** Total 52 Patient underwent endoscopic lumbar foraminal decompression from August 2012 to May 2015. Inclusion criteria were single level, unilateral lumbar foraminal stenosis (Wildermuth Gr 2, 3) regardless of disc herniation with symptoms of NIC and radiculopathy. Remarkable instability, listhesis, ASD cases were excluded in this study. FSVNA (foraminoplastic superior vertebral notch approach) with reamers and several kinds of endoscopic drills was performed for the foraminal decompression. Radiologic parameter (disc height, dynamic x-ray, displacement) were investigated preoperatively and postoperatively and compared. Clinical outcome (VAS, ODI, MacNab criteria) were also evaluated. Complications and failed cases were analyzed. **Results:** The mean age of the 28 female and 24 male patients was 65.2 years. Mean follow-up period was 24.6 months. The mean VAS for leg, back pain and the mean ODI improved from 8.12, 5.24, 63.8% at baseline to 5.32 ($P < .001$), 3.36 ($P < .001$), 47.5% ($P < .001$) at final follow-up. Based on the modified MacNab criteria, excellent or good results were obtained in 80.7% of the patients. Radiologically, disc height and segmental stability was preserved compared to preoperative status. There were 3 cases of transient postoperative dysthesia. 4 patients received revision surgery (1 Endoscopic revision surgery, 2 Interbody fusion, 1 Artificial disc replacement). No patient had postoperative infection, dura tear, postoperative hematoma. Major causes of unsuccessful outcome were remnant leg pain by incomplete decompression and postoperative dysthesia. **Conclusion:** Percutaneous endoscopic foraminal decompression under local anesthesia could be an efficacious and safe surgical procedure for the treatment of foraminal stenosis. Complete decompression of exiting root by thorough understanding of endoscopic lumbar foraminal structure is the key of successful outcome.

A294: Re-thoracoscopy after Thoracoscopically Assisted Spinal Operations in Prone Position: Is It Possible, Is It Dangerous, Why Was It Necessary?

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Introduction: Minimally invasive endoscopic assisted spinal surgery allows a lower complication rate as well as less morbidity than the classical extended thoracotomy. Thoracoscopic surgery in the prone position facilitates the ventrodorsal operations in spine surgery, without the need to change the patient's position during combined approaches. Publications about re-thoracoscopy for spine surgery are scanty. **Material/Methods:** Between August 1996 and June 2014, a total of 2004 patients (mean age 49.9 years) (51% males) underwent thoracoscopic assisted spinal surgery in our department. The indications for surgery were as follows: Trauma in 609 patients (30.4%), Deformity in 578 Patients (28,8%), Spondylodiscitis in 384 Patients (19%), degenerative diseases in 270 Patients (13.5%) and Tumor in 163 Patients (8.3%). All 2004 patients were operated in the prone position using a two-portal technique. Simultaneous posterior (revision) surgery in the same position was performed in 82 of the 91 reinterventions of this study. Analysis of the prospectively collected Data revealed 83 patients (4.1%) in whom a thoracoscopically assisted reintervention, surgery using the same technique has been performed. The data of these 83 patients were analysed with a minimum follow-up of two years. **Results:** The majority of the 83 patients had one thoracoscopic reintervention. In seven patients (8.4%), thoracoscopic surgery was performed more than twice. The mean age was 55.3 years (average 15 and 86 years). The majority were males (61.4%). The mean time lapse between the primary and revision surgery was 20.6 months. The indication for re-thoracoscopic assisted surgery was mostly mechanical in 89% of the cases (such as pseudoarthrosis and adjacent segment disease), followed by recurrent pathology (such as recurrent tumor or spondylodiscitis). In 52 patients (62.7%), the same incisions as the primary surgery have been used. In the rest of the patients new incisions were done to address pathology at other spinal segments. The mean total operation time (= including the posterior reintervention and bone graft-taking) was recorded to be 5.1 hours in the primary surgery and 3.8 hours in the revision including the re-thoracoscopy. **Conclusion:** Thoracoscopic assisted spinal surgery became a well-established procedure despite the high learning curve. Performing this technique in the prone position has many advantages, since it allows several anterior and posterior surgical steps in one postioning and draping. The complication rates as well the operation time were not higher in the revision cases than in the primary cases. Mainly due to the minimal amount of adhesions associated with this procedure, revision surgery in the same thoracoscopic technique proofed possible, safe and effective.

A295: Is the Virgin Surgery or Revision Surgery? Transforaminal Percutaneous Endoscopic Lumbar Discectomy in the Recurred Lumbar Herniated Nucleus Pulposus after Open Lumbar Discectomy

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Introduction: In case of the recurred herniated nucleus pulposus after open lumbar discectomy (OLD), revision surgery is

technically demanding because dural retraction and nerve root mobilization are difficult to operate due to the massive epidural scar. That's why wide laminectomy followed by fusion surgery is generally performed. However, since Kambin's triangle is still remained freely, it could be possible to perform transforaminal percutaneous endoscopic lumbar discectomy (PELD) without fusion surgery as a virgin surgery. **Material and Methods:** We retrospectively analyzed 83 cases who underwent revision surgery (Group A: transforaminal PELD: 35 cases, Group B: Microscopic Lumbar Discectomy: 48 cases) for recurred HNP between March 2010 and April 2014. All of the patients were followed for more than 12 months. **Results:** In group A and B, respectively, the mean age was 50.2 ± 12.9 years and 50.1 ± 11.6 years, sex ratio was male 25 cases: female 10 cases and male 30 cases: female 18 cases, the mean follow-up period was 24.2 ± 11.8 and 33.7 ± 7.9. The operated level of L2-3 / L3-4 / L4-5 were 3 cases / 5 cases / 27 cases in group A and 4 cases / 9 cases / 35 cases in group B. The mean VAS (Visual Analogue Score) prior to surgery was decreased at the 1 weeks, 1 months, 6 months after surgery, from 8.2 ± 0.6 to 2.3 ± 0.8, 1. 9 ± 0.6, 1.6 ± 0.7 and from 8.2 ± 0.7 to 4.5 ± 0.9, 3.3 ± 0.7, 2.4 ± 0.9 in group A and B, respectively. The mean ODI (Oswestry Disability Index) score prior to surgery was decreased at the 1 weeks, 1 months, 6 months after surgery, from 39.2 (78.3%) ± 2.8 to 13.5 ± 2.2, 11.8 ± 1.9, 10.3 ± 2.0 and from 39.0 ± 2.4 to 26.6 ± 3.6, 20.5 ± 3.4, 16.8 ± 3.4 in group A and B, respectively. 1 case (2.9%) of Surgery-related complication of dural tear (1 case: 2.9%), infection (0), hematoma (0) and 9 cases (18.8%) of dural tear (6 cases: 12.5%), infection (1 case: 2.1%), hematoma (2 cases: 4.2%) were occurred in group A and B, respectively. However, surgery-related neurology happened to 2 cases (5.7%) and 7 cases (14.6%) in group A and B, respectively. During the follow-up period, 2 cases (5.7%) and 8 cases (16.7%) of recurrence occurred in group A and B, respectively. **Conclusion:** According to the result, transforaminal PELD reveal the good clinical result of recovery after operation compare to the OLD in recurrent lumbar disc herniation. Transforaminal PELD also had a less chance of the surgery related complication and neurology as a virgin surgery. In conclusion, transforaminal PELD could be considered as one of the minimally invasive surgical options for revision surgery after OLD as a virgin surgery.

A296: Evaluating the Feasibility of Minimally Invasive Lateral Mass Screw Instrumentation of the Cervical Spine: A Cadaveric Study

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Introduction: Minimally invasive techniques for instrumenting the lumbar spine are common in the modern hospital setting, however the same is not true for the cervical spine. Stripping the posterior ligamentous tension band and paraspinal musculature for the placement of lateral mass screws may contribute to development of postoperative kyphosis and chronic pain. The purpose of this study was to investigate and evaluate the feasibility of minimally invasive lateral mass fixation of the cervical spine in a controlled setting. **Materials and Methods:** Lateral mass screws were placed bilaterally into each level from C3 to C7 of 4 cadaveric specimens. Fluoroscopic guidance in the AP plane was utilized to plan an incision one vertebral body below the level of interest, just medial to the lamina-facet junction. Incision through skin and fascia allowed sequential dilation to accommodate a 14 mm tubular retractor. Exposure of the lateral mas allowed visualization of a central starting point that was confirmed with a lateral fluoroscopic image. A starting hole was then created using a bur and followed by a cannulated drill, guidewire and placement of a cannulated 2.5 mm screw. Screw trajectory and accuracy were assessed using fluoroscopy and 3D fluoroscopic reconstructions. **Results:** Lateral mass screws were completely within the substance of the lateral mass 87.5% of the time, with a 12.5% incidence of lateral or anterior breach of the cortical margins. The typical angle of divergence achieved was 12.8 degrees with 45.5 degrees of cranial angulation. There was no incidence of penetration into the transverse foramen or spinal canal. **Conclusion:** Minimally invasive placement of lateral mass screws through a tubular retractor is a viable technique for instrumenting the posterior cervical spine. Despite restrictions from the soft tissues and spinous process, we were able to achieve a trajectory through the tubular retractor that is within the range of techniques described for the open placement of lateral mass screws. Further refinement of the technique is warranted including clinical trials comparing patient outcomes with traditional open techniques.

A297: The Teardrop Technique: Safe and Easy Iliac Screw Placement

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Rationale: Freehand placement iliac screws can be difficult for novices. Typically it requires dissecting the posterior superior iliac spine (PSIS), the use of connectors and may leave palpable screw heads. Choosing a more medial and inferior entry point eliminates these problems, but makes correct positioning more challenging. Despite its advantages, this technique has found only limited acceptance. **Methods:** In a human pelvis the medial and lateral cortices of the ilium were marked with pieces of wire and a CT scan was obtained. The pelvis was placed on a carbon operating table and a C-arm was positioned

in the same way as in a surgical situation to achieve a proper projection of the iliac teardrop. Correlated photographic and C-arm images were obtained. The CT data was entered into the SpineAssist software. Virtual screws were placed through the defined entry point and along the visual axis. The trajectory was evaluated in all three anatomical planes as well as in a drive-through mode. **Results:** In the teardrop view, the lateral iliac cortex becomes almost one solid line, leaving a visual safety margin towards the hip joint and the correct entry point is located very close to the PIIS. In the simulation, we placed virtual screws (120 x 8 mm). Their position was examined in the 3 planes and always exhibited a trajectory that was completely within the ilium. It is possible by means of this technique to position a screw very tightly along the lateral and the inferior iliac cortices, thus providing superior anchoring. **Conclusions:** The outline of the iliac teardrop figure is made up entirely by the iliac cortices, making iliac screw placement using the teardrop technique safe and reproducible. It requires only a C-arm and even novices should be able to safely place iliac screws in this way. Screws placed according to this technique can easily be connected without offset connectors. Supported by this data, the teardrop technique should be taught to residents.

A298: Uniportal Percutaneous Endoscopic Laminotomy with Flavectomy for the Lumbar Canal or Lateral Recess Stenosis

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Introduction: The laminotomy with flavectomy for lumbar canal or lateral recess stenosis evolved from open laminectomy, to the microscope, followed by micro-endoscopic laminectomy In MISS trend. The objective of this study was to evaluate the clinical feasibility and safety of Percutaneous Endoscopic Laminotomy with Flavectomy for the Lumbar Canal or Lateral Recess Stenosis. **Material and Methods:** Total 42 Patients underwent Uniportal Percutaneous Endoscopic Laminotomy and Flavectomy with/without discectomy from August 2012 to May 2015. Procedure was performed with several endoscopic instruments such as drill, punch and dissector in the way similar to conventional microscopic laminotomy and flavectomy. Clinical outcomes (VAS, ODI, modified MacNab criteria) were evaluated. Surgical outcomes including operative time, hospital stay and complications were also investigated. **Results:** Total 44 lumbar levels were decompressed for spinal canal or lateral recess stenosis (Unilateral laminotomy: 29, Bilateral laminotomy via unilateral app: 15). The mean age of the 28 female and 14 male patients was 64.2 years. Mean follow-up period was 13.45 months. The mean VAS for leg pain, back pain and the mean ODI improved from 7.12, 6.24, 69.8% at baseline to 4.32 ($P < .001$), 3.56 ($P < .001$), 46.5% ($P < .001$) at final follow-up. Based on the modified MacNab criteria, excellent or good results were obtained in 90.9% of the patients. Average operation time was 95 $\pm$ 27 minutes. In the late period of the learning curve, operation time was shortened by 2/3. Hospital stay was 1.45 days. There were 1 case of transient postoperative dysthesia, 1 case of motor weakness and 2 case of dura tear. One patient experienced the recurrence of combined HDs and underwent secondary endoscopic revision surgery. There was 1 case of intraoperative conversion to classic microscopic laminotomy due to breakage of lens of endoscope. No patient had postoperative infection, hematoma or revision surgery for the incomplete decompression. **Conclusion:** Percutaneous endoscopic laminotomy with flavectomy is the least invasive and clinically feasible surgical technique for lumbar canal or lateral recess stenosis.

A299: Prophylactic Vertebral Augmentation after Intra-disc Leakage due to Kyphoplasty for the Treatment of Osteoporotic Compression Fracture: A Retrospective Cohort Study

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Introduction: Symptomatic adjacent vertebral fracture AVF is a common complication after kyphoplasty. It usually happens within 6 months after operation, and constitutes majority of new fracture. Intra-disc leakage is as an important risk factor, but there were no studies reported on prophylactic vertebral augmentation in high-risk patients. The aim of the study is to evaluate the clinical outcome of prophylactic vertebral augmentation in selected patients, and identify the risk factors of early adjacent vertebral fracture (AVF). **Material and Methods:** We conducted a retrospective cohort study. Eighty-two patients with intra-disc leakage after kyphoplasty were enrolled and divided into two groups based on whether they received prophylactic vertebral augmentation at the superior level. General conditions, operative details, and complications were recorded. The minimum follow-up was 6 months to ensure that any possible early complications were included. **Results:** In the non-prophylactic group, 9 of 59 (15.3%) patients had an AVF superior to the level of intra-disc leakage, and 8 of 9 (88.9%) occurred within 6 months post-operatively. Overall, 14 (23.7%) patients had a new fracture. In the prophylactic group, no patients had an AVF, but 3 (13.0%) had remote fractures ($P = .047$ and 0.284, respectively). There were no complications associated with vertebral augmentation. The parameters were comparable between the two. General conditions, osteoporosis, and radiological analysis were not significantly correlated with early AVF. Patients with comorbidities, including diabetes and hypertension, and corticoid use history had a higher risk of fracture (odds ratios: 12.0, 95% confidence interval [CI]: 1.0–143 and 34.3, 95% CI: 3.2–364.5, respectively). **Conclusion:** Prophylactic vertebral augmentation can

prevent AVF and associated second surgery, and it can reduce the overall new fracture rate, although this was not statistically confirmed. Patients with comorbidities and corticoid use have a higher risk of AVF. Therefore, we recommend prophylactic vertebral augmentation for intra-disc cement leakage with those conditions.

A300: Volumetric Radiographic Method to Assess Indirect Decompression after ELIF using a New Generation Intraoperative CT Scanner

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Introduction: Two-dimensional radiographic measurement methods have been proposed to evaluate the radiographic outcome after foraminal and central canal decompression through extreme lateral interbody fusion (ELIF). However, the assessment of neural decompression in a single plane may underestimate the effect of volumes on a particular area and current techniques fail to predict the effect of "ligamentotaxis" on central canal, foramen and lateral recess decompression. **Material and Methods:** 7 patients (9 levels) undergoing ELIF were included in a retrospective study. Three independent, blind raters using Osirix-MD software performed volumetric measurements pre- and postoperatively to determine central canal and foraminal volumes. Intra-rater and Inter-rater reliability tests were performed to assess the reliability and repeatability of this novel volumetric method. Two-dimensional measurements of foraminal height and disc height were also measured and compared pre- and postoperatively. **Results:** The inter-rater reliability ranged between 0.800 to 0.952 for each volume measurement (ICC range $P < .0001$ for all comparisons). The test-retest analysis on a randomly selected subset of three patients was 0.78 – 1.00 (range of 0.78 – 1.00) for all three raters. There was a significant increase in right foramen ($25.46\% \pm 6.61$), left foramen ($20.79\% \pm 5.06$), and central canal volumes ($20.69\% \pm 1.33$) after the surgery ($P = .0472$, $P = .0066$; and $P = .0003$, respectively). Additionally, anterior disc height, posterior disc height, left foramen height, and right foramen height increased significantly after ELIF ($P = .0002$; $P < .0001$; $P < .0001$; and $P = .0025$, respectively). **Conclusions:** Here we demonstrate a volumetric analysis technique that is feasible, reliable, and reproducible amongst independent raters for assessing important radiological factors such as central canal and foraminal volume in the lumbar spine. Our results demonstrate that two- and three-dimensional radiographic measures significantly increase in an equivalent amount after performing ELIF surgery. This method may help to understand why current radiological techniques fail to predict the effect of "ligamentotaxis" after ELIF on central canal, foramen and lateral recess volumes.

