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Research article

Can modified Dunn radiographs be an alternative to standing AP pelvis radiographs in the evaluation of pincer femoroacetabular impingement?

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ABSTRACT

The purpose of this study was to compare modified Dunn radiographs with standing anteroposterior (AP) pelvis radiographs in respect of the tilt ratio, lateral centre-edge angle (LCEA), crossover sign, crossover percentage and joint space width measurements. The study hypothesis was that modified Dunn radiographs could be an alternative method to standing AP pelvis images in the evaluation of pincer-type femoroacetabular impingement (FAI). The study included 31 patients with a mean age of 42 years (range: 29–55 years) who had modified Dunn and standing AP pelvis radiographs taken in the radiological evaluation of non-traumatic hip pain between July 2018 and September 2022. Similar tilt ratio values were obtained on standing AP and modified Dunn images ($P = 0.986$). Joint space width showed a decrease in the transition from the modified Dunn position to the standing position, but the difference was not statistically significant ($P = 0.161$). The mean LCEA was measured as $34^\circ \pm 4^\circ$ in the standing position and as $35^\circ \pm 5^\circ$ in the modified Dunn position. No statistically significant difference was determined in the number of patients with a crossover sign or the crossover percentage values in these patients ($P > 0.05$). The data obtained in this study showed that there was no significant difference between images taken in the standing and modified Dunn positions in respect of radiological findings of pelvic tilt and pincer-type FAI. The modified Dunn radiograph is equivalent to the standing AP pelvis radiograph for the evaluation of pincer FAI.

INTRODUCTION

Femoroacetabular impingement (FAI) is a significant cause of hip pain and dysfunction in young, active individuals. Since it was first described in 2003 by Ganz *et al.*, it has increasingly been reported in the literature [1]. Two types of pathomechanism, cam and pincer, have been defined in FAI. In pincer-type impingement, there is over-coverage of the femoral head by the acetabulum [2]. Radiological examinations made together with clinical evaluation form the basis of FAI diagnosis in both mechanisms, and direct conventional radiographs are primarily preferred in the radiological examination required [3].

It has been attempted in the literature to define acetabular over-coverage in pincer-type FAI with different radiological parameters such as lateral centre-edge angle (LCEA), crossover sign/percentage, acetabular inclination and ischial spine sign [4–6]. Although the ideal radiological imaging method in which these radiological parameters can be evaluated is controversial, supine/standing anteroposterior (AP) pelvis radiographs, as well as cross-table lateral, frog-leg lateral and false profile imaging, have been used in various studies regarding preoperative evaluation [7]. Some studies have reported that these radiological parameters can be affected by the patient position (standing/supine) [8, 9]. The supine position has been shown to lead to an iatrogenic and non-physiological increase in anterior pelvic tilt compared with the standing position, and this leads to an increase in the incidence and severity of radiological findings associated with pincer-type FAI [10, 11]. Therefore, it has been recommended that preoperative standard standing AP radiographs should be taken to prevent over-treatment and poor outcomes of patients with pincer-type FAI [12].

In contrast to the ideal radiological imaging techniques recommended in the literature, orthopaedic surgeons require combinations of direct radiographs taken in different positions in the radiological evaluation of young individuals with hip pain in their clinical practice. The modified Dunn radiograph (45° Dunn view), which is important among these images, is used in the diagnosis of cam-type impingement in respect of showing the anterolateral junction of the femur head–neck. When this technique is made in the supine position, the hip is positioned in 45° flexion, neutral rotation and 20° abduction [13, 14]. It is known

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Fig. 1. The positioning for standing and 45° modified Dunn AP views.

that unilateral and bilateral hip flexion in the supine position can affect pelvic tilt [15]. From this starting point, the hip position in the modified Dunn technique may be an important factor to prevent an increase in iatrogenic pelvic tilt.

The purpose of this study was to compare modified Dunn radiographs with standing AP pelvis radiographs in respect of the tilt ratio, LCEA, crossover sign, crossover percentage and joint space width measurements. The study hypothesis was that modified Dunn radiographs could be an alternative method to standing AP pelvis images in the evaluation of pincer-type FAI.

PATIENTS AND METHODS

In this retrospective radiological study, a retrospective screening was made of patients aged 20–60 years with standing AP and modified Dunn images taken in the Orthopaedics Clinic for the radiological evaluation of non-traumatic hip pain between July 2018 and September 2022. Digital standing AP images were taken with the two lower extremities parallel and bearing equal weight, with the feet in a neutral position and a tube-to-film distance of 100 cm. In addition, in respect of presenting contralateral side comparisons, digitally modified Dunn images were taken with the patient positioned supine, both hips in 45° flexion, 20° abduction and the feet in neutral rotation. A positioning coil was used during the modified Dunn imaging to obtain standard angles in each patient (Fig. 1). All images were taken so that the beam crosshair was directed to the centre between the symphysis pubis and the anterior iliac spines.

