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Prognostic Value of the Lateral Center-Edge Angle in Hip Arthroscopy for Femoroacetabular Impingement: A Retrospective Cohort Study

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Purpose: Our study hypothesizes that the prognostic value of sourcil-based lateral center-edge angle (LCEAS) measurements is superior to rim-based (LCEAR) measurements in predicting clinical outcomes of hip arthroscopy for femoroacetabular impingement (FAI). The purpose of our study is to compare these measurement techniques and to identify the threshold values that predict successful patient outcomes.

Materials and Methods: We retrospectively analyzed 125 patients who underwent hip arthroscopy for FAI, with a minimum follow-up of two years. Using both sourcil- and rim-based techniques, we obtained lateral center-edge angle (LCEA) measurements from standardized pelvis anteroposterior radiographs. The modified Harris hip score (mHHS), Nonarthritic Hip Score (NAHS) and visual analog scale (VAS) for pain were used to evaluate clinical outcomes. We performed receiver operating characteristic (ROC) analyses to determine LCEA cutoffs associated with the Patient Acceptable Symptom State (PASS). Multivariate logistic regression analyses identified independent predictors of favorable outcomes.

Results: Postoperative LCEAS decreased from 31.1°±5.4° to 25.8°±6.6° (P=0.003), whereas postoperative LCEAR decreased from 38.7°±6.7° to 32.8°±6.4° (P=0.002). Overall, 80.8% of patients achieved PASS based on mHHS (≥83.3). ROC analysis identified postoperative LCEAS thresholds of ≤28.9° and ≤28.25° as predictors of PASS based on mHHS (AUC=0.702) and NAHS (AUC=0.740), respectively. Multivariate analysis confirmed postoperative LCEAS as an independent predictor of favorable clinical outcomes.

Conclusion: Postoperative LCEAS thresholds of around 28.9° are independently associated with favorable clinical outcomes following hip arthroscopy for FAI. The improved prognostic information provides the rationale for the use of LCEAS over LCEAR in surgical planning and outcome prediction.

Keywords: Femoroacetabular impingement, Lateral center-edge angle, Sourcil-based measurement, Rim-based measurement, Patient Acceptable Symptom State

INTRODUCTION

Femoroacetabular impingement (FAI) is a well-recognized hip disorder characterized by abnormal contact between the femoral head–neck junction and the acetabulum, which leads to labral tears, chondral damage, and eventually osteoarthritis[1]. In radiographic evaluations, the lateral center-edge angle (LCEA) is a key pa-

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rameter to assess acetabular coverage[2]. In the surgical management of FAI to restore optimal hip biomechanics, it is critical to assess the LCEA, prior to surgery, to establish the indications for surgery and to plan cam resection[3,4]. Typically, an angle of 25° to 40° is normal, <25° suggests borderline dysplasia, and >40° indicates acetabular overcoverage[5-8]. These angle measurement ranges guide treatment decisions[5,6,8]. Although LCEA plays a pivotal role to evaluate acetabular coverage in FAI, there is an ongoing debate on the optimal measurement technique[8-10].

The two predominant approaches to measure acetabular coverage are the rim-based technique that measures the angle from the femoral head center to the lateral edge of the acetabular bony rim, and the sourcil-based technique that references the lateral extent of the dense subchondral condensation known as the sourcil[7,8]. Rim-based LCEA (LCEAR) yields high values (~33°-38°), while sourcil-based values are low (~25°-30°), which reflects the extent of functional coverage[9,11]. This discrepancy between the two techniques is clinically significant as the rim-based method may be influenced by osteophytes—overhanging bone or structural irregularities—which potentially overestimates true load-bearing acetabular coverage[6,12,13]. Sourcil-based LCEA (LCEAS) better reflects the biomechanical contact zone and correlates well with outcomes[2,14].

According to Ogata et al.[8], most studies define 40° as the upper limit of normal LCEA and recommend measuring from the lateral edge of the sourcil. However, inconsistencies in clinical interpretation still exist across studies[9,10].

Even though several studies reported no significant outcome differences between overcovered and normally covered hips[3,15,16], others observed inferior outcomes, in particular, with rim-based methods in patients with LCEA >40°[17]. Recent systematic reviews have also emphasized this heterogeneity by noting that rim-based measurements may overestimate coverage, whereas sourcil-based measurements are closely associated with improved functional outcomes and patient-reported results[3]. These conflicting observations underscore the need for further research to clarify the measurement approach and to establish cut off values that best predict clinically favorable outcomes.

