The Association of \( \alpha \) Angle on Disease Severity in Adolescent Femoroacetabular Impingement

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Background: Femoroacetabular Impingement (FAI) is a common cause of hip pain in adolescent patients. Clinical exam and radiographic markers, such as \( \alpha \) angle and lateral center edge angle (LCEA), are commonly used to aid in the diagnosis of this condition. The purpose of this study was to correlate preoperative \( \alpha \) angle and LCEA with preoperative symptoms, intraoperative findings, and preoperative and postoperative patient reported outcomes (PROs) in the adolescent patient.

Methods: A retrospective analysis of prospectively collected data was conducted for all patients who underwent operative intervention for FAI at an academic institution over an 11-year period. Preoperative imaging was obtained and measured for LCEA and \( \alpha \) angle. PROs (modified Harris Hip Score, Hip Disability and Osteoarthritis Outcome Score, and UCLA score) were collected preoperatively, as well as 1, 2, and 5 years postoperatively. Operative intervention was either open surgical hip dislocation or arthroscopic, and intraoperative disease was graded using the Beck Classification system. Patients with minimum 1-year follow-up were included in statistical analysis.

Results: There were 86 hips (64 female hips) included with an average age of 16.3 years (range, 10.4 to 20.5 y), with an average of 37 months of follow-up. There was no correlation between severity of preoperative symptoms or difference between pre and postoperative PROs for both \( \alpha \) angle and LCEA. Overall, significant improvement was noted in modified Harris Hip Score, Hip Disability and Osteoarthritis Outcome Score, and UCLA Score (\( P < 0.001 \) for each). Independent of preoperative symptoms, increased \( \alpha \) angle correlated with more severe intraoperative labral disease (\( P < 0.001 \)), and longer length of labral tear (Corr 0.295, \( P < 0.01 \)). Femoral head and acetabular articular cartilage damage did not correlate with \( \alpha \) angle or LCEA, nor did overall severity of disease.

Conclusions: In adolescent patients with FAI, increased \( \alpha \) angle was found to significantly correlate with labral pathology, including increased length of tear and severity of disease, irrespective of preoperative symptoms or postoperative patient reported outcomes.

Level of Evidence: Level III—retrospective.

Key Words: femoroacetabular impingement, labral disease, \( \alpha \) angle, lateral center edge angle, patient reported outcomes

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METHODS

Design
This is a retrospective analysis of prospectively collected data for all patients who underwent operative management for FAI at a single institution over an 11-year period from January 1, 2008 to February 1, 2019. Before data collection, IRB approval was obtained.

Patients
We originally identified a total of 128 hips from this group. Patients were included if they were between the ages of 10 and 21, had a diagnosis of FAI (as determined by 1 of 3 surgeons and based on clinical and radiographic data), and failed conservative management before operative intervention. Conservative management consisted of a trial of anti-inflammatory medications, activity modifications, and/or hip injection with corticosteroid. Patients were excluded if they had a prior diagnosis of either Legg-Calve-Perthes, slipped capital femoral epiphysis, juvenile idiopathic arthritis, or had sustained a previous fracture or operation on the affected hip (19 patients). Additional patients were excluded due to missing preoperative PROs or a lack of minimum of 1-year PRO follow-up (23 patients). Each hip was analyzed as a separate entry in patients who had bilateral hip involvement. In total, 86 hips were included in this study.

Radiographic Measurements
An AP pelvis, 45 degrees Dunn view or Frog-Leg Lateral, and magnetic resonance imaging were obtained preoperatively. Radiograph techniques were utilized as described by Clohisy et al.13 On the AP pelvis, LCEA was measured via the Sectra PACS system (Sectra, Linköping, Sweden) utilizing the hip dysplasia tool to ensure appropriate leveling of the pelvis and center of the femoral head. The LCEA was defined as the angle subtended between a vertical line and a line from the center of the femoral head (based on best fit circle) and the lateral edge of the sourcil. The α angle was measured on the Dunn radiograph, as previously validated, by a single reviewer using the method described by Notzli and colleagues.2,14 The α angle was measured by first placing a best fit circle over the femoral head. The α angle was then defined as the angle subtended by a line along the femoral neck axis and a line from the center of the femoral head to the point on the anterosuperior head-neck junction where the neck exited from the best fit circle.

PROs
Three PROs were utilized; modified Harris Hip Score (mHHS), Hip Disability and Osteoarthritis Outcome Score (HOOS), and UCLA Score. Patients were administered these surveys at the preoperative visit, and then 1, 2, and 5 years postoperatively.