Patients were excluded from the study if on direct radiographs there were findings of ≥Grade 2 Tonnis degeneration ($n = 18$), dysplastic hips (LCEA < 20°) ($n = 5$) or malrotation ($n = 6$), or if there was a history of hip surgery or lumbar fusion ($n = 7$). Malrotation was defined as a distance of >5 mm between the vertical line passing the symphysis and the centre of the sacrum on the direct radiograph [16] (Fig. 2).

Following the implementation of the exclusion criteria, a total of 31 symptomatic hips of 31 patients were included, comprising 14 (45%) females and 17 (55%) males with a mean age of 42 years (range: 29–55 years). Using the digital radiological imaging programme (Picture Archiving and Communication/Radiology Information System imaging server, Probel), the tilt ratio was taken as the basis for pelvic tilt evaluation [5]. A record was made of the narrowest joint gap for joint space width (mm) [17], LCEA for acetabular coverage [14] and the presence of the crossover sign and crossover percentage for the evaluation of acetabular retroversion [9] (Fig. 3). The images were evaluated by two independent orthopaedic surgeons at two different times at a 2-week interval. The mean values obtained from these evaluations were used in the statistical analysis.

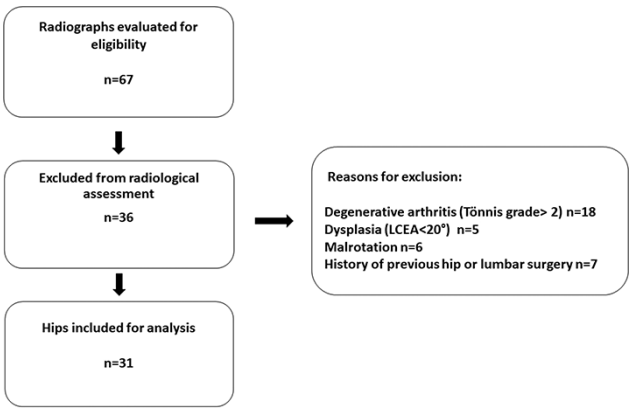


Fig. 2. Patient inclusion flow diagram (n = number of hips).

Statistical analysis

Data obtained in the study were analysed statistically using Statistical Package for the Social Sciences 20.0 software (IBM Corp., Chicago, IL, USA). Intra- and inter-observer reliabilities were calculated using Pearson's correlation coefficients. Dependent variables were evaluated using Student's paired t-test, and categorical variables with the chi-squared test.

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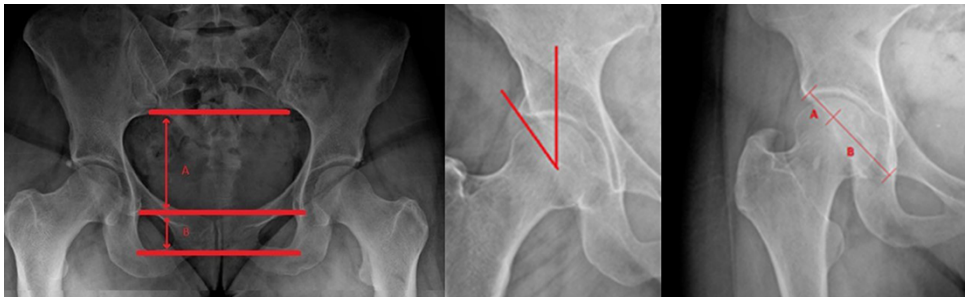


Fig. 3. Tilt ratio (B/A), LCEA and crossover percentage $(A/A+B)$ measurements on AP radiographs.

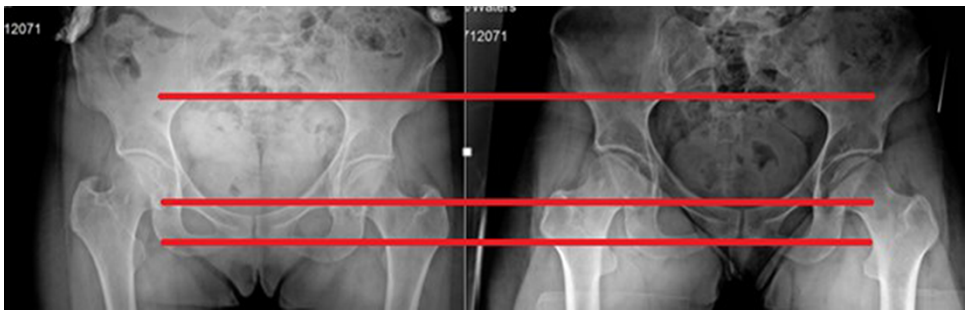


Fig. 4. Standing and modified Dunn AP radiographs of a 42-year-old female demonstrating similar pelvic inclinations.