Similarly, there is an inconsistency in the definition of borderline dysplasia and it is linked to the measurement method. Some authors classify borderline hips using LCEAR, while others rely on sourcil-based measurements[14,15]. Despite the difference in measurement techniques, multiple matched cohort studies and meta-analyses indicate that both short- and long-term outcomes in borderline dysplasia, measured by these techniques, are often comparable to those observed in patients with normal acetabular coverage[3,5]. Therefore, there is a need to determine whether rim- or sourcil-based definitions more accurately reflect prognosis.

Recent studies have begun to define perioperative thresholds that could indicate optimal outcomes[3,15,17]. Matsuda et al.[5] suggested that an LCEAS ≤25° does not compromise stability and can yield excellent postoperative outcomes, particularly in borderline hips. Studies such as those by Sogbein et al.[3] and Wylie et al.[9] underscore the lack of a standardized measurement that demonstrates acetabular coverage. This coverage could be overestimated by the commonly used rim-based techniques than by sourcil-based methods that are increasingly recognized as more functionally and prognostically relevant[3,18]. Recent studies suggest that achieving a postoperative LCEAS between 23° and 28° may optimize outcomes by avoiding both undercoverage and relative overcorrection, which may reduce load-bearing congruity and improve joint mechanics[15].

Our study aimed to compare LCEAR and LCEAS measurements and to identify threshold values that predict the outcomes following hip arthroscopy for FAI. We hypothesized that LCEAS is strongly correlated with outcome prognoses, which helps to define a prognostic upper threshold.

MATERIALS AND METHODS

A total of 125 patients who underwent hip arthroscopy for FAI at a tertiary referral center between January 2018 and December 2022 were retrospectively included in this study. All the patients had a minimum clinical and radiological follow-up of 2 years (level of evidence III). Our study adheres to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for observational studies[19]. We obtained institutional review board approval from the Non-Interventional Research Ethics Committee of Dokuz Eylul University Faculty of Medicine (approval No. 2025/18-13). The written informed consent was obtained from all patients. The FAI was diagnosed based on clinical symptoms and radiographic findings

that specifically included an alpha angle greater than 50° for cam deformity and an LCEAS exceeding 40° for pincer deformity[20-22]. We excluded patients with avascular necrosis, advanced hip osteoarthritis (Tönnis grade >1), previous ipsilateral hip surgery, revision hip arthroscopy, incomplete radiographs, or true hip dysplasia (LCEAS <20°) from the study[23,24]. During the initial screening, 3 patients were excluded as they required revision surgery within the follow-up period. Similarly, 7 patients were excluded due to inconsistent follow-up or missing data. Following these exclusions, the final analysis included a total of 125 patients (Fig. 1).

1. Surgical Procedure and Rehabilitation

A hip surgeon with over 15 years of experience in hip surgery performed the procedures. Patients were positioned supine on a hip arthroscopy–specific traction table with a well-padded perineal post to achieve adequate distraction. A horizontal interportal capsulotomy was created to enhance visualization and access to the central compartment. Using a 4.5 mm arthroscopic burr (approximately 3 to 5 mm), acetabuloplasty was selectively performed to address acetabular overcoverage or labral impingement[25]. Acetabuloplasty was performed with the goal of restoring the rim contour and preserving functional acetabular coverage[25]. Prior to surgery, all patients were evaluated with MRI; however, the final decision regarding labral management was made during the surgical procedure. Irreparable labral tears with extensive cleavage or unstable flaps were debrided, while tears involving the labral base with chondrolabral disruption were repaired using 1 to 3 suture anchors. While under intraoperative fluoroscopic guidance and dynamic arthroscopic examination, the peripheral compartment was accessed and the cam deformity was decompressed after the release of traction. The capsule was left open in all the patients. To limit weight-bearing, the patients were instructed to use crutches for 2 weeks following surgery. Daily passive range-of-motion exercises commenced on the first day after surgery, followed by active range-of-motion exercises and full weight-bearing at 3 weeks. Exercises that included strengthening and light treadmill walking were initiated after 6 weeks. Oral anti-inflammatory medication was administered daily for the first 4 weeks.

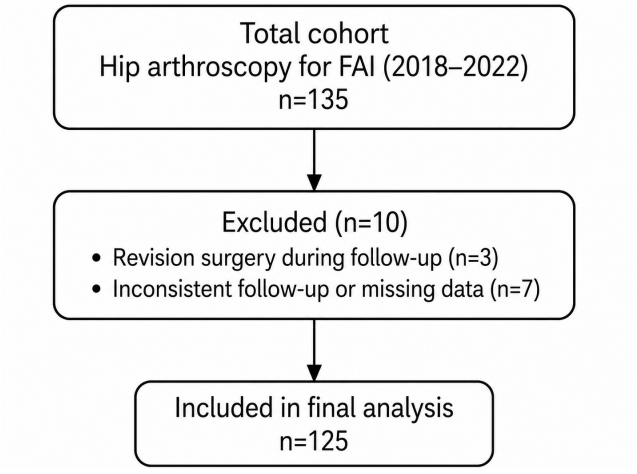


Fig. 1. Flow diagram of selection of study cohort. FAI: femoroacetabular impingement.