A301: Cervical Radiculopathy Treated with Posterior Cervical Cages: Intra-operative and Clinical Outcomes in 76 patients

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Introduction: Minimally disruptive posterior cervical fusion is a surgical option for treating cervical radicular pain in select patients. To achieve stabilization until fusion occurs, a posterior cervical cage is deployed bilaterally between the facet joints, distracting the joints and freeing the nerve root (Figure 1). The cervical cages prevent translation of the motion segment and support fusion in conjunction with standard posterior fusion techniques such as decortication of the lateral masses, rasping of the articular processes, and the application of bone graft. The authors present intra-operative and clinical outcome data for 76 patients with single or multiple-level cervical radiculopathy treated with posterior cervical cages placed bilaterally in the facet joints. **Materials & Methods:** Between 2014 and 2016, 76 patients were treated with a posterior cervical fusion and decompression between two surgical centers. All patients had single or multiple-level symptomatic cervical radiculopathy that had failed conservative management and/or other surgical treatment modalities. In this retrospective study, the patient's NDI score, VAS arm and neck pain scores, neurological status, imaging studies, and adverse events at baseline and post-operative follow-ups scheduled at intervals of 2- and 6-weeks, 3-, 6-,12-, and 24-months were reviewed. The patient's operative time from initial skin incision to skin closure, length of hospital stay, and intra-operative blood loss were also reviewed. **Results:** This cohort of 76 patients had a mean follow-up of 8.22 months (0.5-24 months). The mean age of this cohort was 57 years (34-87 years) and consisted of 40 males and 36 females. Thirty-eight patients had one-level disease treated with this construct, thirty-one had 2-level disease treated, and seven patients had three levels treated. Bilateral posterior cervical cages were placed at the level of C3-C4 in nine patients, twenty-four at C4-C5 (one patient had a unilateral cage placed at this level), fifty-eight at C5-C6, and twenty-eight at C6-C7 for a total of 119 levels amongst all patients. One patient also had a single-level ACDF performed concurrently. All NDI scores ($n = 8$), VAS arm pain ($n = 76$), and VAS neck pain ($n = 76$) scores significantly improved by final follow-up (Figure 2), with a mean NDI improvement of 14.81 (± 0.17; $P = .018$), and mean VAS arm and neck pain improvements of 5.54 (± 2.52; $P < .001$) and 8.16 (± 2.23; $P < .001$), respectively. The mean operative time from initial incision to skin closure was 90.89 minutes (43-248 minutes; $n = 9$), mean blood loss was 24 cubic centimeters (9-48 cc;

n = 9) and mean hospital stay was 25.61 hours (6-96 hours; n = 76). **Conclusion**: Bilateral posterior cervical fusion can treat single or multiple-level cervical radiculopathy via a safe and effective minimally disruptive approach. The use of this posterior cervical cage system to perform a posterior cervical fusion and decompression shows favorable results and offers the surgeon an additional treatment option for cervical radiculopathy in select patients.

Lumbar Stenosis

A302: Blood Transfusions in Elective Lumbar Spine Surgery: Risk factors, Inpatient Outcomes, and Resource Utilization

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Introduction: Limited data exists characterizing risk factors for blood transfusion in elective thoracolumbar spine surgery. Additionally, effects of blood transfusion on inpatient outcomes and health care-resource utilization in this population has not been well established. **Material and Methods:** Utilizing data from the National Inpatient Sample from 2002 to 2012, an estimated 2,483,779 patients undergoing elective thoracolumbar surgery for degenerative conditions or deformity correction were identified. The sample was divided into two cohorts based on whether or not they received a blood transfusion while in the hospital. Risk factors for transfusion, postoperative complications, and health care resource utilization (length of stay, hospital charges, and discharge disposition) were analyzed. Additionally, complications were classified as major or minor. Major complications included acute myocardial infarction, cardiac arrest, septicemia, septic shock, stroke, and pulmonary embolism. Minor complications included deep vein thrombosis, pneumonia, surgical complications, postoperative anemia, and urinary tract infections. **Results:** 290,849 patients (mean age 57.7) received a blood transfusion during their hospitalization and 2,192,930 patients (mean age 57.9) did not; $P < .001$. Multi-level fusion $\geq$9 levels was the most important independent risk factor for transfusion (OR 5.28; 95% CI 5.16 to 5.41; $P < .001$) followed by underlying coagulopathy (OR 2.58; 95% CI 2.51 to 2.66; $P < .001$) and baseline anemia (OR 2.39; 95% CI 2.36 to 2.43; $P < .001$). Blood transfusions were strongly associated with inpatient mortality (0.2% versus 0.1%; $p < 0.001$) and major complications (0.8% versus 2.5%; $P < .001$) including a greater than two-fold increase in rates of myocardial infarction, cardiac arrest, stroke, and pulmonary embolism, and a greater than three-fold increase in rates of septicemia and shock when compared to patients who did not receive a blood transfusion. Blood transfusion status was an independent risk factor for major complications (OR 1.79; 95% CI 1.64 to 1.86; $P < .001$) and inpatient mortality (OR 1.41; 95% CI 1.32 to 1.51; $P < .001$). Patients who received a blood transfusion had longer hospital stays (mean 5.4 compared to 3.3), significantly increased total hospital charges, and were twice as likely to need discharge to a facility other than home ($P < .001$). **Conclusion:** Blood transfusions are associated with poorer inpatient outcomes and a significant increase in consequent health-care resource utilization. Extra efforts should be made to minimize blood loss in those at risk of needing a subsequent blood transfusion following elective spine surgery.

A303: Advanced Age is Associated with Poorer Outcomes and Increased Hospital Resource Utilization in Patients Undergoing Elective Surgery for Degenerative Lumbar Conditions

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Introduction: Based on the US census, the population of those aged 65 and over is projected to experience the greatest increase in size over the next decade, increasing by approximately 18 million in the United States and more than doubling by 2060. Large studies analyzing the effect of advanced age on inpatient outcomes in patients undergoing elective lumbar surgery are limited. **Material and Methods:** An analysis of the National Inpatient sample from 2002 to 2012 was performed. An estimated 2,483,167 patients >25 years old who underwent elective primary or revision fusion or decompression alone for degenerative lumbar conditions were identified. A comparison of demographic information, inpatient outcomes, hospital resource utilization, and discharge disposition was performed for groups of increasing age. Complications were classified as major or minor. Major complications included acute myocardial infarction, cardiac arrest, septicemia, septic shock, stroke, and pulmonary embolism. Minor complications included deep vein thrombosis, pneumonia, surgical complications, post-operative anemia, and urinary tract infections. Specific analysis of outcomes in patients >70 and >80 was additionally performed. There was no source of external funding. **Results:** 734,909 patients (mean age 76.3) over the age of >70 and 1,751,989 patients $\leq$70 (mean age 54.0) were identified in this patient sample; $P < .001$. Patients >70 were more likely to have associated comorbidities (1.90 compared to 1.42; $P < .001$). Patients >70 were twice as likely to experience a major complication (2% compared to 0.8%; $P < .001$) and fatality (0.2% versus 0.1%; $P < .001$). While length of stay was similar between the elderly and younger patients (3.9 compared to 3.6; $P < .001$), patients >70 were more likely to require a discharge to another facility

(32.9% compared to 9.3%). Age >70 was an independent risk factor for major post-operative complications (OR = 1.95; 95% 1.89 to 2.01; $P < .001$), inpatient mortality (OR 2.45; 95% CI 2.18 to 2.75; $P < .001$), and need for transfer (OR = 5.10; 95% CI 5.05 to 5.15; $P < .001$). These increases in inpatient complications, mortality, and need for transfer were further magnified when the same analysis was performed in patients >80. **Conclusion:** The elderly represents a quickly growing patient population in the United States. Advanced age is associated with increased post-operative complications, inpatient mortality, and a substantial increase in the need for transfer to another facility in patients undergoing elective lumbar surgery.

A304: Transforaminal Lumbar Interbody Fusion: Influence on Sagittal Balance

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Introduction: Sagittal balance is expected to influence functional results after spine surgery. Transforaminal lumbar interbodyc fusion (TLIF), first described in 1988 by Harns et al, is one of the treatment options for disk heigh improval. There are several papers that describe clinical results from TLIF, but few explore the relationship between sagittal balance and clinical results. Our aim was to evaluate radiological parameters variation between pre and postoperative periods and to determine its correlation with postoperative clinical results. **Material and Methods:** Between January 2011 and December 2015, 35 patients were submitted to TLIF. We selected 18 patients with complete radiological study and at least 12 months of follow-up. The present data was retrospectively collected by phone interview and clinical and imagiological data consultation. Pain analogue scale, Short-Form Health Survey-36 (SF-36) and Oswestry Disability Index (ODI) were used. Statistical analysis was performed with GraphPad Prism version 6.0 para Windows 8. **Results:** We obtained 6 men and 12 women with 55.50 $\pm$ 11.09 years old by average, a mean follow-up period of 38.44 $\pm$ 14.28 months and a mean hospital stay of 4.13 $\pm$ 2.698 days. Lumbar and radicular pain were significantly lower in postoperative period (2.00 $\pm$ 2.64 versus 6.78 $\pm$ 2.21 and 2.50 $\pm$ 3.00 versus 5.50 $\pm$ 1.78, respectively; $P < .05$). Mean postoperative value for SF-36 was 66.84 $\pm$ 5.24 and 70.0 $\pm$ 4.83 for Physical and Mental Component, respectively. Average postoperative ODI value was 25.78% $\pm$ 20.71. Global satisfaction was 80%. We obtained a significantly higher postoperative disk height (7.83 $\pm$ 3.05 versus 10.37 $\pm$ 2.83; $P < .05$). Pelvic tilt values increased in general (PT; 18.33 $\pm$ 8.75 versus 24.05 $\pm$ 7.82; $P < .05$), there was a slight increase in lumbar lordosis (LL) for 72% of the patients (60.06 $\pm$ 15.44 versus 60.72 $\pm$ 12.21) and a slight decrease in sacral slope (SS), although normal range values were maintained for the latter (40.89 $\pm$ 8.86 versus 39.06 $\pm$ 11.67). Definitive symptoms remission occured for 55% of the patients. From those patients who maintained a normal postoperative pelvic incidence – lumbar lordosis ratio (PILL), 60% had no symptoms at all, when compared with 38% patients that exibited PILL mismatch. We were not able to obtain a correlation between cage position and lumbar lordosis variation before and after surgery. All patients obtained objective bone fusion in computed tomography at 12 months of follow-up. **Conclusion:** TLIF does seem to lead to efficacious disk height correction and might influence, even though in a slight manner, sagittal balance correction and consequent clinical parameters, as it was observed in our findings. Global variations obtained in lumbar lordosis values might be derived from modest influences that TLIF triggers in sagittal balance, as current evidence recall; also, pelvic tilt increases might translate global compensation from sagittal balance. Present data shows that PILL mismatch might be related with residual symptoms, which overlaps current literature. However, in our results, cage position did not correlate with individual variations of sagittal balance, as previously thought, specifically for lumbar lordosis. Future work with larger number of patients and longer follow-up periods are needed to corroborate these findings and extend it to general population.

A305: Robot-Guided Pedicle Screw Fixation for Lumbar Spondylolisthesis: Long-term Clinical Outcomes and Revisions

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Introduction: The accuracy of robot-guided pedicle screws has been proven to be high, but little is known on revision rates. No reports include long-term patient-reported clinical outcomes. A clinical benefit for the patient is unknown. This is the first report on long-term outcomes of robot-guided pedicle screw fixation for single level spondylolisthesis. Literature data were used to compare surgical revision rates and patient-reported outcomes. **Material and Methods:** We retrospectively analyzed prospectively collected data from patients undergoing Minimally Invasive Transforaminal/Posterior Lumbar Interbody Fusion (MI-T/PLIF). Patients were followed up at 6 weeks, 12 months, 24 months and by mailed questionnaires in March 2016 as a final follow up. Visual Analog Scale (VAS) for back and leg pain severity, Oswestry Disability Index (ODI), peri- and postoperative revision rates and sociodemographic factors were analyzed. **Results:** 72 patients fit our inclusion criteria, and had a mean follow up of 32 $\pm$ 17 months. Mean improvements in VAS back pain (49.3%), leg pain (63.4%) and ODI (61.2%) were consistent with previous reports. Length of stay was 2.4 days and operating time was 161 minutes. 89.1% of patients indicated they would choose this treatment again. Ability to work increased from 38.9% to 78.2% ($P < .001$). No instrumentation-related complications occurred, and no revision surgery was needed. Intraoperative

screw repositioning was significantly lower compared to navigated and free hand techniques ($P < .001$). PLIF, high BMI, smoking status, and preoperative ability to work were identified as predictors of reduction in back pain. **Conclusion:** Minimally invasive robot-guided pedicle screw fixation is a safe and effective means to treat spondylolisthesis. It lowers intraoperative screw revisions when compared to published evidence on both free hand and navigated procedures. Moreover, it significantly reduces the revision rate for pedicle screw malposition compared to freehand procedures.

A306: The Utility of Pre-Operative Labs in Predicting Post-Operative Complications Following Posterior Lumbar Fusion

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Introduction: As US healthcare expenditures continue to rise, there is a substantial incentive to reduce the cost of inpatient services. While pre-operative testing requires an estimated 3 billion dollars each year, several studies have suggested that lab results have a minimal impact on clinical decision-making in surgery. Despite the widespread use of pre-operative testing in spine surgery and the large volume of posterior lumbar fusions (PLF) being performed each year, no study has assessed the ability of pre-operative labs to predict adverse events following PLF. The purpose of this study was to explore the relationship between commonly obtained preoperative lab results and post-operative complications following 1-2 level PLF. **Material and Methods:** The 2006-2013 ACS-NSQIP database was employed to identify all patients who underwent 1-2 level PLF. Emergent procedures and patients undergoing unrelated interventions were excluded. Demographic information, pre-operative co-morbidities, and intraoperative characteristics were collected for each patient. Pre-operative labs included sodium, BUN, creatinine, albumin, bilirubin, SGOT, alkaline phosphatase, white blood count, hematocrit, platelet count, prothrombin time, INR, and partial thromboplastin time. Patients were determined to have normal or abnormal values. Incidence of major, minor, and total complications was documented. Patient demographics, pre-operative comorbidities, surgical characteristics, and lab values for the entire cohort were explored for potential associations with the development of postoperative complications using bivariate Chi-squared analysis. Variables resulting in $P < 0.1$ in this analysis were subsequently incorporated into a backward, binary logistic regression model with the presence of a complication as the dependent variable. Three regressions were performed for total complications, minor complications, and major adverse events. Model performance was assessed using the c-statistic and the H-L test was utilized to evaluate model calibration. **Results:** 6788 patients were identified as having undergone PLF, 6507 of which underwent elective 1-2 level fusion. After controlling for age, ASA score, length of surgery, and all significant comorbidities, abnormal sodium ($P = .001$, OR = 2.47, 95CI: 1.45-4.19) and abnormal INR ($P = .029$, OR = 2.33, 95CI: 1.09-4.98) were significantly associated with the development of any complication. Sodium ($P = .04$, OR = 1.61, 95CI: 1.01-2.54) and platelets ($P = .04$, OR = 1.58, 95CI: 1.02-2.44) were associated with minor complications. Meanwhile, creatine ($P = .04$, OR = 1.74, 95CI: 1.02-2.99) and platelets ($P = .04$, OR = 1.71, 95CI: 1.02-2.89) were significantly predictive of major adverse events. All of the models fit the data well (H-L test > 0.5) and exhibited good discrimination (c-statistic values of 0.66, 0.704, and 0.704). **Conclusion:** This study represents the first attempt to assess the utility of pre-operative labs in predicting post-operative complications in PLF. Although the majority of labs were not significantly associated with adverse events, abnormal sodium values, INR, creatinine, and platelets were shown to be predictive of various complications.

A307: Short-Term and Middle-Term Effectiveness of Caudal Injections in Patients with Spinal Stenosis: A Prospective Study

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Introduction: Several treatments have been proposed to reduce the symptoms of spinal stenosis with the caudal injection of corticosteroids and ropivacain being the most dominant. The purpose of this prospective study is to evaluate the effectiveness of this treatment in our clinic. **Material and Methods:** The sample consisted of 148 patients (108 female, 40 male). All inclusion and exclusion criteria were taken into account and the patients signed a written consent form. Apart from demographics, the duration of the symptoms was registered and a MRI of the spine was made in order to evaluate the severity of the condition, how many levels are involved and which level has the largest stenosis. A caudal injection was made in each patient consisted of 2 ml ropivacain +2 ml betamethasone. Visual Analog Scale (VAS), Standing Tolerance Scale (STS), Walking Tolerance Scale (WTS), Patient Satsisfaction Scale (PSS) and Oswestry Disability Index (ODI) were used to evaluate the pain and disability of the patients. All the above parameters (with the exception of PSS) were measured before, 6 weeks after and 6 months after the caudal injection. Statistic tests as Wilcoxon, Mann – Whitney U and Kendall's tau were used in the SPSS 20.0 software to detect possible worsening or

improvement of the symptoms as well as the existence of possible predisposing factors. **Results:** 6 weeks after the injection a statistically significant improvement was noticed in all the tests: VAS ($P = .013$), STS ($P = .02$), WTS ($P = .003$), PSS (MO = 2.46 $\pm$ 1.129), ODI ($P < .001$). However, after 6 months only VAS and ODI showed statistically significant difference ($P = .08$ and $P = .001$ respectively). A statistically significant negative correlation was noticed between the duration of the symptoms and VAS ($P = .035$) and PSS ($P = .002$) in 6 months after the injection was made. No more statistically significant differences were noticed. **Conclusion:** Patients with spinal stenosis can be relieved significantly after caudal injections of corticosteroids but for a short amount of time. Large duration of the symptoms before the injections seems to play a negative role on the middle-term effectiveness of the injections.

A308: Interspinous Process Decompression with the Aspen Device for Lumbar Spinal Stenosis: Results after 2 Years Follow-up

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Introduction: Lumbar spinal stenosis is defined as the narrowing of either the spinal canal or neural foramina.[1] Underlying causes for the stenosis are hypertrophy of the ligament flavum and facet joints, osteophytes, spondylolisthesis, disc protrusion. The Aspen device is a new interspinous process decompression device designed to distract the posterior elements of a stenotic lumbar segment and place it in order to enlarge the foraminal and central canals in those patients with neurogenic intermittent claudication.[2-3] **Material and Methods:** We present 4 years follow-up data on the Aspen patients. The inclusion criteria for the trial were leg, buttock, with back pain relieved during flexion and claudication. The exclusion criteria were chronic motor deficit, cauda equina syndrome, previous lumbar surgery or spondylolisthesis greater than grade I at the affected level. From April 2010 to January 2014, 38 patients have been included in this study. The average age was 57 years. 26 patients had the Aspen implanted at either L3-L4, L4-L5 or L5-S1 levels. 10 patients had the Aspen implanted at both L3-L4 and L4-L5 levels. 2 patients had a grade I spondylolisthesis, the other single or multilevel spinal degenerative stenosis. **Results:** The mean preoperative Oswestry score was 47. The mean postoperative Oswestry score was 16. The mean preoperative VAS score was 8.7 and the mean postoperative one was 3.8. Our results have demonstrated a successful rate in the Aspen interspinous process decompression group at an average of 4 years postoperatively. **Conclusions:** The initial effectiveness data as seen in the significant improvements on both VAS and ODI have also suggested that the Aspen device could be a viable treatment option for patients with low-back pain caused by degenerative disc disease and low grade spondylolisthesis. Furthermore, the characteristic feature of this device is the low invasiveness and the possibility of use it in L5-S1 thanks to the variety of sizes and its simple surgical approach.