RESULTS

Inter- and intra-observer correlation coefficients for each radiological evaluation were between 0.68 and 0.95 [95% confidence interval (CI), 0.47–0.96] and 0.72 and 0.97 (95% CI, 0.63–0.98) for each observer at the two different times, respectively.

In the evaluation of pelvic tilt, similar tilt ratio values were obtained from the standing AP and modified Dunn images ($P=0.986$) (Fig. 4). When all the patients were evaluated, the mean tilt ratio was 0.44 ± 0.12 on standing AP radiographs and 0.44 ± 0.14 on modified Dunn images. The mean standing tilt ratio was measured as 0.47 (range: 0.34–0.68) in females and as 0.43 (range: 0.25–0.76) in males. The mean modified Dunn tilt ratio value was found to be 0.46 (range: 0.28–0.72) in females and 0.44 (range: 0.23–0.73) in males.

Joint space width showed a decrease in the transition from the modified Dunn position to the standing position, but the difference was not statistically significant ($P=0.161$). Joint space width was measured as 0.37 ± 0.04 mm on the standing AP radiographs and as 0.39 ± 0.07 mm on the modified Dunn images. There was no positional significance in respect of the LCEA values ($P=0.162$). The crossover percentage values of the patients determined with crossover sign were measured as similar on the images taken in both positions ($P=0.512$) (Table I).

Table I. Mean values obtained on standing AP and modified Dunn roentgenograms

Radiological parameter	*Standing*	*Modified Dunn*	*P-value*
Tilt ratio	0.44 ± 0.12	0.44 ± 0.14	0.986
Joint space width (mm)	0.37 ± 0.04	0.39 ± 0.07	0.161
LCEA (°)	34 ± 4	35 ± 5	0.162
Crossover sign (number of patients)	8 (25%)	6 (19%)	0.785
Crossover percentage (%)	12 ± 7	13 ± 8	0.512

DISCUSSION

The results of our study show that the anterior pelvic tilt is not affected by the transition from the standing position to the modified Dunn position. Although small changes were observed in terms of joint spacing distance, there was no difference found in the incidence and severity of the radiological findings of pincer-type FAI obtained in both techniques, as a reflection of the prevention of iatrogenic changes in pelvic orientation.

Today, although the pathoanatomy and clinical evaluation of pincer-type FAI are well defined, discussions regarding the accurate radiological diagnosis continue. Plain radiographs obtained in positions such as standing/supine, cross-table lateral and frog-leg lateral are disadvantageous in that they allow a 2D evaluation of a 3D pathology and also in terms of the effect of pelvic orientation on radiological findings; however, they are the first preferred methods among radiological diagnostic modalities because of their simplicity, speed and low cost [7]. In the evaluation of pincer-type FAI, AP pelvis radiographs obtained in standing or supine positions are relatively more preferable. It is possible that only these techniques were compared in the studies on the most appropriate direct imaging technique [8, 12].

The difference between supine and standing positions of the 3D orientation of the spine can lead to changes in radiological

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parameters, thereby incorrect diagnostic evaluations. This orientation change is in the form of a decrease in pelvic inclination from a standing position to a supine position, and this is characterized as a decrease in pelvic tilt. In a radiological cadaver study, Siebenrock *et al.* [9] first suggested that an increase in positional non-physiological pelvic inclination could lead to incorrect measurements associated with an increase in crossover sign and acetabular retroversion. In later studies, the search continued for the ideal radiological measurement to avoid incorrect measurements and provide physiological pelvic tilt. In a radiological evaluation of 50 non-arthritic hips, lower pelvic crossover sign and crossover percentage values together with a decrease in anterior pelvic tilt were determined on AP pelvis radiographs taken in the standing position [8]. Similarly, in a study of 46 symptomatic non-arthritic hips, Jackson *et al.* [12] determined the presence of the crossover sign at the rate of a mean of 9% and the crossover percentage as a mean of 11% on standing AP pelvis radiographs, and these were reported to be significantly lower than the values determined on supine AP pelvis radiographs. From these studies, it was emphasized that standing AP pelvis radiographs should be standard in the radiological evaluation of pincer-type impingement. In the current study, the presence of the crossover sign and the percentage values of these obtained on both standing and modified Dunn AP radiographs were determined to be similar to the values of those studies. Moreover, that there was no significant change in the presence of the crossover sign and the percentage values between the two positions suggest that modified Dunn images could be an alternative to standing AP pelvis radiographs in the sense of preventing incorrect measurements associated with acetabular retroversion.