2. Radiographic Evaluation and Outcome Measures

Two experienced orthopedic surgeons independently performed all radiographic measurements using a PACS (Picture Archiving Communication System)-integrated digital measurement tool with standardized calibration settings. LCEAS was measured on standardized supine anteroposterior (AP) pelvis radiographs, while the alpha angle was assessed from images with a Dunn 45° view. To assess consistency in measurements, we calculated interobserver reliability for key radiographic parameters, including the LCEAS, LCEAR,

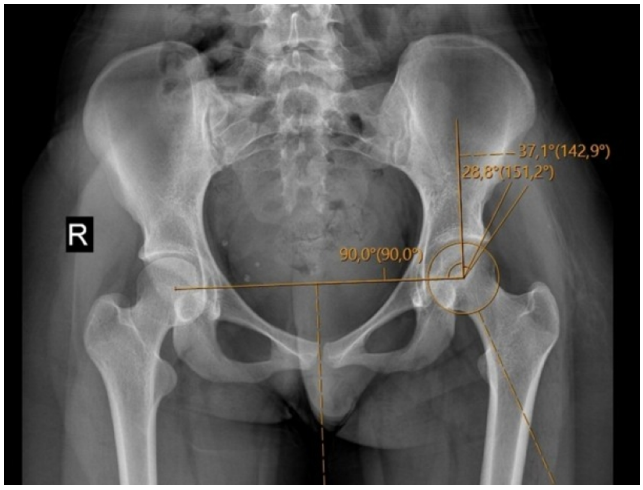


Fig. 2. Anteroposterior pelvis radiograph that shows the two measurement methods for the lateral center-edge angle (LCEA): the sourcil-based LCEA and the rim-based LCEA. The center of the femoral head is used as a reference point in both the techniques. The letter "R" on the image indicates the right side, as is standard in radiographic labeling.

and alpha angle. For statistical analysis, the mean of the measurements of two observers was used to ensure data precision and to minimize individual variability. Acetabular coverage was evaluated by measuring the LCEA using two methods: the rim-based method by Wiberg[7], and the sourcil-based method by Ogata et al.[8]. An illustrative image that details the reference points for these measurements is provided (Fig. 2).

The Tönnis classification was used to grade osteoarthritis using the pelvis AP radiographs[26]. In addition, the alpha angle was measured before and after surgery to further characterize the cam-pincer morphology. Patient-reported outcomes were reported by including the modified Harris hip score (mHHS) and the visual analog scale (VAS) for pain, which were collected by directly contacting patients. An mHHS greater than 83.3 and an Nonarthritic Hip Score (NAHS) greater than 85.6 were defined as the Patient Acceptable Symptom State (PASS), indicating satisfactory postsurgical functions[27-29]. We did not use minimal clinically important difference because patients were followed at different postsurgical time points, rendering standardized calculation impossible.

3. Statistical Analysis

The Kolmogorov–Smirnov test and the Skewness–Kurtosis values were used to assess the distribution of continuous variables. Continuous variables, including age, body mass index (BMI), alpha angle, and LCEA measurements, were expressed as mean, standard deviation, and 95% confidence interval (CI). Categorical variables were expressed as frequencies and percentages. Independent sample *t*-tests for normally distributed variables were used to compare PASS (+) and PASS (−) groups. The PASS (+) group included patients who achieved the PASS threshold based on postoperative mHHS and NAHS, whereas the PASS (−) group consisted of patients who did not reach this threshold.

