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The Association of α 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 α 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 α 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 α 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 α 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 α 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 α angle or LCEA, nor did overall severity of disease.

Conclusions: In adolescent patients with FAI, increased α 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, α angle, lateral center edge angle, patient reported outcomes

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Femoroacetabular impingement (FAI) is a common cause of hip pain in the adolescent athlete.[1] Clinical exam and radiographic markers, such as α angle and lateral center edge angle (LCEA) of Wiberg, are commonly used to aid in the diagnosis of this condition.[2,3] The α angle is a measure of the (cam) morphology of the anterior and superior femoral head-neck junction and is defined as an angle between the femoral neck and the point at which the femoral head loses its sphericity.[4] The loss of the sphericity, or presence of a cam lesion, can lead to impingement between the femoral head and adjacent acetabular cartilage and labrum.[5,6] Impingement can also occur due to pincer-morphology, or over coverage by the acetabulum, leading to abnormal contact between the acetabular rim and femoral head-neck junction.

In adults, α angle has been reported to correlate with preoperative symptoms and the amount of improvement after surgery.[7–9] α Angles > 55 degrees have been associated with hip pain, positive impingement test, and lack of internal rotation.[8] Operative procedures aimed at reducing this angle to <55 degrees have been shown to lead to improved patient reported outcomes (PROs).[7] Although variability may exist, preoperative and postoperative α angles have been documented in 1 population as independent predictors of PROs.[9] Additional radiographic markers that have been shown to provide prognostic and treatment information include Tonnis grade, LCEA, and joint space narrowing.[10–12]

To date, there are no studies which correlate symptom or intraoperative disease severity with α angle or LCEA in the adolescent population. The purpose of this study was to correlate preoperative α angle and LCEA with preoperative symptoms, intraoperative findings, and preoperative and postoperative PROs in the adolescent patient; while evaluating preoperative and postoperative clinical outcomes with operative intervention in this cohort.

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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."

TABLE 1. Procedures Performed

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)

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/m^2 (range, 14.2 to 45.3 kg/m^2). The average α angle was 61.7

TABLE 2. Patient Demographics and Radiographic Measurements

Sex (female), n (%)	64 (74.4)
Age (y)	16.5 (10.4-20.5)
BMI (kg/m^2)	24.1 (14.2-45.3)
Sports participation, n (%)	74 (86.0)
Insidious onset, n (%)	63 (73.3)
Duration of symptoms (wk)	79.9 (10-260)
Follow-up (mo)	37.0 (12-121)
α Angle (deg.)	61.7 (37-105)
LCEA (deg.)	31.6 (20-46)

LCEA indicates lateral center edge angle.

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**

Bold values are statistically significant ($P < 0.05$).
*HOOS total score.
HOOS indicates Hip Disability and Osteoarthritis Outcome Score; mHHS, modified Harris Hip Score.

degrees (range, 37 to 105 degrees) and LCEA was 31.6 degrees (range, 20 to 46 degrees). The average length of follow-up was 37 months (range, 12 to 121 mo).

PROs

Preoperative and postoperative PROs are reported in Table 3. There was a statistically significant improvement in the mHHS, HOOS, and UCLA scores when comparing preoperative to the most recent postoperative values ($P < 0.001$ for each). Table 4 correlates α angle and LCEA to the severity of preoperative symptoms, and the amount of improvement postoperatively. Preoperative UCLA scores showed significant positive correlation with an increased LCEA (Corr 0.215, $P = 0.046$). Otherwise, there was no significant correlation identified between the radiographic measurements and preoperative symptom severity or amount of improvement postoperatively. In addition, we comparted preoperative and postoperative PROs between patients with and without labral tears and did not identify any significant difference between these 2 cohorts of patients.