Surgery
Operative treatment included either open surgical hip dislocation or arthroscopic treatment by 1 of 3 fellowship trained pediatric orthopaedic surgeons. Patients most commonly underwent femoroplasty (94.2%), with concurrent labral repair in many (57%). Other procedures included are listed in Table 1. Intraoperative findings were recorded; the presence or absence of synovitis, femoral head-neck junction anatomy, and the severity of damage to the labrum, and acetabulum and femoral head was classified as outlined by Beck et al.15 Cartilage damage in each location was graded as normal (1), chondromalacia (2), debonding (3), cleavage (4), or full-thickness defect (5). Labral damage was graded as normal (1), degeneration (2), full-thickness tear (3), and detachment (4).16 The labral tear position was described as a clock face position with tear length recorded as the difference between the starting and ending positions, that is, a tear from 1 o’clock to 3 o’clock was recorded as “2.”

Statistical Analysis
Continuous variables were first examined for normality, and nonparametric tests such as Kruskal-Willis test were considered. The change of PROs from pre to post were described by mean and SD, and they were considered with a 1-sample t test. A Spearman correlation was used to evaluate for an association between radiographic measures and PROs. α Angle and labral disease were compared with Mann-Whitney test between 2 groups based on a cutoff 55 for α angle. We defined $P<0.05$ as statistically significant and statistical analysis was performed using SAS version 9.4 (version 9.4, Released 2013, SAS Institute, Cary, NC).

RESULTS

Demographics
Patient demographic data and radiographic measurements are reported in Table 2. A majority of hips were female (74.4%) with an average age of 16.5 years (range, 10.4 to 20.5 y) and an average BMI of 24.1 kg/m² (range, 14.2 to 45.3 kg/m²). The average α angle was 61.7°

| Procedure                        | n (%)  |
|----------------------------------|--------|
| Open (surgical hip dislocation)  | 56 (65.1) |
| Arthroscopic                     | 30 (34.9) |
| Femoroplasty                     | 81 (94.2) |
| Labral repair                    | 49 (57.0) |
| Acetabuloplasty                  | 20 (23.3) |
| Capsular plication               | 14 (16.3) |
| Synovectomy                      | 3 (3.5) |
| Psoas lengthening                | 1 (1.2)  |

LCEA indicates lateral center edge angle.
any signiﬁcant difference between the groups. Intraoperative labral disease and longer labral tear length representing larger cam lesions, correlate with more severe intraoperative labral disease and longer labral tear length in the adolescent patient. It has been well documented that the morphologic abnormalities seen in FAI lead to labral tears and chondral damage with eventual hip degeneration.15,18 In the adult population, α angles have been positively correlated with longer labral tears (0.016 increase per degree, \( P = 0.005 \)) and severity of labral disease (\( P < 0.001 \)).18 Nepple et al19 further demonstrated α angle > 50 degrees to be independently associated with Outerbridge grade 3 or 4 acetabular chondromalacia. Specifically looking at those patients in that study with cam impingement (157 hips, average age 37.9), 82.2% had acetabular cartilage damage.

**Complications and Reoperations**

No complications were reported or recorded within this population. Overall, 10 of the 86 hips (11.6%) went on to have a secondary procedure. These included repeat hip arthroscopy (4), periacetabular osteotomy (3), repeat surgical hip dislocation (1), hardware removal (1), and an aborted procedure due to severity of chondral disease with subsequent osteoarticular transfer system procedure (1).

**DISCUSSION**

This study demonstrates that increased α angles, representing larger cam lesions, correlate with more severe intraoperative labral disease and longer labral tear length in the adolescent patient. It has been well documented that the morphologic abnormalities seen in FAI lead to labral tears and chondral damage with eventual hip degeneration.15,18 In the adult population, α angles have been positively correlated with longer labral tears (0.016 increase per degree, \( P = 0.005 \)) and severity of labral disease (\( P < 0.001 \)).18 Nepple et al19 further demonstrated α angle > 50 degrees to be independently associated with Outerbridge grade 3 or 4 acetabular chondromalacia. Specifically looking at those patients in that study with cam impingement (157 hips, average age 37.9), 82.2% had acetabular cartilage damage.

**Table 3.** Pre Versus Post Patient Reported Outcomes

|                      | Preoperative | Postoperative | \( P \) |
|----------------------|--------------|---------------|--------|
| mHHS                 | 62.8 ± 16.2  | 86.5 ± 15.2   | < 0.0001 |
| HOOS                  | 57.5 ± 18.2  | 85.6 ± 16.4   | < 0.0001 |
| UCLA                 | 6.8 ± 2.8    | 8.2 ± 2.2     | < 0.0001 |