Fisher's exact or chi-square tests were used to compare categorical data. Paired sample *t*-tests were used to evaluate pre- to postoperative changes in mHHS, NAHS, and VAS. Receiver operating characteristic (ROC) curve analyses were conducted to determine the optimal cutoff values of postsurgical LCEAS and LCEAR to predict PASS represented by mHHS ≥83.3 and NAHS ≥85.6 scores, with area under the curve (AUC) values interpreted as acceptable (0.7-0.8) and as excellent discrimination (>0.8). A backward stepwise likelihood ratio method was used to conduct binary logistic regression analysis. Variables with a $P<0.05$ in the univariate analysis were included in the multivariate model. Age, sex, NAHS, mHSS, Tönnis grade, pre- and postoperative alpha angle, pre- and postoperative LCEAS, pre- and postoperative LCEAR were included and adjusted in the multivariate regression model. The variance inflation factor (VIF) was used to assess multicollinearity and tolerance values for all covariates; a VIF <2.5 (equals a tolerance >0.40) was used as the acceptance threshold. The Hosmer–Lemeshow goodness-of-fit test was used to assess model calibration; no significant discrepancy was interpreted from $P>0.05$. Where required, calibration plots and residual/effect measures were also reviewed. The selection of variables was guided by both statistical significance and clinical relevance, in consultation with an experienced orthopedic surgeon. The ROC analysis helped to determine PASS thresholds (mHHS ≥83.3; NAHS ≥85.6). The regression model was designed to identify independent predictors associated with achieving these functional benchmarks. A priori power analysis was not conducted because this was a retrospective observational study based on available consecutive patient data. All analyses were conducted using IBM SPSS Statistics for Windows (ver. 29.0; IBM Corp.), with two-tailed significance levels set at $P<0.05$.

RESULTS

Our study included a final count of 125 hips from patients who underwent hip arthroscopy due to FAI. The overall cohort had a mean age of 34.6±10.9 years, with 85 males and 40 females. There was a mean follow-up duration of 57.6±27.8 months. The majority of patients had Tönnis grade 0 (n=78) or grade I (n=47) osteoarthritis. Active smoking was reported in 47.2% (59/125) of the patients. The mean BMI was 25.8±3.6 kg/m^2. Labral treatment consisted of 22 debridements and 103 repairs across the cohort.

Based on the mHHS (>83.3), 101 patients (80.8%) achieved the PASS (PASS+), while 24 patients (19.2%) did not achieve PASS (PASS−). Patients in the PASS+ group were significantly younger than those in the PASS− group (mean age, 33.2±10.7 years vs. 40.2±11.0 years, $P=0.005$). There was a statistically significant association of sex with achieving PASS. Male patients were more likely to reach the threshold ($P=0.035$).

Table 1. Patient Demographics and Comparisons between PASS (+) and PASS (–) Patients Based on mHHS (n=125)

Parameter	PASS (–) (n=24)	PASS (+) (n=101)	*P*-value
Age (yr)	40.2±11.0	33.2±10.7	0.005*
Follow-up (mo)	53.4±22.8	58.7±29.6	0.417*
Sex, M:F	12:12	73:28	0.035†
Preoperative Tönnis grade	10 (grade 0), 14 (grade I)	68 (grade 0), 33 (grade I)	0.020†
Active smokers	14	45	0.224†
BMI (kg/m^2)	27.3±4.2	25.5±3.3	0.113*
Labral treatment, debride/repair	5/19	17/84	0.766‡
Preoperative α (°)	84.1±6.9	83.5±6.1	0.715*
Postoperative α (°)	60.4±9.3	49.7±6.0	<0.001*

Values are presented as mean±standard deviation or number.
PASS: Patient Acceptable Symptom State, mHHS: modified Harris hip score, M: male, F: female, BMI: body mass index.
*By independent sample *t*-test. †By chi-square test. ‡By Fisher's exact test.

There were no statistically significant differences in achieving PASS, as observed in demographic, radiographic or functional outcomes in subgroup analyses stratified by sex. The prognostic performance of LCEAS and LCEAR remained consistent across the sexes. Similarly, a high number of patients with Tönnis grade 0 achieved PASS compared to those with grade I (*P*=0.020). Other factors that are not significantly associated with achieving PASS, include follow-up duration (58.7±29.6 months vs. 53.4±22.8 months, *P*=0.417), smoking status (*P*=0.224), BMI (25.5±3.3 kg/m^2 vs. 27.3±4.2 kg/m^2, *P*=0.113), and labral treatment type (debridement vs. repair, *P*=0.766) (Table 1).

No significant differences were observed in preoperative alpha angles between PASS groups (83.5°±6.1° vs. 84.1°±6.9°, *P*=0.715). However, the PASS+ group displayed significantly low postoperative alpha angles (49.7°±6.0° vs. 60.4°±9.3°, *P*<0.001), suggesting that more significant correction in cam lesion correlates with better functional outcomes.

Radiographic measurements were performed on AP pelvis and Dunn 45° radiographs. There was excellent agreement in interobserver reliability with intraclass correlation coefficients of 0.93 (95% CI 0.89-0.96) for LCEAS, 0.94 (95% CI 0.90-0.97) for LCEAR, and 0.93 (95% CI 0.88-0.96) for the alpha angle.