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A309: Morphological, Clinical and Self-Assessment Classifications of Lumbar Spinal Stenosis: Useful for Science Only or a Daily Routine?

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Introduction: Lumbar spinal stenosis is frequent diagnosis especially in the elderly. Clinical signs are very variable, but graphical findings are typical. But are they really so typical? Can we rely on our clinical and graphical results? And can we find some rules for the decision about the treatment? When continue in conservatively and when go to surgical surgical treatment. Are there any borders or rules? We decided to study morphological, clinical and patients self-assessment classifications to find corrleations and importance. **Materials and Methods:** Retrospective study, 60 patients selected for surgery for the lumbar spinal stenosis Inclusion criteria were preoperative MR, visual analog scale (VAS), Oswestry disability index (ODI), Swiss Spinal Stenosis Questionnaire and neurological score - (NIS-LSS). We measured MR axial pictures: area of the spinal canal, area of dural sac, Schizas nerve root compression score. The results were statistically processed to study correlation between all categories. **Results:** We have found no correlation between both self-assessment scores and morphological and clinical scales. We have found only weak correlation between clinical scale (NIS-LSS) and Schizas score and area of the dural sac. There is no correlation between clinical scale and area of the spinal canal. **Conclusion:** Our hypothesis - in such a selected group of patients there should be strong evidence of correlation between morphological, clinical scores and self-assessment questionnaires - was disproved. The decision about the way of treatment of the lumbar spinal stenosis remains the same - it depends on the agreement of the surgeon and the patients. There are no classification schemes that can help with the decision. Only the Schizas nerve root compression score has some value and can show some relations between MR and clinical findings, although it is not statistically reliable in our study.

A310: The Predictive Formula of Lumbar Lordosis and Lower Lumbar Lordosis Regulated by Pelvic Incidence among Old Men

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Purpose: Recovering of individual lumbar lordosis (LL), especially lower lumbar lordosis (L-LL) is mandatory in spine fusion surgery. Pelvic incidence (PI) minus lumbar lordosis, or PI-LL value to predict ideal lumbar lordosis has been known to be a fixed parameter around 9°. However there are several reports that PI – LL is variable according to the value of PI. The study of normal subjects using PI calculating ideal LL and L-LL, where most lumbar surgery are performed, was not reported. The purpose of this study was to present the correlation formula for optimum LL and L-LL by PI value. **Materials and Methods:** Standing sagittal radiographs of the whole spine including the pelvis in 150 adult male volunteers (average age: 64.1 ± 6.4) without back pain, or surgery in spine or lower extremity was analyzed. Volunteers with scoliosis, spondylolisthesis, 1–3 segmental disc space narrowing, and/or compression fractures in radiographs were excluded. The following parameters were included: C7 Plumbline (C7 PL), Thoracic kyphosis (TK, T5 upper endplate (UEP) - T12 lower endplate (LEP)), LL (T12 LEP − S1 UEP), L-LL (L4 UEP − S1 UEP), pelvic parameters including PI. The values PI - LL, and PI - L-LL were calculated, and the formula using simple linear regression analysis was performed. A P value of <0.05 was considered statistically significant. **Results:** The average age, height, weight, and body mass index (BMI) were 64.1 ± 6.4 years, 167.0 ± 5.5 cm, 67.3 ± 9.8 kg, and 24.1 ± 3.1 respectively. The average TK was 30.0° ± 8.8°, LL was −57.5° ± 9.0°, L-LL was −41.7 ± 7.0°, PI was 48.6 ± 8.6°, and sacral slope (SS) was 37.3 ± 6.8°. The formula was established as follows: PI –LL = 0.392 * PI - 27.804 ($R^2 = 0.1709$) and PI – LLL = 0.7761 * PI – 28.251 ($R^2 = 0.4942$). **Conclusion:** The values of PI - LL and PI - L-LL increase as pelvic incidence increase. This result will be important references in understanding of normal spinal anatomy and spinal surgery.

Surgical Complications Deformity

A311: Use of the Adult Spinal Deformity (ASD) Frailty Index (ASD-FI) to Predict Major Complications in the Scoli-Risk 1 Multicenter, International Patient Database

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Introduction: Patients with a greater degree of deformity, those with neuromuscular or congenital deformity, and those undergoing more complex procedures including 3 column osteotomies have an increased rate of major complications. In this complex cohort, accurate preoperative risk assessment is even more important. A deformity-specific frailty index (ASD-FI) has been validated in less complex cohorts and was strongly associated with major complication incidence and hospital length of stay (LOS). **Material and Methods:** The Scoli-Risk 1 database only included patients with severe deformity (eg >80 Cobb curvature or congenital deformities) undergoing complex procedures (eg 206/272 patients had 3-column osteotomies). The recently developed ASD-FI was used to calculate frailty scores for all patients. Patients were classified as not frail (<0.3 NF), frail (0.3- ≤ 0.5 F), and severely frail (≥0.5 SF). We then performed a multivariate logistic regression to determine the relationship between ASD-FI cohorts, incidence of major complications, and hospital length of stay (LOS), adjusted for important preoperative and surgical covariates such as operative time and estimated blood loss. **Results:** Of 267 participants, the mean ASD-FI score was 0.33 (0-0.72). The odds of having a major complication was 1.5 [0.9-2.8] ($P = .1$) for F (n = 103) and 3.6 [1.8-7.0] ($P < .001$) for SF (n = 59) compared to NF pts (n = 105). After adjusting for operative covariates, the odds ratios still trended upwards with frailty (1.5 for F, [0.8-2.8] $P = .3$) and 4.1 [1.9-9.2] $P < .001$ for SF). Unadjusted, LOS increased with frailty, increasing 4.0% [-13.5-25.0] ($P = .6$) F and 11.9% [-9.8-38.9] ($P = .3$) SF from the LOS of NF pts. Adjusted, LOS increased 6.5% for F [-6.9-21.7] ($P = .4$) and 18.9% [1.4-39-4] ($P < .05$) for SF compared to NF. **Conclusion:** Frailty, as measured by the ASD-FI, was associated with increased risk of major complications and LOS (after controlling for site/region differences) for complicated ASD patients undergoing complex spine surgery. This validation of the index in the most complex deformity patients reinforces the role ASD-FI could play to improve the accuracy of preoperative risk stratification.

A312: Neurologic Complications Following Complex Adult Spinal Deformity Surgery: 2 Year Follow-up of the Scoli-Risk 1 Prospective, Multicenter, International Study

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Introduction: The neurologic complication rate following complex adult spinal deformity (ASD) surgery is quite variable due to several factors. Most series are retrospective with heterogeneous patient populations & have non-uniform neurologic assessments performed &/or documented before & after surgery. We hypothesized that the neurologic complication rate would be higher than previously reported due to strict prospective grading of the Lower Extremity Motor Score (LEMS) by Asia-Certified evaluators at specific postoperative time points, with gradual improvement over time. **Material and Methods:** The Scoli-Risk 1 trial enrolled 272 patients from 15 centers (9 North American, 3 European, 3 Asia-Pacific) with ASD having primary or revision surgery with a major Cobb of >80° (n = 79), a revision including an osteotomy (n = 165), and/or a complex 3-Column Osteotomy (3-CO, n = 206, 76%). All patients had a complete Lower Extremity ASIA exam performed preoperatively and at specific postoperative time points up to 2 yr follow-up which generated a Lower Extremity Motor Score (LEMS, Max. 50 points = Normal LE Motor function). **Results:** 196 (72%) patients had preoperative & all postoperative time point LEMS available. The patients with normal scores of 50 points preoperatively statistically declined at discharge (49.04, $P < .001$), 6 weeks (49.00, $P < .001$), 6 months (49.62, $P = .001$) & 2 year follow-up (49.66, $P = .002$). Those starting with a motor deficit preoperatively (n = 68; LEMS 43.79), had statistical improvement in their LEMS at 6 months (47.21, $P < .001$) & 2 years postoperative (46.12, $P = .003$). The overall rate of postoperative decline in LEMS was 23% at discharge, 17.1% at 6 weeks postoperative, 9.9% at 6 months, & 10.1% at 2 years postoperative. **Conclusion:** The rate of postoperative motor function decline in ASD patients undergoing complex spinal reconstructive surgery was 23% at hospital discharge improving to 17% at 6 weeks postoperative then further improving to 10% at the 6 months & 2 year follow-up time points. This rate is higher than previously reported due to the prospective, strict nature of LEMS testing in these challenging pts.

A313: Development and External Validation of the Adult Spine Deformity (ASD) Frailty Index (ASD-FI)

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Introduction: In geriatrics literature, the concept of frailty as a physiologic diagnosis was developed as an improved measure of aging. In general surgery cohorts, frailty has been shown to be a better predictor of major complications than age. One validated method of determining frailty is by using a frailty index, which is based on the concept that frailty is an accumulation of deficits. With each deficit, frail patients become increasingly vulnerable to acquiring additional deficits and of having adverse outcomes following surgery. **Material and Methods:** All preoperative variables in a prospective ASD database were analyzed to select those meeting previously validated criteria. 40 variables were identified, the ASD-FI score was calculated as the average of the variables, and this score was used to stratify patients into 3 frailty score cohorts with cut off scores previously defined in the literature: not frail (NF) <0.3, frail (F) 0.3-0.5, severely frail (SF) >0.5. The frailty model was then validated in a prospective ASD database with identical inclusion criteria. We then performed a multivariate logistic regression to determine the relationship between ASD-FI cohorts, incidence of major complications, and hospital length of stay (LOS), adjusted for important preoperative and surgical covariates such as operative time and blood loss. **Results:** In the ESSG database, of 266 patients with at least 2 years follow up, the average ASD-FI score was 0.29 (0-0.8). The adjusted odds of incurring a major intraoperative or postoperative complication were 4.5 [2.0-10.0] ($P < .001$) times greater, those of having a reoperation were 3.8 [1.7-8.9] ($P < .01$) times greater, and the LOS was 9.3 [5.4-13.2] ($P < .001$) days longer for SF (n = 83) compared to NF (n = 80) patients. SF patients were also more likely to develop PJK (4.6), wound infections (5.7, adjusted 10.2), implant related (3.4), and neurologic 4.7) complications than NF patients ($P < .05$). **Conclusion:** The ASD-FI score is associated with increased LOS and risk of major complications,

especially medical complications, wound infections, and PJK. This indicates that frailty assessment could be applied to improve the accuracy of preoperative risk stratification and assist with patient counseling.

A314: Reduced Post-Operative Infections and Revision Surgery with Plastic Surgery Closure in the Treatment of Neuromuscular Scoliosis

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Introduction: A multi surgeon retrospective review looking at postoperative deep space infections after posterior spinal fusion can be difficult to manage and potentially devastating. The overall rate of infection after posterior spinal fusion has been reported as high as 23% in patients with neuromuscular scoliosis. A multilayered plastic surgery closure decreases potential dead space, protecting the spinal instrumentation. We compared surgically treated neuromuscular scoliosis patients with and without plastic surgery multilayered wound closure. **Materials/Methods:** All neuromuscular scoliosis patients treated with posterior spinal fusion from 2008 to 2014 were analyzed. Patients with 2-year follow-up and completed charts were reviewed. Patients were categorized into 2 Groups: Group 1 [Plastic Closure (PC)] – included patients with a multilayered closure and advancement flaps when necessary; Group 2 - Standard Closure (SC). Differences in demographic, radiographic, and clinical parameters were analyzed. **Results:** 50 patients met inclusion criteria for the database, of which 39 had complete 2-year data. Group 1 had 11 patients, each having a multilayered plastic surgery wound closure. Group 2 included 28 patients who had a standard wound closure. There was no difference in age, male gender, number of levels fused, or postop max coronal Cobb angles between the Groups (Table 1). There was a significant difference in deep space infections (0 vs 7, $P = .0057$), revision surgeries (0 vs 7, $P = .0057$), EBL (2425 vs 644 cc, p = 1.46E-06), OR time (467 vs 245 min, p = 1.97E-08), iliac screw fixation (58% v. 21%, $P = .022$), and preop max coronal Cobb angle (58.29 vs 71.99°, $P = .043$) in the PC vs SC Groups, respectively.**Conclusion:** Plastic surgery closure resulted in a statistically significant decrease in infection and revision surgery rates despite this patient cohort having significant increases in blood loss, operative time, and iliac screw fixation, all of which have been shown to increase the risk of infection. Utilizing a plastic surgery closure can reduce dead space, providing better soft-tissue coverage of the spinal instrumentation reducing infections and revision surgery rates.

Table 1.

	PC	SC	p
N	11	29	
Age (yrs)	15.28	17.39	0.255
Male	57%	41%	0.38
# levels fused	14.38	15.5	0.197
Preop Cobb Max	58.29°	71.99°	0.043
Postop Cobb Max	26.88°	25.13°	0.704
EBL (ml)	2425	644	1.46E-06
OR time (min)	467	245	1.97E-08
Iliac screw fixation	58%	21%	0.022
Deep Space infections	0	7	0.0057
Revision surgery	0	7	0.0057

A315: Complication Rates Associated with 3-Column Osteotomy in 82 Adult Spinal Deformity Patients: Retrospective Review of a Prospectively Collected Multicenter Consecutive Series with Minimum 2-Year Follow-Up

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Introduction: Although three-column osteotomies (3CO), including pedicle subtraction osteotomy (PSO) and vertebral column resection (VCR), can provide powerful alignment correction and disability improvement in adult spinal deformity (ASD) treatment, these procedures are complex and associated with high rates of complications. Previous reports on complications associated with 3CO have been primarily based on retrospective complication collection, which may substantially underestimate the true rates. Our objective was to provide a retrospective review of a prospectively collected multicenter consecutive case series of thoracolumbar 3COs performed for ASD. **Materials and Methods**: ASD patients treated with 3CO and eligible for 2-year follow-up were identified from a prospectively collected multicenter ASD database. Early (intraoperative and <6 weeks after surgery) and delayed (>6 weeks after surgery) complications were collected using standardized forms and onsite study coordinators. **Results**: Of 106 ASD patients treated with 3CO, 82 (77%; 68 PSO/14 VCR) had 2-year follow-up (76% women, mean age 61 years, previous fusion in 80%, and mean Charlson Comorbidity Index of 2.1). The mean number of posterior instrumented fusion levels was 13, and 17% also had an anterior fusion. A total of 101 early (43 minor/58 major) and 63 delayed (14 minor/49 major) complications were reported, with 53 (65%) and 44 (54%) patients affected, respectively. Overall, 67 (82%) patients had at least one complication. The most common complications were rod breakage (31%), excessive blood loss (>4 L, 29%), dural tear (21%), new radiculopathy (10%), new motor deficit (10%), proximal junctional kyphosis (PJK,10%) and pleural effusion (9%). The most common early complications were excessive blood loss and dural tear, and the most common delayed complication was rod breakage. 27 (33%) patients had from 1-11 re-operations (total of 44 re-operations). The most common indications for re-operation were rod breakage (n = 15), deep wound infection (n = 15) and PJK (n = 6). Notably, the early complication rate (50%, 9 minor/4major) and types of early and delayed complications reported among the 24 patients that did not achieve 2-year follow-up were similar to the 82 patients that achieved 2-year follow-up. Compared with patients that achieved 2-year follow-up, those lost to follow-up did not differ with regard to age, comorbidity index, number of fusion levels, or length of hospital stay ($P \geq .18$). **Conclusions:** Among 82 ASD patients treated with 3CO, 67 (81.7%) patients had at least one complication (57 minor/107 major). The most common complications were instrumentation failure, excessive blood loss (>4 L), neurologic deficit, and PJK. This study represents one of the most complete and detailed reports to date of early and delayed complications associated with surgical treatment for ASD that includes 3CO. These findings may prove useful for treatment planning, patient counseling, benchmarking of complication rates, and ongoing efforts to improve the safety and cost-effectiveness of patient care.

A316: Bimodal Incidence and Causes of Proximal Junctional Kyphosis (PJK) in Adult Spinal Deformity (ASD)

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Introduction: PJK is a well-known complication occurring in patients (pts) that undergo surgical ASD correction. Acute PJK (aPJK) occurs within the first six weeks, and chronic PJK (cPJK) more than 1 yr after surgery. Both PJK deformities can require surgical treatment. In this study, we aimed to first report the incidence of PJK, and contributing factors to either acute or chronic PJK. **Materials and Methods:** This is a retrospective review of prospectively collected database of consecutive ASD patients. Pts were included if they were >18y, ≥5 levels fused including the pelvis and 2y f/u. Using Glattes criteria, pts were stratified according to timing of PJK: aPJK <6wk, and cPJK >1y. Pts demographics, radiographic parameters, clinical outcomes (HRQL), operative data, complications and revisions rates were studied using univariate and multivariate analyses to identify independent predictors of aPJK. **Results**: 176 pts (61.8 yo) were included. 71 pts (40.3%) developed aPJK, and 39 pts (22%) cPJK. Both groups were similar in age, baseline deformity, and HRQL. aPJK pts were more likely to have Charlson score >2 (39.4% vs. 20.5%), depression (34% vs. 16.2%), greater # of co-morbidities (2.7 vs. 2.0), all $P < .05$.

aPJK pts were more likely to have an abnormal neurologic exam (30% vs. 10.5%), and unable to perform toe-walking test (17% vs.0%), all $P < .05$. aPJK had higher revision rate (21 vs. 10.3%), peri-operative complication rate (14.1% vs. 0%) all $P < .05$. Both groups underwent similar amounts of sagittal correction, # of level fused, #/type of osteotomies, however, aPJK had more proximal LL apex restoration vs more caudal apex restoration in cPJK. aPJK occurred in 50/70 (71.4%) of posterior only approaches vs. 21/40 (52.5%) in combined approaches, $P < .05$. On multivariate analysis depression (OR: 2.99), and abnormal neurologic exam (OR: 4.15) increased the likelihood of aPJK. **Conclusions**: Compared to chronic PJK, Acute PJK pts have more co-morbidities, neurologic deficits, depression, and higher lumbar apex corrections with less caudal correction. In addition, aPJK pts had significantly higher peri-operative complication rates, and were more likely to be revised.