**Table 4.** Preoperative and Postoperative Patient Reported Outcomes and Correlation* to α Angle and LCEA

| Preoperative PRO | Preoperative Score | α Angle | \( P \) | LCEA | ∆Score | Post-PRO Score | α Angle | \( P \) | LCEA |
|-----------------|--------------------|---------|--------|------|--------|--------------|---------|--------|------|
| mHHS            | 62.8 ± 16.2        | 0.041   | 0.711  | −0.036 | 0.743  | 23.5 ± 20.3  | −0.027  | 0.810  | −0.097 | 0.385 |
| HOOS            | 57.5 ± 18.2        | 0.113   | 0.310  | −0.136 | 0.211  | 28.1 ± 20.5  | −0.193  | 0.082  | −0.047 | 0.665 |
| UCLA            | 6.8 ± 2.8          | 0.003   | 0.976  | 0.215  | 0.046  | 1.4 ± 2.8   | 0.020   | 0.860  | −0.162 | 0.145 |

**Table 5.** Intraoperative Findings

| Grade       | n (%)  |
|-------------|--------|
| Acetabular articular cartilage | 1 | 58 (67.4) |
| Labrum disease | 1 | 10 (11.6) |
| Femoral head-articular cartilage | 1 | 76 (88.4) |
| Femoral head-neck junction | 1 | 60 (69.8) |
| Synovitis   | Yes    | 34 (39.5) |

Bold values are statistically significant (\( P < 0.05 \)).
*HOOS indicates Hip Disability and Osteoarthritis Outcome Score; mHHS, modified Harris Hip Score.
†Preoperative total score.
In this adolescent/transitional population, 67.4% and 88.4% of the hips had normal appearing acetabular and femoral head articular cartilage, respectively, compared with only 11.6% with a normal appearing labrum. Thus, it is likely that labral pathology precedes damage to the articular cartilage of the acetabulum and femoral head. In addition, α angles > 55 degrees were identified as causing severe labral damage (average grade 3.0 ± 0.9) compared with ≤ 55 degrees (P = 0.004). This knowledge may guide earlier operative intervention in the adolescent patient with a more severe α angle to prevent further damage to the labrum and articular cartilage. A recently published best practice guideline on hip arthroscopy in patients with FAI suggested early surgical intervention for patients with an α angle > 65 degrees.

In the present study, we demonstrated significant improvement in PROs following operative intervention for FAI. This improvement also did not correlate with our radiographic measurements. Our outcomes are similar to previously published literature.21–30 Litrenta et al.26 similarly demonstrated a significant improvement in mHHS from 64.0 ± 13.9 pre-operatively to 88.1 ± 12.3 post-operatively (P = 0.001). Another study on adolescent patients with FAI treated with surgical hip dislocation, found mHHS to increase from 57.7 to 85.8 postoperatively.30 All studies conclude that surgical treatment successfully treat symptomatic FAI in adolescent patients.

Although there was no association between α angle or LCEA and PROs in this adolescent population, correlation with disease severity was demonstrated. Radiographic measures and reported symptom severity have been reported with variable associations in the adult literature. Guler et al.8 reported increased α angles were correlated with a positive impingement test and hip pain. Lansdown et al.9 noted increasing preoperative AP α angles correlated a lower postoperative mHHS (β = −0.18, P = 0.046) and higher visual analog scale pain score (β = 0.28, P = 0.024), at a minimum of 2-year follow-up. More recently, however, Briggs et al.31 and Kierkegaard et al.32 both failed to identify a correlation between α angle and postoperative PROs.31,32

Psychological conditions may distort the associations of FAI morphology and preoperative and postoperative PROs. Hampton et al.33 suggested psychological factors, such as depression, anxiety, or pain catastrophizing, play a role in the presentation and outcomes in patients with hip disease. Another study demonstrated that patients who undergo hip arthroscopic surgery have an increased prevalence of psychiatric diagnoses.34 As a result, radiographic measurements may be only 1 out of many variables effecting PROs.

The rate of reoperation in this study was 11.6%, which is on the upper end of published data (3% to 13%).23,26,27 Three of the 10 patients who underwent reoperation had a periacetabular osteotomy, indicating these patients’ hip pain was later determined to be secondary to microinstability, as opposed to impingement. Differentiating between microinstability and impingement in patients with a cam lesions and borderline dysplasia (defined by LCEA < 25 degrees) can be difficult. As such, noted in Table 6, a decreased LCEA was associated with an increased risk of reoperation (P = 0.034). Further research to identify preoperative factors that may improve diagnostic accuracy and prognosis for adolescent FAI is warranted.

A primary limitation of this study is the variability introduced by multiple surgeons. Arthroscopic treatment versus open surgical hip dislocation was employed by differing surgeons exclusively for treatment of the condition. In addition, the data rely on intraoperative grading of labral and cartilage pathology that, while utilizing established criteria, is subject to variability among the 3 surgeons. Although the data were collected in a systematic prospective manner, the study is subject to the flaws of retrospective review and limited follow-up.

**CONCLUSIONS**

Increased α angle significantly correlates with labral pathology, including increased length of tear and severity of labral disease, irrespective of preoperative symptoms or postoperative PROs. Further research is needed to determine if earlier intervention in the adolescent population with larger cam lesions is warranted to prevent further damage to the labrum and articular cartilage.

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