Intraoperative Findings

Intraoperative findings as defined by the Beck Classification are listed in Table 5. Only 11.6% of hips had a normal appearing labrum, whereas 67.4% acetabulum and 88.4% femoral head articular cartilage appeared normal. When dichotomizing the labral findings as either normal or abnormal (Table 6), increased α angle was associated with labral pathology. Table 7 groups α angle into 2 distinct groups and demonstrates α angles > 55 degrees have an average labral grade of 3.0 ± 0.9, which is significantly higher ($P = 0.004$) compared with ≤ 55 degrees (2.2 ± 1.0). In addition, length of labral tear was significantly longer with α angle > 55 degrees ($P = 0.031$) with a mild correlation (Corr 0.295, $P = 0.007$).

TABLE 5. Intraoperative Findings

	Grade	n (%)
Acetabular articular cartilage	1	58 (67.4)
	2	11 (12.8)
	3	7 (8.1)
	4	7 (8.1)
	5	3 (3.5)
Femoral head articular cartilage	1	76 (88.4)
	2	8 (9.3)
	4	2 (2.3)
Labrum disease	1	10 (11.6)
	2	28 (32.6)
	3	20 (23.3)
	4	28 (32.6)
Femoral head-neck junction	1	60 (69.8)
	2	21 (24.4)
	4	2 (2.3)
	5	3 (3.5)
Synovitis	No	52 (60.5)
	Yes	34 (39.5)

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.[15,17] 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 ($P < 0.001$).[18,19] Nepple et al[19] 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 4. Preoperative and Postoperative Patient Reported Outcomes and Correlation* to α Angle and LCEA

	Preoperative PRO					Difference Between Pre-PRO and Post-PRO				
		α Angle		LCEA			α Angle		LCEA	
	Score	Corr	*P*	Corr	*P*	ΔScore	Corr	*P*	Corr	*P*
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

Bold value is statistically significant ($P < 0.05$).
*Corr is Spearman rank correlation coefficient.
†HOOS total score.
LCEA indicates lateral center edge angle; HOOS, Hip Disability and Osteoarthritis Outcome Score; mHHS, modified Harris Hip Score; PRO, patient reported outcome.

TABLE 6. Intraoperative Disease to α Angle and LCEA

Labral Disease	Grade = 1	Grade ≥ 2	*P*
α Angle	50.0 ± 9.8	63.3 ± 14.6	**0.004**
LCEA	33.5 ± 6.9	31.81 ± 6.4	0.43
Femoral head-neck junction			
α Angle	64.3 ± 14.9	56.1 ± 13.0	**0.01**
LCEA	31.3 ± 6.5	33.6 ± 6.1	0.14
Acetabular articular cartilage			
α Angle	61.05 ± 14.3	63.0 ± 15.7	0.58
LCEA	32.3 ± 7.0	31.5 ± 5.3	0.78
Femoral head articular cartilage			
α Angle	61.9 ± 15.6	60.3 ± 13.1	0.97
LCEA	32.2 ± 6.6	30.6 ± 5.3	0.55
Reoperation rate	No	Yes (n = 10)	
α Angle	61.3 ± 14.6	64.7 ± 15.9	0.49
LCEA	32.5 ± 6.4	28.0 ± 5.5	**0.03**

Bold values are statistically significant ($P < 0.05$).
LCEA indicates lateral center edge angle.

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 more severe labral disease (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 α angle > 65 degrees.[20]

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 64.6 ± 15.9 preoperatively to 88.1 ± 12.3 postoperatively ($P < 0.001$). Another study on adolescent patients with FAI treated with surgical hip dislocation, found mHHS to improve 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 ($\beta = -0.18$, $P = 0.046$) and higher visual analog scale pain score ($\beta = 0.28$, $P = 0.024$), 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.

TABLE 7. α Angle and Labral Disease

	α Angle ≤ 55 deg.	α Angle > 55 deg.	*P*
Labral disease*	2.2 ± 1.0	3.0 ± 0.9	**0.004**
Tear length†	0.9 ± 1.4	1.3 ± 1.2	**0.031**

Bold values are statistically significant ($P < 0.05$).
*Average Beck classification grade.
†Average tear length.

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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