A317: Risk Stratification for Patients Undergoing Surgical Correction of Scoliosis Based on the Rates of Perioperative Complications in a Tertiary Hospital between 2010-2014 and the Review of the Current Literature

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Introduction: The reported incidence of complications after spine surgery varies widely, although many strategies have being developed to make this surgery safer, there is still a high rate of complications. The objective of this study is to determine the complication rates associated with surgical treatment of scoliosis and to assess variables associated with these complications. The literature to date was reviewed on risk factors for spine surgery and a risk stratification is proposed. **Material and Methods:** A retrospective review of hospital charts of patients with scoliosis who underwent surgical correction at a tertiary hospital between 2010-2014 was performed. Demographic variables, surgery characteristics and perioperative complications rates were assessed. Central tendency measures were made, a bivariate analysis and finally a logistic regression was performed. The literature to date was reviewed and a risk stratification was developed. Taking in to account the etiology, patient characteristics like age and weight, the radiological measurements, lab values and the patient past records, the potential risk for the major types of complications can be determined and therapeutic interventions are proposed to prevent them. **Results:** A total of 318 Cases fulfilled inclusion criteria. The most common etiology for scoliosis was idiopathic (47%) followed by neuromuscular (27%) and congenital (23%). The main rates of complications according to the bivariate analysis with the etiology are as follows: for neuromuscular scoliosis, pneumonia (23.8%), pleural effusion (15.87%) and urinary tract infection (6.34%); for idiopathic scoliosis was pneumonia (2,77%) and for congenital scoliosis was urinary tract infection (1.88%). All these results with a $P < .05$. A logistic regression was made and age was a significant risk factor to present complications. The risk stratification that was designed consist in a section subdivided by the major types of complications, the risk factors associated to each complication were listed as a checklist so that they can be compared with patient information. Based on these results the next section of therapeutic interventions can be interpreted to choose the proper action. **Conclusions:** The rates of complications after scoliosis correction surgery remain high; risk stratification assesses the particular risks of each patient to present specific complications and therapeutic interventions can be made in time to reduce complication rates. This risk stratification can also provide appropriate preoperative counseling on the risks and benefits of surgery.

A318: Safety Attitudes Among Spinal Care Professionals: Results of an International Survey

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Introduction: Safety culture as a concept emerged from examining organizations that have been successful in minimization of adverse events in hazardous working conditions, such as the aviation. An adverse event is defined as "any unfavourable and unintended sign (including an abnormal laboratory finding), symptom, or disease temporally associated with the use of a medical treatment or procedure that may or may not be considered related to the medical treatment or procedure. In medicine, safety culture is gaining more and more importance as an outcome to improve clinical practice. In 1999, for example, The Institute of Medicine published the report 'To Err is Human' which established that improving safety culture was as a crucial element in improving the quality of health care in the US. Organizational factors such as safety climate, work environment factors such as staffing, team factors such as teamwork, and staff factors such as overconfidence are factors influencing risk and safety in clinical practice. Purpose of this study is to evaluate these factors among spinal professionals worldwide. **Material and Methods:** An online survey was distributed to members of AOSpine International in 2016. The survey consisted out of three parts: (1) demographics of the respondents; (2) the Safety Attitude Questionnaire (SAQ) and (3) expectations of who is responsible for improving the safety culture. The SAQ measured the job satisfaction, teamwork climate, safety climate, the perceptions of management, stress

recognition and the working conditions of the respondents. Multivariate logistic regression was performed to identify factors associated with safety attitudes. **Results:** A total of 356 respondents, majorly spine surgeons, responded. Gender, continent, occupation, tenure, and the amount of employees in the clinic were all not associated with the team climate, safety climate, stress recognition or management perceptions of the respondents ($P > .05$). Respondents in Africa have a significant lower score (OR: 0.19, $P < .05$) on working conditions, compared to spine professionals in Asia. Respondents in North America had the highest odds to have a significantly higher score (OR: 4.04, $P < .05$) than respondents in Asia. Overall, the majority expected the surgeon to be mainly responsible for improving the safety culture in the OR and at management level. **Conclusion:** Surgeons were expected to play a central role in improving the safety culture. The continent of the responders is a factor that may affect the safety attitudes among spinal professionals.

A319: Searching for Optimal Position of Bone Graft in Order to Prevent Dislodgement in Multiple Anterior Cervical Corpectomy and Fusion

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Introduction: Dislodgement of a bone graft after anterior cervical corpectomy and fusion is one of the most severe complications which should be avoided because it may cause to compression of spinal cord. The purpose of this study is to clarify risk factors for graft dislodgement after cervical corpectomy and fusion. **Material and Methods:** Between April 2013 and May 2016, thirty seven patients (twenty three men; mean age, sixty four yr) who underwent anterior cervical corpectomy and fusion combined with corpectomy for two vertebra, grafting fibula and plating for cervical spondylotic myelopathy or ossification of posterior longitudinal ligament were investigated retrospectively. All patients put on cervical collar after surgery. Three type of graft position were defined as neutral postion: distance between posterior surface of vetebra and proximal edge of bone graft are similar to distance between posterior surface of vetebra and distal edge of bone graft, Z position: proximal edge of graft is located posteriorly to distal edge of bone graft, reverse Z position: distal edge of graft is located posteriorly to proximal edge of bone graft by measuring on lateral view of X-ray or on sagittal view of CT scan. **Results:** There were four cases of graft dislodgement (10.8%) which proximal edges of grafts were migrated posteriorly. Then three patients of them required halo vest without neurological symptoms progressed, one who complained progressive symptoms of myelopathy required posterior decompression and instrumentation as a revision surgery. Regarding graft position in patients without graft dislodgement, twelve cases showed neutral position, nineteen showed Z position, two showed reverse Z position, and all of four graft dislodgement cases showed Z position. **Conclusion:** We clarified risk factors for dislodgement of bone graft after anterior cervical corpectomy and fusion. Z position of bone graft is a possible risk factor of graft dislodgement.

Arthroplasty Cervical

A320: 30-day Readmission and Reoperation after Single-level Anterior Cervical Discectomy and Fusion versus Cervical Disc Replacement

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Introduction: Anterior cervical discectomy and fusion (ACDF) is one of the most commonly-performed surgical spine procedures, typically used to alleviate or halt progression of myeloradiculopathy. However, ACDF inherently decreases motion between the two fused vertebral segments, which has led to the advent of non-fusion techniques such as cervical disc replacement (CDR). Long-term analysis studies have shown that CDR is generally associated with either similar or lower complication rates than ACDF, including post-operative pain, adjacent segmental degeneration, segmental range of motion, and neurological degeneration. However, there is limited data on the short-term outcome of ACDF vs. CDR, particularly in terms of early reoperation or readmission rates. Thus, the purpose of this article is to compare 30-day readmissions and reoperations between patients who underwent single-level ACDF vs. CDR. **Material and Methods:** We used the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database from 2013 to 2014. Inclusion criteria were adult patients who underwent single level ACDF or CDR for cervical spondylosis. Primary outcome measures were 30-day readmissions and reoperations. Data analyses were performed in Stata SE 12. Logistic regression analysis was used to assess the independent effect of procedure (ACDF vs. CDR). **Results:** A total of 7019 patients met inclusion criteria; 6,468 patients (92.1%) underwent single-level ACDF and 551 patients (7.9%) underwent CDR. Readmission rates were 2.6% for ACDF versus 0.5% for CDR ($P = .002$). When stratified by age groups, only patients between the ages of 41 to 60 who underwent ACDF had significantly higher readmission rates when compared to CDR (2.5% vs. 0.6%, $P = .037$). Reoperation rates were 1.3% for ACDF and 0.5% for CDR ($P = .130$). After controlling for patient age, sex, BMI, smoking status, history of COPD, diabetes, hypertension, steroid use, and ASA class, patients who underwent CDR were significantly less likely to undergo a 30-day readmission

compared to patients who underwent ACDF (OR 0.31; 95% CI, 0.09 – 0.98; $P = .048$). On the other hand, also after multivariate analysis, CDR was not associated with lower odds of reoperation (OR 0.72; 95% CI, 0.22 – 2.39; $P = .603$). **Conclusion:** Patients who underwent single-level ACDF had a higher readmission rate than single-level CDR due to related complications. When stratified by age, this was also seen only in the 41 to 60 years old age group. No significant difference in 30-day single-level ACDF or single-level CDR related reoperation rates were found.

A321: Cervical Disc Arthroplasty versus Anterior Cervical Discectomy and Fusion (Short and Long Term Follow Up): A Systematic Review of Randomized Controlled Trials

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Introduction: Anterior cervical discectomy and fusion (ACDF) is considered a standard surgical treatment for cervical disc disease that is non-responsive to conservative treatments. ACDF provides decompression of the neural structures, segmental stabilization, restoration and maintenance of the normal lordotic curvature of the cervical spine.Despite the success of the ACDF procedure, long term outcome studies increasingly focused on multiple adverse effects in both short and long terms. Cervical fusion reduces motion at the fused segment resulting in increased motion and increased intradiscal pressure at adjacent levels with up to 25% of operated patients may develop recurrent radicular symptoms from adjacent level disease within 10 years of operation. Pseudarthrosis, dysphagia and complications associated with autologous graft site are other adverse outcomes reported as well.To overcome ACDF drawbacks, Cervical disc arthroplasty was designed to preserve motion at the desired segment thereby reducing mechanical changes at the adjacent segments, avoid limitations of fusion, and allow faster return to daily activities. **Materials and Methods:** A systematic literature review was done using electronic databases and reference lists of key articles searching for randomized controlled trials comparing cervical arthroplasty versus ACDF. The inclusion criteria were prospective, randomized controlled trials comparing arthroplasty and fusion with minimum follow up of 2 years. The exclusion criteria were studies that didn't have a prospective, randomized controlled design, those with follow up time less than 2 years, retrospective studies, and case series. Studies were evaluated for level of bias. **Results:** Twenty three randomized controlled trials were identified that met the inclusion criteria. With a minimum follow up period of 2 years and maximum follow up period of 7 years. Patient reported clinical outcomes were assessed using the Neck Disability index (NDI), Visual Analog Scale (VAS) of neck and arm pain, short form 36 (SF-36). Overall success, implant-related complications, secondary surgeries, and return to work were compared as well.At short term follow up, cervical arthroplasty wasn't inferior to ACDF at all postoperative measures. However, at long term follow up, cervical arthroplasty had better overall success, better NDI score, lower VAS of neck and arm pain, better range of motion at the operated level, fewer secondary surgical procedures, and faster return to work. Some of the differences were not statistically significant. **Conclusion:** ACDF is considered a standard surgical treatment for cervical disc disease. It has some drawbacks, like increased motion and increased intradiscal pressure at adjacent levels, leading to a higher rate of adjacent segments degeneration.Our review suggests that cervical arthroplasty is a safe and effective method for treating cervical disc disease and is a viable alternative to ACDF with at least equivalent (2 years follow up) or even better clinical outcome (>4 years follow up). Cervical arthroplasty patients have superior spine kinematics at the operative and adjacent levels, theoretically minimizing adjacent level disease.Although the majority of cervical arthroplasty patients had a clinically significant overall success, some studies showed similar outcomes.Future studies are necessary before strong recommendations can be made to prove that this technology supersedes ACDF.

A322: Multi-level Fusion versus Hybrid Surgery in Three-Level Cervical Disc Disease: Retrospective Matched Analysis of Clinical and Radiologic Results in Minimum 2-Year Follow-up

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Introduction: Anterior cervical discectomy and fusion (ACDF) results in loss of mobility at the index segment and creates increased stress on adjacent segments, resulting more rapid disc degenerations. Symptomatic adjacent segment disease (ASD) occurs in 25% of patients, within 10 years after the initial ACDF surgery. Multi-level fusion leads to a substantially greater increase in intradiscal pressure than single level surgery. As a promising alternative, artificial disc replacement (ADR) has emerged and it has been demonstrated that ADR can maintains motion at the index level and decreases strain on the adjacent segments for prevention of ASD. The optimal surgical technique for 3-level cervical disc disease (CDD) remains uncertain. Hybrid surgery, consisting of ADR combined with ACDF, has been reported with favorable results for 2-level cervical disease. In this context, hybrid surgery (2-level ACDF/ADR) for 3-level CDD may be a reasonable alternative to multi-level ACDF to prevent symptomatic ASD. The objective of this study was to compare clinical and radiologic outcomes of 3-level ACDF and hybrid surgery in terms of postoperative adjacent segment degenerations. **Material and Methods:** Between May 2008 and September 2012, 18 patients

with 3 consecutive levels CDD between C3/4 and C6/7 who underwent hybrid surgery were retrospectively reviewed. Study group were matched paired to 18 patients of 3-level ACDF group based on age, gender and the operated levels. All patients were followed clinically and radiologically for a minimum of 24 months. All operations were conducted with two surgeons with the same surgical protocols. For ACDF surgery, allograft spacers were inserted and anterior cervical plate was placed over the entire fused segments. In hybrid group, ADR was performed in the segment that had less degenerative changes and had greater physiologic motion (C5–C6 > C4–C5 > C6–C7 > C3–C4). Either Prodisc-C or Prestige artificial disc was implanted according to the surgeon's preferences. Retrospective analysis of perioperative parameters included factors such as operative time, fluoroscopic time, postoperative opioid use, blood loss, length of hospital stay, surgical drainage, transfusion and complications. Neck Disability Index (NDI) and visual analogue scale (VAS) scores for neck and arm pain were obtained before surgery, 1, 3, 6, 12 and 24 months after surgery for each group. Radiological analysis was conducted via lateral radiographs in flexion, extension, and in neutral position before surgery and routine postoperative intervals. Radiological measurements including angular range of motion (ROM) of C2–C7 and adjacent segments and cervical lordosis were measured using the Cobb method with PACS software. The radiological evidence of adjacent level changes including new osteophyte formation, narrowing of disc space, end-plate sclerosis and anterior longitudinal ligament (ALL) calcification was assessed. **Results:** The demographic and perioperative data showed no statistical differences between 2 groups. Both groups showed significant improvement in NDI and VAS scores postoperatively and continued improvements were observed in both groups until 2 years. Although no significant differences in NDI scores existed between 2 groups at 3 and 6 month postoperatively ($P = .333$,.055 respectively), hybrid group experiences a trend towards better results at 12 and 24 months ($P = .001$, .018 respectively). VAS scores for postoperative neck pain were significantly less in the hybrid group at 6 and 12 months (4.7 ± 1.6 vs 3.3 ± 1.3; $P = .018$, 3.5 ± 1.6 vs 2.3 ± 1.7; $P = .045$ respectively), but there was no differences at the final follow-up (2.5 ± 1.6 vs 2.2 ± 1.9; $P = .110$). There was no difference in arm pain relief between the groups. Both group exhibited decreased C2-C7 ROM when compared with preoperative values. The cervical motion was significantly limited immediately after surgery and then gradually recovered. The hybrid group showed greater C2-C7 ROM recovery compared to ACDF group at the final follow-up ($36.3 \pm 7.9^\circ$ vs $29.5 \pm 7.4^\circ$; $P = .034$). Although, superior adjacent segment ROM for ACDF group was significantly increased from 12 month after the surgery, the hybrid group remained hypo-mobile during the follow-up periods. The ACDF group exhibited hyper-mobility at inferior adjacent segment ROM from 6 month after the surgery; however, the hybrid group showed no difference during the follow-up periods except final follow-up. Significantly increased ROM at inferior adjacent segments was observed in both groups compared with preoperative values at the final follow-up, but the compensatory ROM was less in hybrid group. Significant recovery of cervical lordosis was observed in both group compared with preoperative values ($P = .004$, $P = .009$ respectively). But no statistical difference was found between two groups ($P = .937$). Adjacent disc space narrowing was observed equally in both groups. New osteophyte formations were found only in ACDF groups (11%. 2/18). Other degenerative changes were not observed in both groups. One patient with dysphagia and one with hoarseness were found in each group. In Hybrid group, 1 patient underwent emergency re-operation for epidural hematoma. Heterotopic ossification was found among 11.1% (2 out of 18) of patients in hybrid group. No other complications such as implant failure, infection or C5 palsy was developed in both groups. **Conclusion:** In this study, hybrid surgery consisting of 2-level ACDF and ADR was shown to be safe and effective for 3-level CDD. Compared with ACDF, the hybrid surgery exhibited better neck pain improvement, C2-C7 ROM and less impact at adjacent level. The hybrid surgery may be a promising alternative to fusion surgery for 3-level CDD. Longer-term follow-up is warranted.

A323: In Vivo Study on the Effect of Cervical Arthroplasty on Cervical Spine Biokinematics

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Background: Despite being the gold standard treatment for cervical disc herniation, ACDF may be considered a non-physiological procedure as it results in loss of segmental motion and induces biomechanical changes at adjacent disc levels. The purpose of this study is to investigate the effect of cervical arthroplasty on cervical spine disc center of rotation and range of motion at instrumented and adjacent levels. **Material and Methods:** Thirty-one patients were submitted to one or more cervical arthroplasties with M6. Radiological parameters were measured preoperatively and postoperatively at 6 months, and 1-year FU. Ranges of motion (ROM), global and segmental, and center of rotations (CORs) at instrumented and adjacent levels were analyzed using specific validated motion analysis software (SpineView 2.4). **Results:** Thirty-one patients with a mean age of 51.7 (range 35-69) were implanted with forty-six M6 cervical disc prosthesis. Mean FU is 12 months. Fourteen were pure M6 cases, whereas seventeen were hybrid constructs adding fusion to M6. In single level cervical disc prosthesis, CORs at index level tend to locate superior and posterior at 6-months post-operatively normalizing at 1-year. Measuring the distance to an elliptic distribution of normalized asymptomatic confirms the same tendency, from 7% to the ellipse pre-OP to 12% at 6-month ($P < .05$), and 6% at

12-year (P > .05). Minimal changes at adjacent levels CORs were observed in different time-points. At instrumented level, the mean X-COR was pre- operatively calculated to 34.8% versus 30.2% at 6-months and 33.4% at 1-year (P > .05); the mean Y-COR was preoperatively calculated to -23.5% versus -2% at 6.months (P < .05), and −31.6% at 1-year (P > .05). At index level, an increase of ROM from a mean pre-OP of 6° (4-7°) to 11° (6-15°) at 6-months, and 14° (16-12°) at 1-year was observed (P < .05), with a non significant decrease at inferior adjacent level ROM from a mean of 7° to 5° and no change at superior adjacent level (mean 11 to 12°) (P > .05). Implanting a single level cervical disc prosthesis did improve without statistical significance the global range of motion (C2-C7) from 40 to 45°, at pre-OP to 1-year post-OP, respectively (P > .05). When inserted adjacent to a fusion, M6 arthroplasty tended to normalized the CORs of the index level at 6 months, without affecting the location of CORs of the superior natural level. The ROM remained unchanged both at index and superior adjacent level at 1-year. The decrease at 12months of global ROM (mean 46 to 47°) equals the decrease of ROM at the fusion level (P > .05). These changes are observed whether M6 is implanted above or below a fusion. In multilevel M6, index levels ROM changes from a mean of 9° to 11° and from 11° to 9° with minimal decrease in ROM at natural superior level (12° to 11[a]) (P > .05). **Conclusions:** M6 tends to considerably restore qualitative kinematics in the cervical spine at the index level at 1-year, with minimal changes at adjacent levels. Restoring mobility and CORs at index level and at adjacent levels may elude hypermobility and biomechanical stresses at adjacent levels. The extent of motion was preserved along with quality of motion.