In terms of acetabular coverage, preoperative LCEAS and LCEAR values did not differ significantly between the PASS (+) and the PASS (–) groups (LCEAS: 31.1°±5.4° vs. 32.3°±6.0°, *P*=0.322; LCEAR: 38.7°±6.7° vs. 39.8°±7.2°, *P*=0.453). Postoperatively, both parameters showed significantly low values in the PASS+ group (LCEAS: 25.8°±6.6° vs. 30.3°±5.9°, *P*=0.003; LCEAR: 32.8°±6.4° vs. 37.6°±7.0°, *P*=0.002) (Table 2).

Table 2. Radiologic Outcomes (Pelvis AP Measurements) between PASS (+) and PASS (–) Patients

Measurement method	Time	PASS (–)	PASS (+)	*P*-value
LCEAS (°)	Preop.	32.3±6.0	31.1±5.4	0.322*
	Postop.	30.3±5.9	25.8±6.6	0.003*
LCEAR (°)	Preop.	39.8±7.2	38.7±6.7	0.453*
	Postop.	37.6±7.0	32.8±6.4	0.002*

Values are presented as mean±standard deviation.
AP: anteroposterior, PASS: Patient Acceptable Symptom State, LCEAS: sourcil-based lateral center-edge angle, LCEAR: rim-based lateral center-edge angle, Preop.: preoperative, Postop.: postoperative.
*By independent sample *t*-test.

Following surgery, clinical outcomes significantly improved. The mHHS increased from 57.3±11.2 to 91.2±10.0, with 80.8% achieving PASS (*P*<0.001). NAHS increased from 54.4±10.4 to 87.2±10.3 (*P*<0.001) and VAS pain scores decreased from 6.8±1.4 to 1.4±1.4 (*P*<0.001).

We performed ROC analysis to evaluate the accuracy of postoperative LCEA measurements—both LCEAS and LCEAR—to predict clinically meaningful outcomes following hip arthroscopy for FAI (Table 3). To predict PASS based on mHHS, the cut-off value for postoperative LCEAS was ≤28.9°, with a sensitivity of 71%, specificity of 71%, and a *P*-value of 0.01. The corresponding cut-off value for postoperative LCEAR was ≤34.2°, yielding a sensitivity of 70%, specificity of 72%, and a *P*-value of 0.02. Similarly, to predict PASS based on NAHS, postoperative LCEAS ≤28.25° showed a sensitivity of 76%, specificity of 70%, and a *P*-value of 0.01, while LCEAR ≤34.2° resulted in a sensitivity of 72%,

Table 3. ROC Analysis of LCEA Measurements (Pelvis AP) to Predict PASS

Measurement	Cutoff (°)	AUC	Sensitivity (%)	Specificity (%)	*P*-value
PASS based on mHSS ≥83.3					
Postoperative LCEAS	≤28.9	0.702	71	71	0.01*
Postoperative LCEAR	≤34.2	0.709	70	72	0.02*
PASS based on NAHS ≥85.6					
Postoperative LCEAS	≤28.25	0.740	76	70	0.01*
Postoperative LCEAR	≤34.2	0.706	72	70	0.02*

ROC: receiver operating characteristic, LCEA: lateral center-edge angle, AP: anteroposterior, PASS: Patient Acceptable Symptom State, mHHS: modified Harris hip score, LCEAS: sourcil-based lateral center-edge angle, LCEAR: rim-based lateral center-edge angle, NAHS: Nonarthritic Hip Score, AUC: area under the curve.
*P<0.05.