No significant difference was determined between the positions in respect of LCEA values. Moreover, the LCEA values were determined to be similar to those in previous studies in the literature [8, 18]. There are different opinions about the effect of pelvic inclination on the LCEA. Jackson *et al.* [12] emphasized that the LCEA did not change with varying pelvic tilt. In studies of 31 patients with developmental dysplasia of the hip, Troelsen *et al.* reported that a decrease was observed in the LCEA with the transition from a supine position to a standing position. However, in the same study, it was emphasized that the intra-observer reliability was low. In another cadaver study [18], although it was similarly emphasized that there could be a decrease in LCEA with decreasing anterior pelvic tilt, how much artificially produced pelvic orientation could reflect the *in vivo* changes was open to debate. In the current study, no change in the joint space width values was determined with repositioning. It is known that the effect of weight-bearing in a non-arthritic hip does not change the joint space [19, 20]. Although it was predicted that there would be contact of different areas of the joint in the modified Dunn imaging than in the standing position, this was not observed to contribute to the change in joint space in the current study.

With the transition from the standing position to the supine position, significant changes occur in spinopelvic alignment. In the pelvic component, these changes are in the form of pelvic tilt and decrease in pelvic inclination, and significant measurement differences can be observed between positions [21]. Pelvic inclination also can be affected by hip joint mobility as a dynamic component of sagittal alignment. In particular in the supine position, with the start of hip flexion, there is seen to be a decrease in anterior pelvic tilt from the early angles of joint range of movement. This change in pelvic inclination can be obtained with both active and passive hip flexion unilaterally and bilaterally [15, 22]. Pelvic inclination evaluated with tilt ratio in the current study showed similarity on the images taken in both positions. When taking the modified Dunn images, bilateral 45° passive hip flexion was obtained with the use of a positioning coil, suggesting that a non-physiological anterior pelvic tilt increase which can develop due to the supine position can be overcome.

The fact that modified Dunn radiographs in pincer-type FAIs offer similar measurement values to standing AP radiographs can provide advantages in different aspects. Incorrect measurements made in the preoperative radiological evaluation because of FAI can lead to excessive bone trimming during the operation. The need to prevent over-treatment is the basis of the search for the ideal preoperative radiological imaging in pincer- and mixed-type impingements [23]. Although there is the recommendation of standing AP pelvic imaging in the preoperative evaluation, these cannot be used intraoperatively. The fact that modified Dunn imaging can be obtained in the supine position may contribute to the prevention of false measurements during the intraoperative period as well as in the preoperative period. In addition, modified Dunn imaging is currently used in the evaluation of radiological findings related to the diagnosis of cam-type FAI [13]. Similarly, the usability of this method in the diagnosis of pincer-type impingement may enable the evaluation of different or combined FAIs with a single scan. This can undoubtedly provide benefits such as cost- and time-savings, especially the amount of radiation that patients are exposed to. Of course, in the modified Dunn technique, the relative difficulty of the scan due to the patient's position and the need for a coil can be seen as a disadvantage at the point of standardization.

There were some limitations to this study, primarily the relatively low number of the sample. A significant factor in this was the selection of radiographs taken within the standards and on which there was no malrotation. If there had been AP radiographs taken in the supine position in addition to the standing AP radiographs, this would have strengthened the study hypothesis in respect of comparison with modified Dunn images. However, this was not possible because of the low number of patients with radiographs taken with three different techniques.

In conclusion, the results of this study demonstrated no significant difference between standing AP radiographs and modified Dunn radiographs in respect of the crossover sign and crossover percentage parameters related to pelvic inclination and acetabular retroversion. The modified Dunn radiograph is equivalent to the standing AP pelvis radiograph for the evaluation of pincer-type FAI.

DATA AVAILABILITY

The data sets generated and/or analysed during the current study are not publicly available due to reasons of sensitivity of human data but are available from the corresponding author on reasonable request.

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CONFLICT OF INTEREST STATEMENT

None declared.

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LEVEL OF EVIDENCE

Level IV: Retrospective study.

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