A324: Hybrid Surgery for Multilevel Cervical Degeneration Disc Disease

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Introduction: Cervical radiculopathy and myelopathy are common pathologies in adult patients and have been shown to cause significant disability. Surgical options include posterior decompression and fusion, anterior cervical discectomy and fusion (ACDF) and cervical disc arthroplasty (CDA). To date, ACDF is the most accepted treatment with a satisfactory clinical outcome. Such a procedure is highly effective in terms of resolving symptoms, improving nerve function, and restoring the physiological curvature of the cervical spine. It has been pointed out that fusion may result in acceleration of adjacent segment degeneration (ASD). In this scenario, CDA has been proven to be beneficial in terms of preserving motion of the cervical spine and possibly reducing ASD. Controversy exists as to the ideal surgical techniques that could benefit patients with multilevel cervical disc diseases (MLDDD). Hybrid surgery (HS) that incorporates ACDF and CDA at different levels can be considered a possible option since it combines the advantages of both techniques in terms of vertebral stability and spine motion preservation. **Methods:** This prospective study enrolled patients with MLCDDD who underwent HS. Thirty consecutive patients who underwent HS were compared with patients who underwent ACDF and CDA at the same level of surgery. Patients were followed up for more than 3 years. Intraoperative parameters, clinical features and outcome scores were recorded. Radiological assessments included overall range of motion (ROM), disc height (DHI), and changes in adjacent disc spaces. **Results:** Duration of surgery was significantly shorter for ACDF compared with HS and CDA ($P < .05$). The VAS, SF-36, JOA, and NDI scores improved significantly after surgery in all the patients without significant differences among the groups. Cervical ROM increased significantly in CDA and HS groups as compared with ACDF-treated patients ($P < .05$). The mean DHI at the treated level was significantly restored after surgery in all the groups. The HS group returned to work faster (28 days) when compared with both ACDF (59 days) and CDA (63 days) ($P < .05$). **Conclusions:** The findings provided suggest that hybrid construct is a safe and effective surgical strategy for decompression in patients with multilevel cervical disc diseases. Studies with larger sample sizes and longer follow-up periods are required to confirm the results of the present study.

A325: Efficacy and Safety of Lumbar Arthroplasty in Degenerative Disc Disease

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Introduction: Arthrodesis is the established gold standard for the surgical treatment ofrefractory low back pain due to lumbar degenerative disc disease. 32 years ago it resurfaces treatment by lumbar arthroplasty SB Charite, showing that non-fusion allows closer to the physiology of the disc treatment and reducing complications. Current technological development has enabled a better design and evolution of lumbar arthroplasty. **Material and Methods:** Retrospective longitudinal study were included 80 patients who had low back pain with or without radicular component and met the radiographic criteria including the loss of disc height, low intensity RM-T2, changes cymbals and disc protrusion. All patients underwent arthroplasty ProDisc or Activ between 2000 and 2008. The age was between 23 and 56 years. They were evaluated before and after surgery at 3, 6, 12 and 24 months. Demographics and clinical

parameters were collected if it had only low back pain or lumbar pain associated with radicular component, values disability index Oswestry (ODI and analog-visual scale (VAS), level of patient satisfaction, the success criteria and radiographic analysis of disc height, range motion of the operated segment. Security also proceed analyzing complications was evaluated. **Results:** 18 men and 62 women. Average age of 38 years. Thirteen patients (16%) had been previously operated via posterior discectomy technique on the same site. They were treated as follow: L5-S1 level 60 patients (75%), L4-L5 level19 patients (23.7%) and one patient L3-L4 level (1.3%). ODI was compared between preoperatively and 24 months postoperatively, noting an average reduction of 53.86%. The average reduction for VAS back pain in the period of 24 months compared to the preoperative was 63.83% and a low back pain with radicular component also fell by 60.20%. These changes were statistically significant ($P \leq .05$). Levels of patient satisfaction: 82% completely satisfied and satisfied 18% of patients. After surgery disc height was increased to an average of 12 mm ($P < .001$). The movement in the affected segment increased from 4 degrees to 7 degrees on average after surgery ($P < .004$). There were no cases of displacement, dislocation, migration or component failure of the prosthesis. Complications related to the approach presented in 11 patients, accounting for 13.75%. **Conclusion:** Arthroplasty is recommended on one segment as an effective treatment so much safe for patients with degenerative disc disease who meet the inclusion criteria: both low back pain alone or low back pain with radicular component. The benefits were significant and were maintained through 24 months after total disc replacement. There seems to be differences in outcomes among patients with previous surgery and without this, nor among patients with chronic low back pain and those with associated radicular component. The two prostheses used L4-L5 vs L5-S1 level is not influenced the results. No complications related to the implanted device is presented. The careful and proper patient selection is essential in planning an optimal surgical outcome

A326: 2 Years Functional Outcome is Predictive of a Long-Term Results: A 10 Years Follow-up of BRYAN© Cervical Disc System on a 70 Patients' Series

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Introduction: To illustrate 10 years experience andclinical follow-up data of 70 Italian patients treated with BRYAN cervical spine system for degenerative disc disease. To prospectively assess the intermediate and long-term radiographic characteristics of disk replacement surgery with the Bryan Cervical Disc and to correlate these results with clinical outcome. **Materials and Methods:** A cross-sectional retrospective study was designed. We studied NRS and NDI using a "Do It Yourself" web-survey method. Time-points were pre-operative and 6 months, 2, 5, 10 years post-operative. **Results:** 70 patients were included in this retrospective study. Pre-operative NRS and NDI mean values were 6.34 $\pm$ 1.44 and 40.74 $\pm$ 9.03%. 6 months post-operative were 2.16 $\pm$ 1.37 and 16.17 $\pm$ 10.24%. 2 years post-operative were 2.16 $\pm$ 1.37 and 16.17 $\pm$ 10.24%. 5 years post-operative were 2.07 $\pm$ 1.34 and 15.66 $\pm$ 11.08%. 10 years post-operative were 1.87 $\pm$ 1.49 and 14.50 $\pm$ 11.44%. Pre-operative NRS and NDI mean values were lower than 2 years post-operative values ($P < .0001$) using U test of Mann-Whitney. There was no stastistically difference of NRS and NDI mean values between all other time points. **Conclusion:** The majority of patients had excellent clinical outcome. After 2 years post-operative there is no statistical increase in clinical outcome and it is highly prognostic of long-term results.

A327: Current Practice of Cervical Disk Arthroplasty: A Survey among 387 AOSpine International Members

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Introduction: The position of cervical disk arthroplasty (CDA) in spinal practice is controversial. This is probably due to the lack of studies with a large sample sizes and long-term outcomes. Therefore we aimed to evaluate the opinions of spine surgeons towards the use of CDA in the current treatment of cervical disk herniation (CDH). **Material and Methods:** A web-based survey was sent to all the members of AOSpine International by email using Survey Monkey on July 18, 2016. A single reminder was sent on August 18, 2016. Questions included geographic location, specialty, associated practice site, amount of operations performed annually and the use and expectations of three frequently applied surgical techniques. **Results:** A total of 387 surgeons responded. Almost all (97.9%) of the responders were male with a mean of 15.0 $\pm$ 9.7 years of clinical experience. The majority of our responders were orthopedic surgeons (54.6%). 84.3% of our responders use ACDF as the standard operation technique for treatment of CDH. Only 7.3% performs CDA as standard approach, whereas 47.8% surgeons perform CDA at all. The most common arthroplasty device used is the Pro-Disc C. Low evidence for benefits and costs were the most important reasons for not offering CDA. The risk of adjacent level disease was considered smaller for CDA as compared to ACDF. The biggest disadvantage was the costs of CDA. **Conclusion:** In this survey, CDA is not considered to be the treatment of choice for CDH, but is claimed to reduce the risk of adjacent level disease. Lack of enough evidence on the effectiveness and higher costs were disadvantages and considered reasons for not offering CDA.

A328: Total Disc Replacement. Part I: Assessment of Clinical Outcomes and Disc Prosthesis Survival in the Lumbar Spine

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Study Design: Prospective observational cohort study. **Objective:** To determine the long-term clinical results and prosthesis survival in patients treated with lumbar total disc replacement (TDR). **Summary of Background Data:** Fusion has become the current standard surgical treatment for lumbar degenerative disease. TDR is an alternative treatment that seeks to avoid fusion-related adverse events, specifically adjacent segment disease. **Methods:** Sixty-eight consecutive patients treated with TDR from 2003-2008 were invited to follow-up and complete a Visual Analog Scale (VAS) for back and leg pain, the Dallas Pain Questionnaire (DPQ) and the Short Form-36. These surveys were also administered to the subjects prior to their index TDRs. Data on re-operation were collected from the patients' medical records. **Results:** Fifty-seven (84%) patients were available for follow-up at a mean 10.6 years post-operative (range, 8.1-12.6 years). There was a significant improvement from pre-op to latest follow-up in VAS (6.8 vs 3.2, $P < .000$) and DPQ (63.2 vs 45.6, $P = .000$) in the entire cohort. Nineteen patients (33%) had a revision fusion surgery after their index TDR. Patients who had a revision surgery and statistically significant worse outcome scores at last follow-up compared to patients who had no revision. Thirty patients (52.6%) would choose the same treatment again if they were faced with the same problem. **Conclusion:** This study demonstrated significant improvement in long-term clinical outcomes, similar to previously published studies, and 2/3 of the discus prostheses were still functioning at follow-up. However, there is still a lack of well-designed long-term studies, thus requiring further investigation.

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A329: Predicting Sagittal Balance Correction after Bilateral Pelvic Osteotomy: A Mathematical Model

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Introduction: Conventional spinal sagittal deformity correction procedures involve significant risk, morbidity and cost. An osteotomy site at the level of the pelvis may provide a viable alternative. Theoretically, the more distal osteotomy site produces a longer lever arm to correct sagittal vertical axis (SVA). This study investigated the relationship between pelvic osteotomy opening angle (OA) and effect on spinopelvic sagittal parameters using a mathematical predictive model. **Materials and Methods:** Virtual BPO (anterior inferior iliac spine to the sciatic notch) was created on full-length lateral x-ray of a sagittally deformed spine. Predictive equations correlating OA with spinopelvic parameters were derived using geometric relationships. Fixed spinal curvature was assumed. Image was rotated to reduce pelvic tilt (PT) to 10° and neutralize its compensatory effect. A geometric model (MATLAB) calculated spinopelvic parameters (SVA, pelvic incidence [PI], PT and T1 pelvic angle [TPA]) produced by progressively increasing the OA. These values were compared to optimal balance criteria in the literature. **Results:** Osteotomy OA correlated negatively with PI, TPA and SVA, and positively with PT. From baseline SVA of 22 cm, OA 21° reduced SVA to 5 cm. OA 23° reduced TPA to 14°. OA 30° increased PT to 20°. OA 26° decreased PI-LL to 10°. Thus, OA range of 26°-30° resulted in optimal sagittal deformity correction. Within this range, PI decreased 19°-21° from baseline. **Conclusions:** Predictive relationships between pelvic osteotomy OA and spinopelvic parameters were shown, thus providing proof of concept that sagittal balance may be achieved via pelvic osteotomy. Demonstrating negative correlation between OA and PI refutes conventional notion that PI is a fixed parameter. In patients with fixed lumbar lordosis (LL), correction may be achieved by decreasing PI to match LL. Since baseline abnormal PT causes partial SVA correction, rotation of the image during planning for BPO is necessary to neutralize the compensatory PT and unmask the true extent of deformity.

A330: A Less Invasive Technique for 360 Degree Deformity Correction in Ankylosing Spondylitis: Does It Really Make a Difference?

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Introduction: Ankylosing spondylitis (AS) is a seronegative spondyloarthritis that can severely alter the normal spinal sagittal balance resulting in functional and social disability. Although the traditional open corrective surgeries have provided radiographic correction, they are associated with relatively high morbidity and mortality. Therefore, a new less invasive technique has been developed in an attempt to achieve both radiographic and clinical improvement while minimizing the possible surgical risks of conventional open approaches. The aim of this study is to describe and evaluate this innovative technique for management of thoraco-lumbar sagittal imbalance (TLSI) in AS. **Material and Methods:** Fifty-one patients (43 males and 8 females) with TLSI due to AS, who underwent 360 degree deformity correction through this technique in our hospital between 2008 and 2013

with a minimum of 2-year follow-up were retrospectively analyzed and included in the study. The main steps of the technique are: (1) Posterior percutaneous spinal instrumentation (2) Posterior mini-open microscopic-assisted osteotomy. (3) Anterior thoracoscopically- and / or retroperitoneoscopically-assisted osteotomy and reconstruction. All steps are done in the same prone position. Sagittal vertical axis (SVA), T1 pelvic angle (TPA), osteotomy angle (OA), angle of fusion levels (AFL) and chin-brow vertical angle (CBVA) were used to evaluate radiographic outcomes and degree of correction. Clinical outcomes were assessed by Oswestry Disability Index (ODI) and visual analogue scale (VAS). **Results:** The patients had a mean age at operation of 49.02 years. The mean total operative time was 419.31 $\pm$ 100.23 minutes (163.53 $\pm$ 52.51 minutes for anterior procedures and 253.75 $\pm$ 69.32 minutes for posterior procedures) while the intraoperative blood loss ranged from 50 to 2100 ml with a mean of 698.24 ml. In one third of the patients, two or even three osteotomies were performed. SVA, TPA and CBVA showed a statistically significant improvement after surgery ($P < .0001$). The mean correction was 28.93 $\pm$ 8.02° for patients with single osteotomy and 46.58 $\pm$ 13.16° for patients with more than one osteotomy, while the mean loss of correction was 1.05 $\pm$ 1.70°. In the present study, not only the mean ODI improved significantly from 48.67 $\pm$ 7.86 preoperatively to 19.25 $\pm$ 10.22 at the latest follow up ($P < .0001$), but also 94% of the patients showed >30% improvement from the baseline ODI. Moreover, the changes in ODI were significantly related to the changes in SVA, TPA, AFL, OA, and CBVA. Dural tear and transient radiculopathy were the most common reported complications. **Conclusions:** The idea behind the implementation of minimally invasive technologies in the correction of AS deformity is not to reduce muscle damage in an already damaged nonfunctioning muscle but to minimize the extent of surgical trauma to an already vulnerable patient with several medical comorbidities. The ability to perform 360 degree deformity correction through a less invasive anterior and posterior approaches has significantly reduced blood loss and facilitated post-operative course and in the same time provided a well maintained correction with satisfactory clinical outcomes. We believe that this novel technique, although technically demanding, dose offer a safe and effective alternative for traditional open surgery in managing TLSI due to AS.

A331: Surgical Strategy Can Mitigate Effects of Patient Factors on Pseudarthrosis Rate at 2 Years Following Adult Deformity Surgery (ASD)

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Introduction: Pseudarthrosis is a common complication following spine fusions in ASD and has a major impact on patient morbidity. Both surgical strategy, such as the use of interbody fusion (IBF) and choice of biologics (BMP-2, iliac crest bone graft, bone marrow aspirate, etc), and patient characteristics (age, smoking status, osteoporosis) have been associated with pseudarthrosis rate in previous studies. **Material and Methods:** Four surgeons determined fusion grades at 2 yrs postoperatively for all patients in a prospective, multi-center, ASD database. All patients who exhibited pseudarthrosis posteriorly or, if anterior IBF performed, both posteriorly and anteriorly were considered pseudarthrosis. IBF, type of biologic, osteoporosis, age, smoking status, and frailty, assessed using the ASD Frailty Index (ASD-FI) and split into three cohorts (not frail NF, frail F, and severely frail SF), were analyzed for association with fusion rate. **Results:** In a multivariate regression model of frailty and various preoperative and operative characteristics, odds of pseudarthrosis in F was 2.8 [1.1-7.0] ($P < .05$) and in SF was 3.4 [1.0-11.2] ($P < .05$) times less than for NF patients. Patients who had IBF had a much lower risk of pseudarthrosis (OR 0.17 [0.08-0.39] $P < .001$), those who had BMP-2 also had a lower risk (OR 0.39 [0.19-0.79] $P < .05$), and female patients had a higher risk (OR 4.5 [1.2-17.7] $P < .05$). On univariate analysis, smoking status had an increased risk of pseudarthrosis (OR 1.9), however it was not significant. Osteoporosis had a decreased risk (OR 0.77), which was also not significant. Pseudarthrosis rate with only autologous biologics was 25.8% whereas the rate with bmp-2 was 12.1% (Pearson's $chi^2 = 9.1$, $P < .01$). Increasing age had a decreased risk of pseudarthrosis (by decade OR 0.72 [0.61-0.87] $P < .001$), which was no longer significant on multivariate analysis controlling for surgical parameters. **Conclusion:** Surgical factors (IBF and BMP-2 usage) had the greatest protective impact on pseudarthrosis rate. While osteoporosis and increasing age were also shown to have a protective impact on univariate analysis, these were likely confounded by surgical parameters. This was supported by the lack of significance on multivariate analysis. Frailty, as measured by the ASD-FI, was the strongest predictor of pseudarthrosis, followed by smoking status. While patient factors such as frailty, osteoporosis, and smoking status, have an impact on pseudarthrosis rates, surgical factors can mostly mitigate this effect.