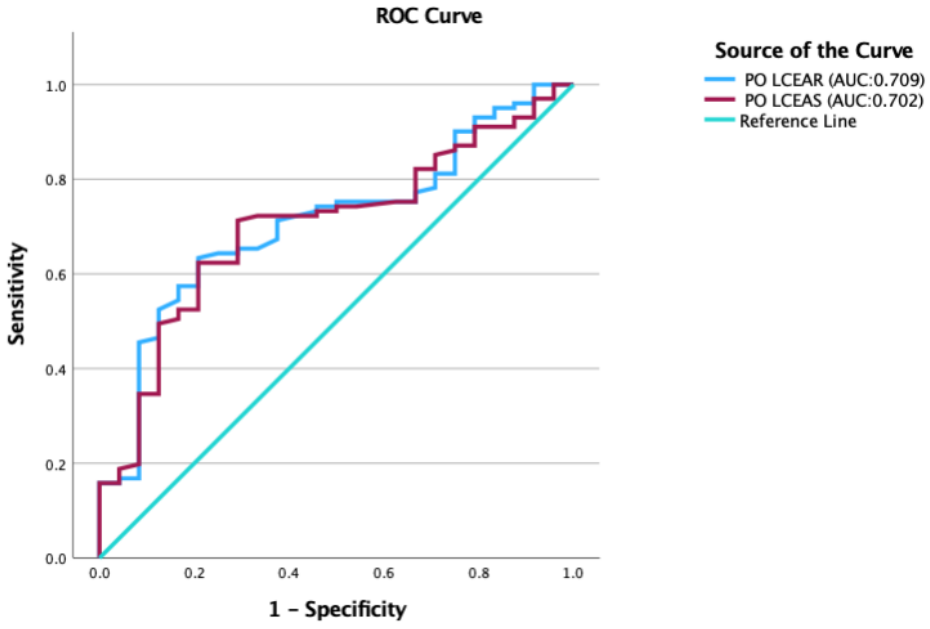


Fig. 3. Postoperative (PO) LCEAS and LCEAR for PASS-mHHS ≥83.3 (P<0.001). The blue line represents LCEAR, and the maroon line represents LCEAS. LCEAS: sourcil-based lateral center-edge angle, LCEAR: rim-based lateral center-edge angle, PASS: Patient Acceptable Symptom State, mHHS: modified Harris hip score, ROC: receiver operating characteristic, AUC: area under the curve.

specificity of 70%, and a P-value of 0.02.

To predict PASS based on mHHS ≥83.3, the optimal postoperative LCEAS threshold was ≤28.9°, yielding 71% sensitivity and 71% specificity. The AUC was 0.702 (95% CI 0.596-0.808, P<0.001), as shown in Fig. 3. For the PASS threshold defined by NAHS ≥85.6, LCEAS (≤28.25°) value demonstrated statistical significance (AUC=0.740, 95% CI 0.648-0.832, P<0.001) with 76% sensitivity and 70% specificity, as detailed in Fig. 4.

We performed multivariate logistic regression analysis to identify independent predictors of achieving PASS that is defined by mHHS (≥83.3) and NAHS (≥85.6) cut-off values (Table 4). The analysis included a broad range of covariates: demographic factors (e.g., age), baseline radiographic parameters (preoperative alpha angle, Tönnis grade, LCEAS, and LCEAR), and postoperative parameters (postoperative alpha angle, LCEAS, and LCEAR). Before multivariate modeling, patients were classified based on key ROC-derived cut-off values (e.g., LCEAS ≤28.9°). Univariate comparisons were performed to assess differences between groups. The statistically significant variables in univariate analysis (P<0.05) were included in the multivariate logistic regression, using a backward stepwise likelihood ratio method. In the final model, postoperative LCEAS and alpha angle were able to independently predict PASS. However, LCEAR did not retain statistical significance to predict PASS. Model calibration was adequate based on the Hosmer–Lemeshow goodness-of-fit test (P>0.05). Multicollinearity did not appear problematic; VIFs for all the predictors were <2.5 (tolerance >0.40).