A332: Spinal Deformity Correction Outcomes after Long Fusion with or without Pelvis Fixation in Adults

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Introduction: The purpose of our research is to study the incidence of distal adjacent segment disease (DASD) and to evaluate the health-related quality of life (HRQOL) parameters after long fusion with or without pelvis fixation including L5-S1. **Material and Methods:** A retrospective study was held on 75 patients with thoracolumbar spine deformation operated from 2009 to 2011. Inclusion criteria were the following: age 44-60 years, adolescent idiopathic scoliosis (AIS), normal L5-S1 (Pfirrmann grade 1-2) and satisfactory global spine alignments after operation. Patients were divided into two groups according to preoperative difference in sagittal and coronal spinopelvic parameters. The first group included 39 patients who underwent long fusion from upper thoracic spine (T3-4) to the pelvis. The second group consisted of 36 patients, who were treated using long fusion from upper thoracic spine to L5 without pelvic fixation. Groups were evaluated with HRQOL-scales including VAS, SF36 and SRS-24. Radiographical assessment included Cobb coronal angle, thoracic kyphosis, lumbar lordosis, sagittal vertical axis, central sacral vertical line. Radiographical, HRQOL-parameters and complications with a 3-year minimum follow-up were analyzed and compared between two groups. The comparisons were done using independent sample Student t-test. A p-value of less than 0.05 was **Results:** In both groups satisfactory global spine alignments were achieved. After 3 years significant difference was not found ($P > .05$). In early postoperative period the HRQOL-scores (VAS, SF36, SRS-24) of the patients were slightly higher in the first group, but we did not get statistical difference between groups ($P > .05$). In the first group no cases of DADS occurred after 3 months. The second group showed a higher number of DASD (n = 8, 22%). Finally, after 3 years the second group had significantly worse results ($P < .05$) of HRQOL-scores and numbers of DASD (n = 14, 39%). **Conclusion:** Despite good condition of L5-S1 before operation in both groups, after 3 years follow-up long fusion with extending to the pelvis provided better outcome than long fusion with extending only to L5.

A333: Risk Factors for 30-Day Readmissions and Reoperations after Three-Column Osteotomy for Complex Spinal Deformity

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Introduction: Three-column osteotomy (3CO) for complex spinal deformity is a technique that involves bony resection of the anterior, middle, and posterior columns of the spine with associated reconstruction in an effort to restore spinal alignment. In recent years, the rate of utilization of 3CO has significantly increased, with a reported 3.2-fold increase in the use of PSO between 2008 and 2011 alone. The purpose of this study is to report the 30-day readmission and reoperation rate after 3CO for complex spinal deformity using a large multicenter prospective database, and identify risk factors for these occurrences. **Material and Methods:** The prospectively-collected American College of Surgeons National Surgical Quality Improvement Program database (2012 – 2014) was reviewed. Inclusion criteria were adult patients who underwent 3CO. The rate of 30-day readmission/reoperation was examined, and the association between patient/operative characteristics and outcome was investigated via univariate analysis. Readmissions were categorized as related or unrelated to the primary procedure. **Results:** There were 299 patients who underwent a 3CO for spinal deformity. The rate of 30-day readmission and reoperation was 11.0% and 8.4%, respectively; 7.7% of readmissions were related to the primary procedure and 3.3% were unrelated. The most common unique cause for readmission was wound infection in 27.2% of cases. Among reoperations, the most common unique indications were wound infection (20.0%) and implant-related complications (20.0%). Patients who experienced a readmission were significantly more likely to be obese (60.6% vs. 37.6%, $P = .011$) and have a history of chronic obstructive pulmonary disease (COPD; 18.2% vs. 4.1%, $P = .001$). Likewise, patients who needed reoperation were more likely to have COPD (16.0% vs. 4.7%, $P = .020$) and a history of chronic steroid use (20.0% vs. 5.8%, $P = .008$). Interestingly, revision procedures, multilevel 3CO, or number of levels fused was not associated with readmission nor reoperation. **Conclusion:** Wound complications and short-term implant-related complications are important causes of readmission and/or reoperation after 3CO. Preoperative factors such as obesity, chronic lung disease, and chronic steroid use may significantly increase the risk of 30-day morbidity following these procedures.

A334: Clinical and Radiographic Assessment of a Hybrid Minimally Invasive Approach in Moderate-Severe Adult Lumbar Deformity

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Introduction: Minimally invasive surgery (MIS) is becoming an alternative tool in the treatment of adult spinal deformity (ASD) with the aim to reduce perioperative complications due to surgical access morbidity. However, when you have to treat

a moderate or severe deformity, MIS techniques cannot often be employed alone. Hybrid surgical approach refers to the MIS techniques associated with traditional posterior open surgery that includes segmental instrumentation, decompression and/or osteotomies. **Material and Methods:** We performed a prospective study analyzing data collected from 27 patients (21 women and 6 men, mean age 66 years) underwent hybrid surgical approach, involving minimally invasive lateral interbody fusion and supplementary posterior open approach by performing various degrees of segmental decompression, posterior column osteotomies and instrumented fusion. The inclusion criteria were: age >45 years; lumbar spine deformity with at least one parameter among coronal Cobb angle >20°, pelvic tilt (PT) > 25°, mismatch between pelvic incidence (PI) and lumbar lordosis (LL) greater than 10°, sagittal vertical axis (SVA) > 60 mm; Oswestry Disability Index (ODI) greater than 20 (moderate disability or more). Clinical outcomes were assessed by using ODI and visual analog score (VAS) for back and leg pain while radiographic measurements included coronal cobb, LL, PT, PI-LL mismatch, SVA and disc angle (DA) at each level of cage application, evaluated preoperatively, 6 month and 1 year postoperatively. Mean operative time (OT), estimated blood loss (EBL) and any complications were reported. **Results:** Strumented levels were in mean 6 for patient (range 4-10), with a total number of 49 cages implanted through the lateral trans-psoas approach. The mean cages for patient were 1,8 (1-3). At 1-year follow-up, the patients achieved statistically significant mean improvement in VAS back pain (from 7.9 to 4.7, $P < .01$), VAS leg pain (from 5.8 to 2.8, $P < .01$), ODI (from 49 to 26, $P < .01$). Mean radiographic data changed as follow: coronal cobb from 33.1° to 7.9° ($P < .01$), LL from 32,7° pre-op to 49,6° post-op ($P < .01$), PT from 23,8° to 20,2°, PI-LL mismatch from 15.8° to 4.6° ($P < .01$), SVA from 53.8 mm to 33.1 mm ($P < .01$). DA at each level of cage application changed from −0.5° to −6.2° at last follow-up ($P < .01$). Mean operative time was 370 min (range 190 – 440) and EBL was 1220 ml (range 600 – 1750). There were 1 major (postoperative proximal junctional kyphosis) and 9 minor complications. **Conclusion:** Minimally-invasive lateral lumbar interbody fusion combined with posterior open approach is an effective method to achieve a good correction of the radiographic parameters improving quality of life in patients with adult lumbar deformity.

A335: How Does The Sagittal Profile Change With Lumbar Surgical Decompression Without Fusion?

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Introduction: There exists a growing literature to support aggressive surgical corrections including osteotomies to correct sagittal malalignment in adult spinal deformities. However, there is a dearth of literature to guide the extent of contribution of forward stoop or sagittal malalignment secondary to physical compression on neural structures per se. The present study was aimed at carrying out a prospective cohort study to assess the impact of lumbar surgical decompression without fusion on sagittal profile. **Materials and Methods:** Consecutive patients undergoing lumbar decompression surgeries for symptomatic spinal canal stenosis and/or disk herniations at a single center during the time period from May 2014-May 2015 were included in the study. Patients with unequivocal evidence of instability and revision surgeries were excluded. All patients had detailed clinical and radiological evaluation prior to the surgery and three months following the surgery. Radiological evaluation included standard anteroposterior view, lateral views in flexion and extension and whole-length spine radiographs in the standing position. Radiological parameters studied were segmental lordosis over the operated motion segments [SL], global lumbar lordosis [GL], sacral slope [SS], sagittal vertical axis [SVA] and disk heights at involved levels. Disk heights were measured using distortion compensated roentgen analysis [DCRA]. Involved levels were considered to have a collapsed disk if the height was less than 50% of the cranial adjacent healthy segment. Clinical outcome was assessed using Macnab's criteria. **Results:** Sixty-three patients with mean age 47.33 + 15.06 years included [21 males and 42 females]. Decompression was carried out at one, two and three levels in n = 45, 15 and 3 patients, respectively. SL improved from 15.33 + 12.23° to 17.82 + 11.54° [two-tailed $P = .0009$, paired t-test]. GL improved from median 53° [-19° to 66°] to 56° [1° to 74°] [two-tailed $P < .0001$, Wilcoxon matched-pairs test]. SS improved from 33.43 + 11.23° to 36.21 + 11.42° [two-tailed $P = .01$, paired t-test]. SVA improved from +3.92 + 68.64 mm to -15.88 + 44.32 mm [two-tailed $P = .01$, paired t-test]. Subset analysis was done in patients with and without disk collapse. SL, GL and SS showed a statistically higher improvement in patients without disk collapse [0.05°, 1.34° and 0.37° improvement in SL, GL and SS in patients with disk collapse vis-à-vis 3°, 7.73° and 3.82°, respectively] [two-tailed $P = .002$, .002 and .01, respectively]. Though SVA too, had a higher improvement in patients without disk collapse [23.48 + 37.08 mm] as compared to those with disk collapse [10.63 + 15.15 mm], it did not approach statistical significance [two-tailed $P = .46$, Mann-Whitney test]. Barring one patient with a fair result, all others had an excellent/good outcome on Macnab's criteria. There was no statistically significant correlation noted between clinical and radiological outcomes. No correlation was found between the number of levels operated upon and radiological outcomes. **Conclusions:** Lumbar decompression surgery without fusion too, can lead to improvement in sagittal profile. This improvement is muted though, in patients with disk collapse. Though preliminary, this data can be helpful in templating decisions in adult spinal deformities.

A336: Safety and Efficacy of Multilevel XLIFs Approaching the Convex Side of Adult Scoliosis Above 30 Degrees

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Introduction: Over the last decade, XLIF has been also used to improve coronal curves by its ability to generate high corrective symmetrical forces due to lateral, deep insertion of large interbody cages. The recommended procedure, based on anatomical observations provides for access from the concave side of the curve. **Material and Methods:** We enrolled 25 adult scoliosis with Cobb angle > 30°. All XLIFs from T11 to L5 was performed by a convex side approach. Complications were compared with those reported in the pertinent literature. **Results:** We observed no major vascular, intestinal or ureteral injuries. Our complications were: 2 pleural lacerations; 1 hematoma; 4 transient weaknesses; 1 permanent genitofemoral damage; 1 deep vein thrombosis. These complications did not differ significantly (Chi square [0.05]) with those reported in the literature or were less severe. The coronal correction was on average 10.8 (8-18), with no significant differences between 3 or 4 cages ($P = .061$). **Conclusion:** Reasons that support XLIF from the concave side of spine deformities are questionable. In our experience, approach from the convex side did not result in serious complications: moreover, they may appeared fewer and less severe. When the curve is more than 30°, surgical technique may be more simple and quick, because the apical rotated vertebra is more posterior and extremely superficial in the convex side. By a transverse skin incision of 3-4 cm, centered on the VB, 2 disks can be removed. Psoas manipulation, actions on the contralateral annulus and osteophyte, foraminal decompression and deformity correction are similar to those described for the concave approach.

Tumor 3

A337: En Bloc Resection versus Intralesional Surgery in the Treatment of Giant Cell Tumor of the Spine

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Introduction: Giant cell tumor of the spine is a rare primary bone tumor known for its local aggressiveness. Optimal surgical treatment remains to be determined. This is a multicenter, ambispective observational study with the objective to quantify local recurrence and mortality rates after surgical treatment of spinal giant cell tumor and to determine whether en bloc resection with wide/marginal margins is associated with improved prognosis compared to an intralesional procedure. **Material and Methods:** The AOSpine Knowledge Forum Tumor developed a comprehensive multicenter database including demographics, presentation, diagnosis, treatment, mortality, and recurrence rate data for giant cell tumor of the spine. Patients were analysed based on surgical margins, including Enneking appropriateness. **Results:** Between 1991 and 2011, 82 patients underwent surgery for spinal giant cell tumor. According to Enneking classification, 59 tumors (74%) were classified as S3-aggressive and 21 as S2-active (26%). The surgical margins were wide/ marginal in 27 (36%) patients and intra-lesional in 48 (64%) patients. 39/77 (51%) underwent Enneking appropriate (EA) treatment and 38 (49%) underwent Enneking inappropriate (EI) treatment. 18 (22%) patients experienced local recurrence (LR). LR occurred in 11 (29%) EI-treated patients and six (15%) EA-treated patients ($P = .151$). There was a significant difference between wide/marginal margins and intra-lesional margins for LR ($P = .029$). Seven (9%) patients died. LR is strongly associated with death (RR 8.9, $P < .001$). Six (16%) EI-treated patients and one (3%) EA-treated patient died ($P = .056$). With regards to surgical margins, all patients that died underwent intralesional resection ($P = .096$). **Conclusion:** En bloc resection with wide/marginal margins should be performed when technically feasible as it is associated with decreased LR. Intra-lesional procedure is associated with increased LR. Mortality strongly correlates with LR.

A338: Predictive Factors for Survival in Surgical Series of Symptomatic Metastatic Epidural Spinal Cord Compression: A Prospective North American Multi-Centre Study in 142 patients

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Introduction: Symptomatic Metastatic Epidural Spinal Cord Compression (MESCC) afflicts up to 10% of all cancer patients and is associated with shortened survival and worsened quality of life. This study aims to identify the key survival predictive factors in MESCC patients who were surgically treated for a single symptomatic lesion. **Material and Methods:** 142 MESCC patients were enrolled in a prospective North American multi-center study and followed postoperatively to death or at least 12 months. Using univariate analyses, Kaplan-Meier methods, and log-rank tests the predictive value of various clinical variables were assessed. Non-collinear predictors with $P < .05$ in univariate analyses were included in the final Cox proportional hazards model. **Results:** The overall median survival was 7.7 months (range: 3 days – 35.6 months); breast cancer had the longest median survival (12.1 months). Eight patients (7%), whose primary cancer were lung (3), kidney (3), sarcoma (2), prostate (1), and breast (1), died within 30-days postoperatively and 88 had died at 12 months (62%). Univariate analyses yielded eight significant predictors for survival: the growth of primary tumor (Tomita Grade 1 vs Grade 2 and 3), BMI, gender, preoperative SF-36 physical component, EQ-5D, and ODI scores as well as the presence of either visceral or extraspinal bony metastasis. The multiple regression analysis revealed that the Tomita grade (Grade 1 vs Grade 2 and 3; HR: 2.81, $P = .007$), the absence of visceral metastasis (HR: 2.01; $P = .0044$), and higher score on SF-36 physical component (HR: 0.95, $P < .0001$) were independent predictors for longer survival. **Conclusion:** Slow growing tumor (Tomita Grade 1), absence of visceral metastasis, and lower degree of preoperative physical disability, as reflected by a higher score on the SF-36 physical component questionnaire, are good predictive factors for survival in selected patients who underwent surgical treatment for a focal symptomatic MESCC lesion.

A339: Validity and Reliability of the Spine Oncology Study Group Outcomes Questionnaire (SOSGOQ)

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Introduction: Evaluating health related quality of life (HRQOL) has become increasingly important especially in oncology. Therefore, the Spine Oncology Study Group Outcomes Questionnaire (SOSGOQ) was developed as the first spinal oncology specific measure. With previous confirmation of the content validity the purpose of this study is to test the construct validity and reliability of the SOSGOQ. **Methods:** The AOSpine Knowledge Forum Tumor conducted a multicenter prospective observational study where patients underwent surgery and/or radiotherapy for the treatment of spinal

metastases. Patient demographic, diagnostic, treatment, and quality of life data were collected. Construct validity was assessed at 12 weeks post-treatment by correlating the subdomains of the SOSGOQ to the relevant subdomains of the SF-36 or the NRS score using Spearman's rank correlation. The SOSGOQ score is inverse to the SF-36 score. Reliability of the SOSGOQ was assessed using the Intraclass Correlation Coefficient (ICC) between 12 weeks post-treatment and the reassessment after 4-9 days. The Cronbach's alpha was used to test for internal consistency. **Results:** A total of 238 eligible patients were included in the observational study in the nine participating centers. Thirty-six patients in two centers also participated in the sub-study to test the reliability of the SOSGOQ. Twenty-six patients underwent radiotherapy alone and ten underwent surgery with or without additional radiotherapy. Correlation of the SOSGOQ subdomains to the relevant SF-36 subdomains showed a strong to very strong correlation (Spearman's rank range -0.61 to -0.83). Correlation of the subdomain pain to the NRS score was strong (Spearman's rank = 0.72). The reliability for the total SOSGOQ score demonstrated to be excellent with an ICC of 0.84. **Conclusion:** Construct validity of the SOSGOQ was confirmed by correlation of the SOSGOQ to the relevant subdomains of the SF-36 and the NRS score. Furthermore, the SOSGOQ showed excellent reproducibility. The SOSGOQ is a valid and reliable tool to measure HRQOL outcomes in patients undergoing treatment for spinal metastases.