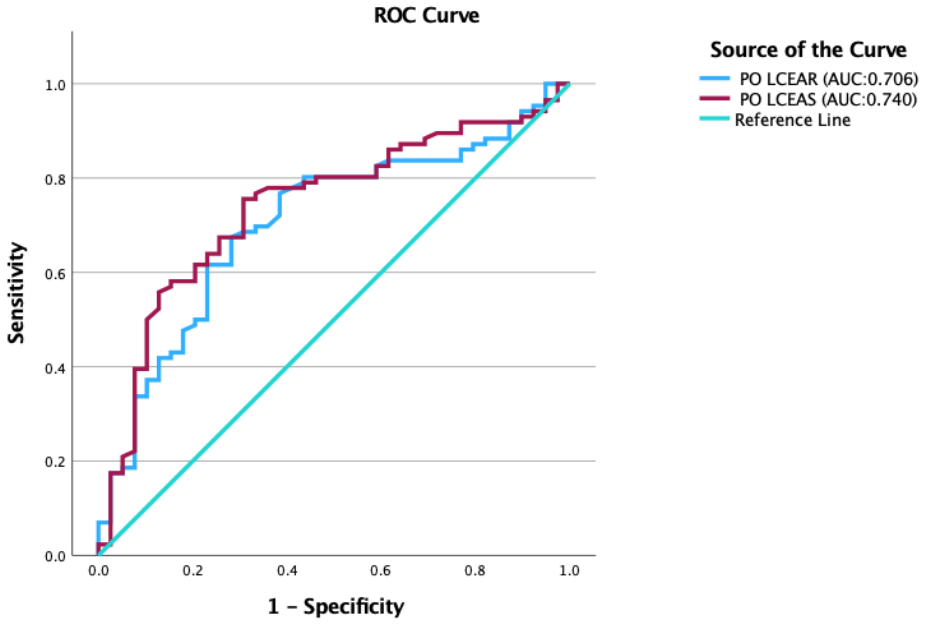


Fig. 4. Postoperative (PO) LCEAS and LCEAR for PASS-NAHS ≥85.6 (P<0.001). The blue line represents LCEAR, and the maroon line represents LCEAS. LCEAS: sourcil-based lateral center-edge angle, LCEAR: rim-based lateral center-edge angle, PASS: Patient Acceptable Symptom State, NAHS: Nonarthritic Hip Score, ROC: receiver operating characteristic, AUC: area under the curve.

Table 4. Logistic Regression Analysis

Variable	OR (95% CI)	*P*-value*
PASS based on mHSS ≥83.3		
Sex	0.049 (0.010-0.252)	<0.001
Postoperative AP α	0.841 (0.780-0.907)	<0.001
Postoperative LCEAS	0.904 (0.822-0.994)	0.037
PASS based on NAHS ≥85.6		
Postoperative AP α	0.895 (0.843-0.950)	<0.001
Preoperative NAHS	1.054 (1.008-1.103)	0.022
Postoperative LCEAS	0.905 (0.843-0.971)	0.006

PASS: Patient Acceptable Symptom State, mHHS: modified Harris hip score, AP: anteroposterior, LCEAS: sourcil-based lateral center-edge angle, NAHS: Nonarthritic Hip Score, OR: odds ratio, CI: confidence interval.
*Multivariate analysis included variables with P<0.05 in univariate analysis and calculated using the backward stepwise likelihood ratio (LR) method.

DISCUSSION

It is imperative to precisely quantify acetabular coverage for hip preservation[15]. Our study addresses this issue by comparing the prognostic performance of LCEAS and LCEAR measurements to predict successful outcomes of hip arthroscopy for FAI. We propose critical postoperative threshold values—LCEAS ≤28.9° and LCEAR ≤34.2° to achieve PASS based on mHHS ≥83.3. Similarly, we propose LCEAS ≤28.25° and LCEAR ≤34.2° for PASS based on NAHS ≥85.6. These are among the first ROC-derived postoperative LCEA cutoffs directly linked to validated patient-reported outcome measures, which is consistent with contemporary reviews that emphasize functional, patient-anchored thresholds[9,15]. Clinically, our observations suggest that postoperative LCEAS values above 28° or 29° and LCEAR values above 34° may represent relative overcoverage that is associated with inferior functional outcomes. Values maintained below these thresholds supports improved patient-reported recovery. When objective radiographic measurements are aligned with functional recovery thresholds, these cutoffs offer a practical and evidence-based guide to optimize surgical planning and postoperative evaluation in FAI.

Our ROC analyses demonstrated that the preoperative LCEAS threshold of ≤28.9° predicted prognoses. Our findings are consistent with recent ROC-based investigations in hip preservation that emphasize the importance of functionally validated cutoff values[16,30]. For PASS-NAHS, LCEAS again showed better discrimination (AUC=0.740), with high sensitivity (76%), while LCEAR (AUC=0.706) performed modestly with 72% sensitivity.

These results align with the idea that LCEAS, which measures the functional weight-bearing surface of the acetabulum, is clinically more relevant in predicting outcomes[8,9,14]. Although this level of accuracy may seem modest, the observation is clinically meaningful since a single radiographic parameter—LCEAS—demonstrated independent predictive value for prognosis. Notably,

in multivariate logistic regression models that incorporate key clinical and radiographic variables, LCEAR lost its statistical significance. This is probably because the presence of rim osteophytes or anterior overcoverage leads to the overestimation of LCEAR, which limits its functional relevance. This further supports the limited independent prognostic utility of LCEAR when compared to that of sourcil-based measurements.