A340: Minimally Invasive Iliac Screw Fixation as a Palliative Option in Management of Painful Metastatic Lumbosacral Deformity

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Introduction: Pelvic fixation via iliac-screws is a crucial technique in stabilizing metastatic lumbosacral deformity. MIS iliac-screw fixation avoids complications of an open approach and is a viable palliative option in treating patients with painful instability and advanced disease, unsuited for major reconstruction. In this study we share our clinical experience in the use of MIS iliac-screw fixation in treatment of painful metastatic LSJ deformity. **Material and Methods:** Seven patients with lumbosacral metastatic deformity who underwent MIS lumbopelvic stabilization using iliac-screws were prospectively studied. At presentation these patients had severe axial back pain in erect posture with significant resolution when supine, indicating underlying mechanical instability. **Results:** Mean cohort age was 58 years (27-73). Median preop SIN and Tokuhashi scores were 13 and 9 respectively. All patients were instrumented successfully without conversion to open technique. Mean preoperative and postoperative Cobb angle was 10° and 4.2° respectively. There were no neurological deficits or wound complications postop. Postoperative CT scans showed no iliac-screw and sacroiliac joint bony violation. Mean time for commencement of adjuvant therapy was 2.6 weeks. At 6-month follow-up the visual analogue score (VAS) for each case was considerably better than at preop (median scores for back and leg were 3 and 2 respectively) Average follow-up was 12 months (8-20). No screw breakage, wound complication, symptomatic implant prominence and SI joint pain were noted at last spine surgery follow-up. **Conclusion:** MIS iliac-screw fixation is feasible, reproducible and can be employed without complications in metastatic spine without dynamic neurological deficits. This opens a new avenue of surgical management for metastatic lumbosacral disease patients, who otherwise may be inoperable and provide better soft-tissue control and earlier postoperative adjuvant treatment opportunity.

A341: Patient-Reported Outcomes After Surgical Stabilization of Spinal Tumors: Symptom-Based Validation of the Spinal Instability Neoplastic Score (SINS) and Surgery

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Introduction: Neoplastic spinal instability is defined as movement-related pain, deformity or neurologic compromise under physiologic loads with SINS developed in order to facilitate the diagnosis. While data supporting SINS validity and reliability exist, there is paucity of evidence that mechanical instability correlates with patient-reported pain and disability and that surgical stabilization significantly improves these patient-reported outcomes (PRO). Establishment of association between SINS and PRO supports the validity of SINS as a diagnostic instrument and confirms the benefit of surgical stabilization in the setting of neoplastic mechanical instability. **Materials and Methods:** PRO, including Brief Pain Inventory (BPI) and MD Anderson Symptom Inventory – Spine Tumor (MDASI-SP), were prospectively collected. Patients who underwent instrumented surgical stabilization for spinal tumor treatment between July 2014 and August 2016 and who had pre-operative and post-operative PRO data available were included. Age, gender, primary tumor, surgical stabilization technique, epidural spinal cord compression (ESCC) grade, pre-operative SINS data, duration of follow-up and survival were collected. SINS was analyzed as a continuous and ordinal categorical variable (Stable 0-6, Low Indeterminate 7-9, High Indeterminate 10-12, Unstable 13-18). Association between SINS and pre-operative symptom burden was analyzed using Spearman Rank Coefficient (ρ) and an extension of the Cochran-Armitage trend test. The association between

symptom change after surgery and pre-operative SINS categories was also analyzed. P-values less than 0.05 were considered statistically significant. Analyses were performed in SAS (version 9.4) and Stata (version 13.0). **Results:** A total of 150 surgeries were performed on 134 patients (mean 61.8 years old). 118 patients had both pre- and postoperative PRO data. 119 patients underwent open stabilization and 31 had percutaneous stabilization. The average time of first postoperative assessment was 34.7 days (6-279 days) after surgery. The most common primary tumors were non-small cell lung (N = 33), renal cell carcinoma (N = 19), breast (N = 14), prostate (N = 13), and sarcoma (N = 13). 2 patients had primary spine tumors (1 hemangioma, 1 chordoma). There was a statistically significant positive correlation between increasing pre-operative SINS and the severity of pre-operative pain as measured by BPI worst pain ($\rho = 0.18$, $p = 0.02$), BPI average pain ($\rho = 0.23$, $p = 0.005$), and MDASI pain ($\rho = 0.2$, $p = 0.01$) items. Increasing pre-operative SINS also correlated with increasing severity of pre-operative functional impairment measured by BPI walking ($\rho = 0.23$, $p = 0.006$), MDASI activity ($\rho = 0.28$, $p = 0.0006$), and MDASI walking ($\rho = 0.22$, $p = 0.009$) items. Similar associations were noted when SINS was analyzed as an ordinal categorical variable. The magnitude of symptom relief after surgery positively correlated with pre-operative SINS, with patients with higher pre-operative SINS experiencing greater symptom relief as measured with BPI worst pain ($p = 0.03$), BPI average pain ($p = 0.02$), BPI activity ($p = 0.04$), and MDASI pain ($p = 0.04$) instruments. **Conclusion:** The association between increasing SINS and symptom burden provide PRO-based validation of SINS as an instrument for diagnosis of spinal instability. The larger decrease in the severity of pain and activity interference experienced by patients with pre-operative neoplastic spinal instability supports the role of surgical stabilization for pain relief and improved functional status in the setting of mechanically unstable spines.

A342: Is Intraoperative Neurophysiological Monitoring Valuable Predicting Postoperative Neurological Recovery?

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Introduction: We investigated the ability of intraoperative neurophysiological monitoring to predict postoperative neurological recovery in intradural-extramedullary spinal cord tumors. **Material and Methods:** From 2010 to 2014, we operated on 173 intradural-extramedullary spinal cord tumor patients with intraoperative neurophysiological monitoring. We retrospectively compared preoperative and postoperative clinical status using a modified McCormick grading scale and correlated with intraoperative neurophysiological monitoring. We followed patients for at least 1 year and correlated neurological outcomes with intraoperative changes in intraoperative neurophysiological monitoring. We then compared the degree of intraoperative neurophysiological monitoring change with the duration of the neurological deficit. **Results:** Monitorability was 92% and 57% with transcranial motor-evoked potential and somatosensory-evoked potential modalities, respectively. Waveform attenuation on transcranial motor-evoked potentials was detected in 8.17% of cases. For somatosensory-evoked potentials, waveform attenuation was detected in 7% of the patients. A multimodality approach incorporating any transcranial motor-evoked potential changes had a sensitivity of 0.91 and a specificity of 0.98. The McCormick grade scale increased until 1 month in patients with alarm criteria on transcranial motor-evoked potentials ($P < .05$). **Conclusion:** Patients suffered neurological deterioration in case of abolishment or >50% irreversible attenuation of the waveform in transcranial motor-evoked potentials. All patients gradually recovered after 1 postoperative month with alarm criteria from 50% to 80% irreversible amplitude drop on transcranial motor-evoked potentials.

A343: En Block Spondilectomies for Malignant Neoplasms in Children: Review of 18 Cases

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Introduction: The major problems performing a spinal wide resection are the proximity, contiguity, and sometimes invasion of the great vessels, the parenchymatous organs, the chest wall and the central and peripheral nervous system. In children, in addition to all that, we meet the difficulties of choosing the length of the instrumentation, the small size of the pedicles and vertebral bodies, the fragile hemodynamic balance and the management of post-operative pain. **Material and Methods:** Over the past 12 years we have performed 18 total spondilectomy single or multilevel (one to five vertebrae in en block excision), 6 cervical, 4 thoracic and 8 lumbar, with a resection of a minimum of 2.8 to a maximum of 12 cm. The age of our patients was between 4 and 16 years old with a mean follow-up of 26 months. The pathologies treated were primary aggressive bone lesions: 6 osteosarcomas, 4 Ewing's sarcoma, 3 malignant high grade schwannomas, 1 leiomyosarcoma, 1 high grade rhabdoid tumor, 1 giant cell tumor (aggressive), 1 chordoma, 1 osteoblastoma osteosarcoma-like. **Results:** We systematically performed a 360° circumferential reconstruction, connecting the anterior artrodesis with the posterior fixation, compressing the entire instrumentation at the end of the

surgery. The final stability over the time has been systematically carried out by an anterior interbody fusion between the adjacent vertebrae to the resection, always made with the iliac autograft with which we have filled the different anterior cages used (carbon, titanium, homograft massive bone bank). The choice of the length of the posterior instrumentation was always very difficult, preferring short strumentations, whenever possible, to save spine for future growth. We had a distal junctional kyphosis due to breakage of the instrumentation (successfully re-operated), an distal junctional kyphoscoliosis due to failure of the arthrodesis (successfully re-operated), two neurological worsening (one completely healed, one with only partial recovery), 4 local recurrences (9, 12, 34 and 39 months) with systemic progression of the disease. **Conclusion:** The high complication rate in our series is explained by the complexity of this type of surgery in children, which any how permits to obtain satisfactory oncological results. Based on our results we can say that even in pediatric patients with multilevel vertebral primary aggressive tumors it is possible to perform correct oncological resections with a final positive outcome higher than 70%.

A344: Index for Extent of Surgery for Metastatic Spine Disease: "Intrusiveness Index"

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Introduction: The spine is the prime target organ in the skeletal system as a metastatic site for the majority of primary tumours of epithelial origin. Surgery has an established role in management of metastatic spine disease (MSD). Spinal oncologic surgeries aimed at decompression and stabilization of the neural and osseous elements respectively remains an integral part in maintaining the quality of life in the terminal years of these patients. Due to the vast spectrum of patterns and severity of spinal metastases, a multitude of surgical techniques are employed. In analyzing variables influencing surgical outcomes, comparing data between institutions, and weighing clinical options of treatment, a standardized scoring system that compares the extent of surgery with outcome variables will be useful for surgeons and patients alike in both research and treatment planning. **Methods:** Surgery for MSD can include anterior, posterior or combined approaches to the spinal column. We devised a metastatic spine surgery scoring system based on surgical intrusion of the vertebral column. The score is based on number of vertebrae instrumented posteriorly or anteriorly, the number of levels decompressed by posterior approach, extent of anterior decompression dictated by total/partial corpectomy, posterior fusion and vertebroplasty. The index was validated by the retrospective analysis of patients undergoing metastatic spinal surgery from 2005-2014. Data collected included patient demographics, type of primary tumour, type and extent of surgery, blood loss and transfusion, surgical duration and complications. The relationship between the intrusion score and outcome measures such as blood loss, blood transfusion, operative time and post-operative complications were analyzed. **Results:** A total of 241 patients were included in the analysis. The median age was 60 years (range:25-87) with gender distribution of 127 males(53%) and 114 females(47%). The median score of Intrusiveness Index was 7 (range:1-20). Multivariate analyses revealed that the Intrusiveness Index score was independently associated with increased amount of blood loss, increased odds of blood transfusion and prolonged operative time after adjusting for a number of potential confounders. With every one score increase in Intrusiveness Index, there was a 42 ml increase in mean blood loss (95%CI:29-51, $P = .01$), 10 minutes increase in mean operative time (95%CI:5-18, $P = .01$) and 1.1 times increased odds of blood transfusion (95%CI:1.05 -1.19, $P = .03$). There was a tendency towards increased odds of developing postoperative complications with an increase Intrusiveness Index score in but this was not significant (OR = 1.06, 95%CI:0.91 - 1.23, $P = .08$). **Conclusion:** This novel Intrusiveness Index correlates well with surgical outcomes, in particular with blood loss, transfusion requirements and operative time. We believe that it will have significant utility in clinical practice for clinical decision making and predicting risks and potential complications. In addition, this index would facilitate research by allowing fair comparisons between different types of operative procedures and operative outcomes between institutions.

A345: Utility of Intraoperative Neuromonitoring in the Resection of Spinal Tumors

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Introduction: The role of intraoperative monitoring (IOM) in the resection of spinal tumors is understudied compared to its use in other conditions of the spine. The aim of this study was thus to assess the utility of Somatosensory-Evoked Potentials (SSEP) and Transcranial Electric Motor-Evoked Potentials (MEP) in the resection of intramedullary, intradural extramedullary, and extradural spinal tumors and evaluate the ability of both single and multi-modal monitoring to predict postoperative neurological deficits. **Materials and Methods:** A retrospective analysis of consecutive patients who underwent a spine tumor resection with the use of IOM at a single institution between August 2009 and March 2013 was performed. Demographic, clinical and neuromonitoring data were collected pre-operatively, during surgery, at the moment of discharge, and at a six-month follow-up visit. Three cohorts were established based on the anatomical location of the tumor:

intramedullary, intradural extramedullary, and extradural. Patients with significant bilateral or unilateral loss of amplitude in SSEPs or MEPs during surgery were identified and the rate of neurological deficits was assessed. **Results:** A total of 52 patients were analyzed. All of the patients underwent surgery using a posterior approach. The average age of the cohort was 46 years (SD of 21 years) with 25 (48.1%) males and 27 (51.9%) females. A significant change in intraoperative SSEPs or MEPs was detected in 14 cases. Fourteen patients (26.9%) developed permanent post-operative neurological deficits. SSEPs significantly predicted post-operative deficits in the resection of intramedullary tumors ($P = .015$; AUC = 0.83) as well as intradural extramedullary tumors ($P = .048$; AUC = 0.70). MEP monitoring did not predict post-operative deficits in the resection of intramedullary ($P = .20$; AUC = 0.69) or intradural extramedullary tumors ($P = .308$; AUC 0.63). Neither SSEPs nor MEPs predicted post-operative deficits in the resection of extradural tumors. **Conclusion:** The efficacy of intraoperative neuromonitoring during spine tumor resection surgery is highly dependent on tumor location relative to the spinal cord and dura. In spinal tumors approached primarily via a posterior approach, the accuracy of SSEPs and their ability to predict post-operative deficits increases the closer the lesion is located to the spinal cord, thus demonstrating greatest accuracy and predictive capacity for post-operative deficits in the resection of intramedullary tumors. For spine tumor resections employing a posterior approach, MEP and multi-modal monitoring may not confer a benefit in predicting permanent neurological deficits.

Novel Technologies 2

A346: One-Stage Posterior Selective and Localized Circumferential Decompression with Dekyphosis and Instrumented Fusion for Thoracic Myelopathy due to Multilevel Ossification of Posterior Longitudinal Ligament

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Introduction: The results of surgery for thoracic myelopathy caused by multilevel OPLL have been unfavorable. All the existing surgical decompressive methods, including posterior circumferential decompression and anterior decompression, are technically demanding and associated with a high rate of complications. This study is to evaluate the feasibility and surgical outcomes in patients with multilevel OPLL of the thoracic spine treated by one-stage posterior selective and localized circumferential decompression with dekyphosis and instrumented fusion. **Material and Methods:** This is an one-stage posterior operative procedure. The circumferential decompression level is selected before surgery following two standards: being the most stenotic level of the spinal canal and locating at the apex of the kyphosis of the stenotic segments. During the operation, instrumented fixation and wide laminectomy is performed firstly. At the already selected level, bilateral facetectomy and transforaminal localized extirpation of the OPLL is performed, followed by appropriate V-shaped osteotomy, compressing to reduce thoracic kyphosis by approximately 10 degrees (dekyphosis) and to shorten the spinal cord by approximately 10 mm. Twelve patients who underwent posterior selective and localized circumferential decompression with dekyphosis were included in this study. Japanese Orthopedic Association (JOA) scores and recovery rates were used to evaluate the outcomes. Twenty one cases who suffered from thoracic spinal stenosis due to multilevel OPLL were surgically treated before December 2015, among which 5 were male and 16 were female, with an average age of 48.2 (32 ~ 59) years old. The average segment number of OPLL was 6.9 (3 ~ 11). The preoperative Japanese Orthopaedic Association (JOA) score was 4.1 averagely (1 ~ 8). **Results:** The average operation time was 4.2 hours (range 3.0 ~ 7.0 h) and the average blood loss was 1510 m1 (range 400 ~ 6000 ml). The segment number of laminectomy was 8.0 averagely (range 5 ~ 13). The segment number of selective circumferential decompression and dekyphosis was two in 2 cases, and one in 19 cases. The average dekyphotic degree of all decompression levels was 9.1° (range 2 ~ 25°).The shortened length of vertebral canal was 3.9mm (0 ~ 6.9 mm). All 21 cases were followed up for more than 6 months, and the latest average JOA score was 9.3 (range 1 ~ 11), while the recovery rate was 74.1% averagely (range -100% ~ 100%). **Conclusion:** In cases of thoracic myelopathy due to multilevel OPLL, a dramatic degree of neurologic recovery can be obtained by one-stage posterior selective and localized circumferential decompression with dekyphosis and instrumented fusion, despite the other levels of OPLL remaining, even for those patients in whom the spinal cords are severely damaged before surgery. We recommend this one-stage posterior decompression and dekyphosis procedure be selected for patients whose thoracic spinal cord are impinged anteriorly by multilevel OPLL, especially when the physiological kyphosis is relatively severe.

A347: 5-year Experience with Magnetically Controlled Growing Rods for the Management of Early-Onset Scoliosis: Results, Complications and Considerations for Final Treatment

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Introduction: A new method for the management of early-onset scoliosis (EOS) has been recently introduced: it consists of a magnetically controlled growing rod (MCGR) that allows gradual outpatient distractions under control of an external remote device. We present a series of 14 patients with EOS

managed with MCGR (Ellipse TM MAGEC System, Irvine, CA). **Material and Methods:** We implanted MCGR in 14 patients affected by EOS with various aetiology. Scoliosis and kyphosis angles, T1-T12 and T1-S1 length were evaluated preoperatively, postoperatively, and at the last follow-up. A visual analogue scale score was used to evaluate pain during outpatient rod distraction procedures. The mean follow-up is 34 months. All patients attended distractions of the magnetic rod through an external remote control every 3 months. The mean predicted distraction was 3 mm at each lengthening session. **Results:** The mean Cobb angle value was 64.7 ± 17.4 degrees (range, 45 to 100 degrees) preoperatively and 28.5 ± 13.9 degrees (range, 15 to 59 degrees) at the latest follow-up. The mean T1-S1 length value was 27.1 ± 5.4 cm (range, 16 to 34.8 cm) preoperatively and 32.8 ± 4 cm (range, 26.5 to 39 cm) at the latest follow-up. The mean T1-T12 length value was 16.2 ± 2.7 cm (range, 10 to 19 cm) preoperatively and 20.6 ± 2.9 cm (range, 15.5 to 23.5 cm) at the latest follow-up. The average monthly T1-T12 height increase was 0.8 mm, whereas the average monthly T1-S1 increase was 0.9 mm. Two patients experienced a rod breakage and 1 patient had a pull-out of the apical hooks. In cases of rod breakage, the magnetic rod was removed and replaced. In case of pull-out, apical pedicle screws have been positioned in substitution of hooks. **Conclusion:** Although implant-related complications could occur, as in all EOS growing rods procedures, MCGR can be effectively used in patients with EOS. This spinal instrumentation can overcome many of the complications related with the traditional growing rods implants. In our experience, rod breakage occurred only in patients with a single magnetic rod instrumentation. First case was a patient with a severe thoracic kyphosis. In effect, the management of kyphosis with the MCRG is quite challenging. Moreover, a marked kyphosis was also the cause of pull-out of the apical hooks. Instead, in the second case of rod breakage, we reported a failure of the internal magnet of the rod. This procedure can be effectively used in outpatient settings, minimizing surgical scarring, surgical site infection, and psychological distress due to multiple surgeries needed in the traditional growing rods system, improving quality of life, and saving health care costs. Because of progressive ankylosis, avoiding final surgical fusion at skeletal maturity is a viable option for patients treated with growing rods who have satisfactory final alignment and trunk height, a minimal gain in length at the last distraction, and no clinical or radiographic evidence of implant-related problems.