In our study, an LCEAS of approximately 28° represents an optimal threshold to achieve favorable outcomes following hip arthroscopy for FAI. This aligns with the findings of Wylie et al.[9] who report that in asymptomatic individuals the mean LCEAS was 24.9° compared to a mean LCEAR of 33.4°, demonstrating a consistent offset between functional and anatomical measurements. This was further confirmed by Megerian et al.[10] who also emphasized the anatomical and functional divergence between the rim and sourcil reference points. This distinction is pivotal in clinical practice as rim-based overestimations could misguide the extent of acetabuloplasty, especially in borderline dysplastic or overcovered hips. To lend support to this observation, Johannsen et al.[2] found no significant relationship between postoperative LCEAR and functional improvement, despite achieving a mean postoperative LCEAR of 33.9°. This suggests that rim-based coverage may not correlate with symptomatic relief[2]. Taken together, these findings reinforce that a postoperative LCEAS around 28° represents a practical and prognostically meaningful target. Our findings also support the use of sourcil-based measurement as the standard clinical reference in hip preservation surgery.

Studies using the sourcil-based method have variably defined overcoverage as LCEAS ≥39° to 40°, yet no study has demonstrated significant differences in postoperative outcomes between overcovered and normally covered hips[5,6,31]. One analysis even noted higher revision rates in patients with LCEAS 25 to 35° compared to those of both the overcoverage and borderline dysplasia groups[2]. Other data suggest that precisely indicated acetabuloplasty yields results comparable to non-overcoverage cohorts, whereas excessive rim resection may impair recovery in global pincer cases[32,33]. Rim-based studies produced mixed results. Chandrasekaran et al.[17] reported inferior outcomes in patients with global overcoverage (LCEAR >40° plus coxa profunda), whereas Kingery et al.[33] found no significant differences between global, lateral, or absent overcoverage groups. For borderline dysplasia, most studies define LCEA <25° and consistently report that outcomes are comparable to those of normal hips when surgery is appropriately performed[7,8,34]. Matsuda et al.[5] show similar improvements in the 20° to 25° group, if iatrogenic instability is avoided.

In multivariate regression, the consistent significance of postoperative alpha angle and LCEAS highlights the multifactorial nature of successful hip preservation[11,35]. This underscores the importance of assessing both femoral and acetabular morphology to optimize outcomes[6,11]. These observations are consistent with athlete-specific data showing that postoperative alpha angle cutoffs around 46° predict a return to sport[36]. Given that rim-based measurements may be distorted by osteophytes or anatomical overhang, relying on sourcil-based landmarks could prevent overtreatment or undercorrection[13,33]. In our cohort, labral treatment type was not significantly associated with PASS. As observed in previous studies such as those by Larson et al.[12], Hatakeyama et al.[11], and Maldonado et al.[6], labral preservation can impact outcomes, particularly, in young patients. Our findings suggest that other variables, such as acetabular morphology and cam correction, may be strong prognostic predictors in this context[6,11,12].

Several clinical variables were associated with postoperative success. Young age (mean age, 33.2 vs. 40.2 years, P=0.005) correlated with the achievement of high PASS, consistent with Maldonado et al.[6] who identified age as a key predictor of favorable outcomes. The male sex was also associated with better outcomes (P=0.035), in line with the results of Kingery et al.[33] who reported better PASS scores in men with acetabular overcoverage. Preoperative Tönnis grade 0 was more frequent in the PASS groups (P=0.020), supporting Ueland et al.'s observation[28] that even mild degeneration negatively affects prognosis. In contrast, BMI, smoking status, and labral treatment showed no significant associations, echoing prior reports of limited predictive value. Notably, although preoperative alpha angles were similar (84.1° vs. 83.5°, P=0.715), greater postoperative correction was achieved in the PASS (+) group (49.7° vs. 60.4°, P<0.001). This finding, consistent with those of Lansdown et al.[1] and Mansor et al.[21], underscores that adequate cam decompression is critical, and our regression confirmed postoperative alpha angle as an independent predictor of PASS.

Our study has several limitations. There is potential selection bias due to the retrospective design, which precludes causal inference. Due to the three-dimensional complexity of acetabular morphology, all radiographic measurements based on plain radiographs may not fully capture the structure. Advanced three-dimensional imaging and incorporation of femoral version may yield more accurate thresholds[37]. Although we adjusted for key confounders, such as age, sex, BMI, and smoking, we did not account for other factors, including spinopelvic alignment and capsular management. Further prospective multicenter studies are required to validate the prognostic value of the proposed LCEAS and LCEAR thresholds.

CONCLUSION

In our study, LCEAS demonstrated a favorable prognostic value than LCEAR in predicting outcomes associated with hip arthroplasty. Postoperative LCEAS thresholds of ≤28.9° for mHHS and ≤28.25° for NAHS were associated with improved functional recovery and pain reduction, offering practical guidance for balanced acetabular resection. Furthermore, when these thresholds are integrated with intraoperative fluoroscopy-based imaging or software that calculates real-time LCEAS values, it could help surgeons optimize acetabular correction and potentially improve patient prognosis.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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