A348: Pedicle Screw Accuracy using 3D Printed Custom Made Guides

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Introduction: Pedicle screw systems are very useful for the treatment of spinal diseases. As their use has increased significantly, so has the rate of related complications due to screw malpositioning. New technologies have been applied to spinal instrumentation to increase the accuracy of pedicle implant, and thus decrease the rate of screw related complications. CT navigation and robotics are two alternatives to improve screw precision. However, the amount of radiation given to the patient in CT navigation is considerably high, and in this phase robotics can significantly increase surgical time. Alternatively, 3D printed tubular guides are more frequently used in operating theater for thoracolumbar spine surgery. This kind of hardware is usually patient-specific, following vertebral anatomy acquisition from a preoperative CT scan. Among the different available systems, Medacta MySpine uses a preoperative low-dose protocol CT to obtain spinal images of the patient and create custom-made guides. These are helpful in driving the preparing instruments and the pedicle screws in the correct position, maximizing length and decreasing the risk of pedicle wall violation and of related complications. **Material and Methods:** Patients with idiopathic and adult thoracolumbar deformity were included in this prospective study. A preoperative low dose CT scan according to the MySpine protocol was performed to create custom-made guides for the insertion of pedicle screws at the instrumented levels. After surgery, the patients underwent a control low dose CT scan to determine the accuracy of the pedicle screws placement and to measure violation of the pedicles. **Results:** In this series a total of 143 pedicle screws were implanted using the 3D stamped custom guides. Of these, 87.4% of the screws were completely intrapedicular, and this value rose up to 93.7% considering the screws with less than 2 millimeters of pedicle violation. Violation between 2-4 mm occurred in 4.9% of the screws. Only 1.4% of the screws presented a violation greater than 4 mm, although no medial violation of the pedicle was observed in any of these cases. **Conclusion:** The MysSpine Medacta system provides reduction of x-ray exposure of the patients and surgeons. In addition, the precision of the 3D printer allows a perfect fit between the guide and the corresponding vertebra, increasing the accuracy of the system. Our study suggests high accuracy of screw positioning inside the pedicles using the MySpine Medacta system, allowing for a reduction of complications related to screw misplacement.

A349: Safety and Efficacy of A Novel Anterior Decompression Technique (Vertebral Body Sliding Osteotomy) for Ossification of Posterior Longitudinal Ligament of the Cervical Spine: Comparison of Postoperative Outcomes between Vertebral Body Sliding Osteotomy and Anterior Corpectomy and Fusion

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Introduction: Anterior corpectomy and fusion (ACF) with or without the floating method for cervical ossification of the posterior longitudinal ligament (OPLL) is known to be associated with a higher incidence of surgery-related complications including cerebrospinal fluid (CSF) leakage and neurologic deterioration. To avoid these complications, we have developed a novel anterior decompression technique (vertebral body sliding osteotomy; VBSO). Its basic concept is to expand the spinal canal by anteriorly translating the involved vertebral bodies as well as ossified masses. The purpose of this study is to attest the efficacy and safety of VBSO by comparing its postoperative outcomes to those of conventional anterior corpectomy and fusion (ACF). **Material and Methods:** Twenty-four consecutive patients who needed anterior decompression for cervical myelopathy with OPLL underwent VBSO by a single surgeon. Other 38 patients consecutively underwent ACF by another single surgeon. In 16 out of 38 ACF patients, OPLL masses were partly remained by the floating method due to severe dural adhesion. All the patients were followed for more than 2 years after surgery and their medical records and radiographic data were analyzed. Operation time, estimated blood loss (EBL), postoperative neurologic outcomes by Odom's criteria, and the incidence of surgery-related complications were investigated. Various radiographic parameters including the spinal canal widening on CT axial images, the degree of remaining cord compression on MRI, and pre- and post-operative sagittal alignment were also measured. The clinical and radiographic outcomes were statistically compared between the two groups. **Results:** The mean operation time and EBL in VBSO group were significantly smaller than those in ACF group. Sixteen patients in ACF group (42.1%) showed various surgery-related complications (neurologic deficit in 2 patients, CSF leak in 4, graft migration in 3, and pseudarthrosis in 7). On the contrary, there was no neurologic deterioration, no dural tear, and no graft migration except 2 pseudarthrosis (8.3%) in VBSO group ($P < 0.05$). Neurologic improvements showed no significantly difference between the two groups ($P = 0.128$). On radiographic data, the mean canal widening was significantly greater in VBSO group than in ACF group (4.79 ± 1.34 mm vs. 3.21 ± 1.76 mm, $P < .05$). Preoperatively, VBSO group had a significantly less mean lordotic curve, which was improved postoperatively much more than that of ACF group ($-2.17 \pm 9.21^\circ \rightarrow -10.78 \pm 9.07^\circ$ in VBSO, $-9.56 \pm 10.36^\circ \rightarrow -6.71 \pm 9.58^\circ$ in ACF, $P < .01$). **Conclusion:** The vertebral body sliding osteotomy could provide similar neurologic outcomes with shorter operation time and less bleeding compared with the conventional corpectomy procedure for cervical myelopathy with OPLL. Since surgeons do not need to directly manipulate the OPLL mass or dissect the interspace between the OPLL and dura mater, this technique could significantly decrease the complications such as dural tear, CSF leak, and neurologic deterioration. Furthermore, as it is based on the multi-level discectomy and fusion technique, it would be more helpful to correct a less lordotic or kyphotic sagittal curve into a physiologic lordosis.

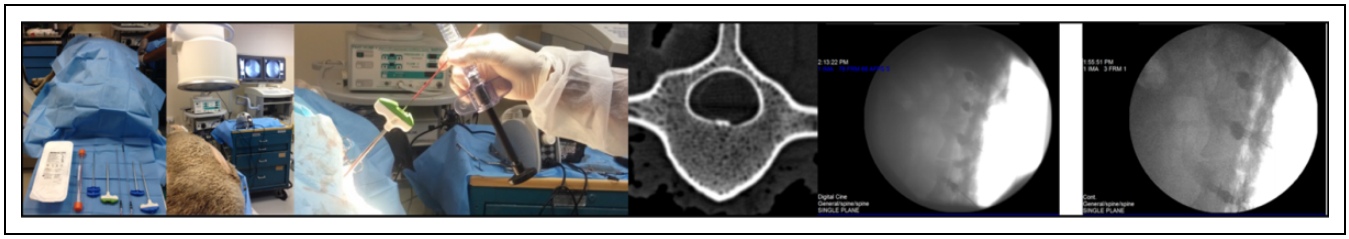
A350: Kyphoplasty Cement Encapsulation Biodegradable Balloon Catheter: Animal Study

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Background and Purpose: Vertebral body compression fractures due to osteoporosis is the most common fracture in patients with osteoporosis (1). Kyphoplasty surgical procedure were introduced and performed to stop the pain caused by pathologic spinal fractures, to stabilize the bone, and to restore some or all of the lost vertebral body height due to the compression fracture. One of the major concerns with the technique is extravasation of the cement material. This was reported to a range of 4.8% - 39% in some reports (2). We tested the feasibility of a Cement Encapsulation Biodegradable Balloon Catheter in Kyphoplasty therapy over 14 days in healthy animal model. Synthetic biodegradable polymers have been investigated for the above applications. Poly (glycolic acid) (PGA), Poly (lactic acid), (PLA) and their copolymers have been researched for a wider range of applications. **Materials and Methods:** Cement Encapsulation Biodegradable Balloon Catheter System comprised of five components: 1) Biodegradable Shaft made from the balloon materials to support the balloon; non-compliant Biodegradable Balloon to inflate inside the vertebral body and accumulate the cement; Silicone Inflation Valve, one-way valve to hold cement inside balloon catheter after inflation shaft is removed; Delivery Stainless Steel Shaft, temporary inflation shaft removed from balloon catheter after inflation; Balloon Catheter Release Shaft, push shaft to push balloon forward while inflation shaft is removed. Balloons were percutaneously implanted, under X-Ray guidance, into the vertebral body of 4 levels L1-L4. Two animals undergo standard Kyphoplasty therapy followed by Cement Encapsulation Biodegradable Balloon Catheter implementation inflated with contrast medium to mimic PMMA inflation. Animal model used; Sheep, 2 Females with weight ranging between: 75-90 kg. There was no significant difference between the performances of the system between the two animals. One animal was deadened post procedure and the harvested spine was sent to CT scanning to learn about the balloon and catheter formation. Second animal was kept alive to examine balloon degradation process over time. Every other day the live animal was X-Rayed to examine the balloon integrity by examining the content of contrast medium inside the balloon. **Results:** Two animals were tested and implanted with 8 Biodegradable Balloon Catheters. The balloons degraded over a period of 12-14 days in the live animal model. The implant procedure was accepted by Kyphoplasty therapies trained physicians. No infections or thromboembolic events occurred during the implant procedure or during the examination period. No adverse events were recorded

throughout the study period. **Conclusion:** A pre-clinical diagnosis of the biodegradable balloon inflation on the vertebral body was performed. Although it was a small sample size, but it was shown that the material and procedure was safe in-vivo. Further investigation is required with cement to investigate the mechanics of fluid dynamics of bone reconstruction under X-Ray. Synthetic polymers can be prepared with chemical structures tailored to optimize physical properties of the biomedical materials and with well-defined purities and compositions to enhance performance and reduce crossing profile of the balloon catheter.



Tools. Animal Catheter and Insertion Tools CT Scan of Balloon X-Ray Imaging: Balloons Implanted in Spine.

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A351: Spontaneous Correction of Vertebral Rotation using Apifix in Adolescent Scoliosis

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Object: To present our experience using a new system for the treatment of adolescent idiopathic scoliosis and the first outcomes. **Material and Methods:** A new system (Apifix) has been used in 8 adolescents with progressive scoliosis of 32°-52°. This system corrects the scoliosis without fusion. No blood transfusion was needed. The surgical time was about 1 hour, and the hospital stay was 3 days. After three weeks, a special program of physiotherapy was started to expand further the system. The Cobb angle, the parameters of sagittal balance and the vertebra rotation (using Nash-Moe technique and spinometry), has been evaluated during a follow-up of 3 years. **Results:** A spontaneous vertebra derotation average of 35% was noted using Nash-Moe evaluation. The Cobb angle average improved from 37° to 17.2°. Immediately postoperatively a scoliosis improvement of 13° (range: 17°-4°) was noted, and after the physiotherapy other 5° (range: 1°-8°) of improvement was achieved. The sagittal balance parameters remained unchanged. **Conclusions:** A spontaneous derotation of the vertebra is documented in our cases but further research in more patients, and in longer follow-up is needed. This system offers an option between conservative treatment and spinal posterior fusion to be used as an internal brace.

A352: Wearable Augmented Reality to Aid Percutaneous Procedures in Spine Surgery

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Introduction: Aim of the study was the evaluation of the efficacy of the use of a new wearable AR video see-through system based on Head Mounted Displays (HMDs) to guide the position of a working cannula into the vertebral body through a transpedicular approach without the use X-Ray images guidance. **Material and Methods:** We describe a head mounted stereoscopic video see-through display that allows the augmentation of video frames acquired by two cameras with the rendering of patient specific 3D models obtained on the basis of preoperative radiological volumetric images. The system does not employ any external tracker to detect movements of the user or of the patient. User's head movements and the consistent alignment of the virtual patient with the real one, are accomplished through machine vision methods applied on pairs of live images. Our system has been tested on an experimental setup that simulate the reaching of lumbar pedicle as in a vertebral augmentation procedure avoiding the employment of ionizing radiation. Aim of the study is to evaluate the ergonomics and the accurancy of the systems to guide the procedure. We performed 4 test sessions with a total of 32 kirschner wire

implanted by a single operator wearing the HMD with the AR guide. The system accurancy was evaluated by a post-operative CT scan. **Results:** The most ergonomic AR visualization comprise the use of a pair of virtual viewfinders (one at the level of the skin entry point and one at the level of the trocar's bottom) aligned according to the planned direction of the trocar insertion. With such AR guide the surgeon must align the tip of the needle to the center of the first viewfinder placed on the patient's skin. indeed the viewfinder barycenter provides a 2 degrees of freedom (DoFs) positioning guide corresponding to the point of insertion preoperatively planned over the external surface of the model. The second viewfinder is used by the surgeon to rotate and align the trocar according to the planned direction of insertion (2 rotational DOFs). After the first test series a clamping arm has been introduced to maintain the reached trocar's trajectory. The post-operative CT scan was registered to the preoperative one and the trajectories obtained with the AR guide were compared to the planned one. The overal results obtained in the 4 test session show a medium error of 1.18+/-0.16 mm. **Conclusions:** In the last year there was a growing interest to the use of Augmented Reality systems in which the real scene watched by the surgeon is merged with virtual informations extracted from the patient's medical dataset (medical data, patient anatomy, preoperative plannig). Wearable Augmented Reality (WAR) with the use of HDMs allows the surgeon to have a "natural point of view" of the surgical field and of the patient's anatomy avoiding the problems related to eye-hand coordination. Results of the in vitro tests are encouraging in terms of precision, system usability and ergonomics proving our system to be worthy of more extensive tests.

A353: The Assessment of 3-D Spinal Balance and Range of Motion using the Microsoft Kinect System

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Introduction: Accurate measurement of spine motion is challenging due to the complex anatomy and motion of the spine. Presently, clinical assessments of spine motion are limited to subjective observations and static goniometric measurements or radiographic measurements. More advanced techniques, such as three-dimensional motion analysis, allow for quantitative assessment of spine motion. These techniques are the gold standard in spine motion analysis, but are cost, size, and time-prohibitive for everyday use. Recently, alternative technologies of motion analysis have emerged and may be appropriate for measuring motion of the spine in a clinic setting. The utility of clinical motion analysis can be found in both pre-operative assessment and biomechanical coaching postoperatively. This study presents the application of the Microsoft Kinect system to measure motion of the thoracolumbar spine static and functional tasks. This system represents a low-cost alternative to measure spinal balance and range of motion in a clinic setting. **Material and Methods:** Prospective case series of five patients with adult spinal deformity after multilevel spinal fusion and two patients with lumbar disc herniation. Surface reflective markers were affixed to bony landmarks of the thoracolumbar spine. Motion of the markers was captured by the Microsoft Kinect system and custom MATLAB software for neutral, flexion extension, and sit-to-stand activities. Sagittal alignment, coronal alignment, and segmental motion of each functional spinal unit were calculated post-hoc using custom MATLAB software. Alignment parameters were compared to radiographs. Data were compared using a t-test ($P < .05$). **Results:** The mean positive sagittal balance for Kinect and radiographic data was 5.8 ± 1.9 cm and 4.2 ± 1.9 cm, respectively ($P = .27$). The mean thoracic alignment is 41.5 ± 8.2 degrees of kyphosis and the mean lumbar alignment is 5.8 ± 12.4 degrees of lordosis in neural position. Implementation in clinic was not obstructive to clinic flow. **Conclusion:** The Microsoft Kinect system can be used to measure clinically-relevant spine parameters in a clinic setting. Soft tissue overlying the bony anatomy may limit accuracy. Future studies will apply this technique to measure spine motion in a spectrum of spine disorders before and after intervention.

A354: Anterior Distraction of the Atlantoaxial Joints for Basilar Invagination: A New Technique

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Introduction: Distraction of the atlanto-axial joints for treatment of basilar invagination has become an option in recent years. The posterior approach described in literature has a small but definite risk of injury to the vertebral arteries, C2 root ganglion and can be associated with difficult hemorrhage from the sub occipital paravertebral venous plexus. The unilateral anterior retropharyngeal approach offers a safe and simple corridor to expose both the atlanto-axial joints for adequate preparation and manipulation for distraction and fixation for the ultimate goal of joint fusion. **Material and Methods:** Since Jan 2012 till Sept 2016 25 patients of basilar invagination with or without atlantoaxial dislocation have been treated by unilateral right sided anterior extrapharyangeal wedge shaped titanium cage distraction with bilateral fixation of lateral mass of atlas to body of axis. **Results:** The odontoid process migrated downwards in all cases with relief of the cervicomedullary compression. Spasticity improved in all cases. Transient deviation of the tounge due to retraction neurapraxia of the hypoglossal nerve and weakness of lower lip due to marginal mandibular nerve stretch were tha only complications in 3 patients. Follow up has been for 3 years in 12 patients. Vertebral artery, venous plexus and C2 root were not injured in any

case. **Conclusion:** Basilar invagination can be reduced by spacer in the atlanto-axial joint. Recently this technique has been recommended for syringomyelia and Chiari malformation. However posterior surgery has inherent difficulties such as risk vertebral artery injury, paravertebral venous plexus hemorrhage and necessity of sacrificing the C2 ganglion in most cases.[1] The anterior extrapharyangeal approach offers a safe corridor to achieve all the aims of the posterior operation without the problems of posterior approach.[3] The surgery is performed in supine position with extension which aids in reduction of the atlanto-axial dislocation after opening of the joints and excising the pannus behind the anterior arch of the atlas. Unlike the posterior approach which disrupts the sub occipital and C2 spinous process muscle attachments, the anterior approach, is through muscle planes preserving muscle attachments which are essential for craniovertebral stability. Wedge shaped cage distracts the joint and reduces the atlantoaxial dislocation. The large bone mass of the atlas and body of axis allow ample opportunity for easy, safe and rigid fixation of the atlanto-axial joint. The unilateral anterior retropharyngeal approach offers a safe corridor to both the atlanto-axial joints, for distraction and fixation for fusion.

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