Influence of Acetabular Labral Tear Length on Outcomes After Hip Arthroscopy for Femoroacetabular Impingement Syndrome With Capsular Plication

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Background: The literature on the effects of labral tear on patient-reported outcomes, midterm pain, and overall patient satisfaction is limited.

Purpose: To determine the effect of labral tear length on postoperative outcomes after hip arthroscopy for femoroacetabular impingement syndrome (FAIS).

Study Design: Cohort study; Level of evidence, 3.

Methods: Consecutive patients undergoing primary hip arthroscopy for FAIS from January 2012 to January 2016 were identified in a prospectively collected database. All patients completed the Hip Outcome Score–Activities of Daily Living (HOS-ADL), Hip Outcome Score–Sports Subscale (HOS-SS), modified Harris Hip Score (mHHS), and visual analog scale for pain and satisfaction. Patients were stratified by labral tear length into small (<2.5 cm) or large (≥2.5 cm) based on the receiver operating characteristic curve analysis. Patient characteristics and outcomes were analyzed with multivariate linear regression analyses to identify predictors of labral tear length. Binary logistic regression analysis was performed to determine whether labral tear length predicted the likelihood of achieving the minimal clinically important difference.

Results: Of the 747 eligible patients, 600 (80.3%) had 2-year reported outcomes and were included in the final analysis. Mean age, body mass index, and tear length were 33.5 ± 12.3 years, 25.4 ± 9.2 kg/m^2, and 2.7 ± 0.7 cm, respectively. Men had higher frequency of large tears when compared with women (77% vs 43.7%, $P < .001$). Independent *t* test demonstrated significant differences in 2-year outcomes between patients with tears <2.5 and ≥2.5 cm, respectively: HOS-ADL (87.3 ± 16.3 vs 84.3 ± 18.1, $P = .033$), HOS-SS (76.6 ± 23.5 vs 70.5 ± 27.7, $P = .005$), mHHS (82.5 ± 18.0 vs 78.5 ± 18.2, $P = .009$), and satisfaction (83.5 ± 23.4 vs 77.8 ± 34.9, $P = .026$). Binary logistic regression analysis demonstrated that labral tear length is an independent predictor of visual analog scale for satisfaction, HOS-ADL, HOS-SS, and mHHS. Binary logistic regression analysis demonstrated that patients with small labral tears had a higher likelihood of achieving the minimal clinically important difference for the HOS-SS (odds ratio, 1.61; 95% CI, 1.39-1.92; $P < .02$) and the patient acceptable symptomatic state for the mHHS (odds ratio, 1.56; 95% CI, 1.11-2.2; $P = .038$) than those with larger tears.

Conclusion: Labral tear length is independently predictive of patient-reported outcomes after hip arthroscopy for FAIS. Furthermore, patients with smaller tears (<2.5 cm) had better outcomes and a higher likelihood of achieving a minimal clinically important difference at 2-year follow-up. However, the mean differences between changes in pre- and postoperative outcomes were relatively small and may not be clinically meaningful.

Keywords: hip arthroscopy; femoroacetabular impingement; labral tear; patient-reported outcomes

The acetabular labrum is a complex structure that is critical to function within the hip joint. It is the main structure for preserving the suction seal, ensuring wider coverage of the femoral head,[6-8] reducing femoroacetabular joint contact pressures, and providing negative intra-articular pressure that provides stability to the hip joint.[26] Recent studies reported up to a 38% prevalence of femoroacetabular impingement and labral tears among asymptomatic young adults.[11,16] Labral tears can lead to disruption of the suction seal, causing mechanical imbalances within the hip joint.[27] Labral repair, the most common procedure performed in arthroscopic hip surgery, attempts to correct

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this pathology.[3,13,17] Previous studies demonstrated the importance of maintaining the labrum continuity and subsequent hip suction seal, which preserves near-normal contact between the femoral neck and the labrum and prevents microinstability.[24,27] The importance of restoring labral function during hip arthroscopy also has clinical implications, as a recent meta-analysis reported excellent outcomes after labral repairs, with significantly improved patient-reported outcomes (PROs), 87% return to sports, and a low reoperation rate (5.5%) at a mean 29.5 months of follow-up.[22]

Although hip arthroscopy has demonstrated positive outcomes, meticulous patient selection is vital for achieving the desired outcomes. It is well documented in the literature that poor prognostic factors for hip arthroscopy include the following: age >50 years, significant joint space narrowing, acetabular dysplasia and retroversion and full-thickness chondral lesions in the femoral head, and/or subchondral marrow changes in the femoral head and acetabulum detected in magnetic resonance imaging. Among intrinsic factors that could play a role in postoperative outcomes, the influence of the size of the labral tear (and subsequent repair) has yet to be determined. The purpose of this study was to determine the effect of labral tear length on postoperative outcomes after hip arthroscopy for femoroacetabular impingement syndrome (FAIS). It was hypothesized that significant improvements in functional outcomes and PROs would occur regardless of labral tear length at a minimum 2-year follow-up.

METHODS

Patient Selection and Study Design

This study was approved by our institutional review board (12022108-IRB01). Data from consecutive patients undergoing primary hip arthroscopy for FAIS from January 2012 to January 2016 were collected and analyzed. Inclusion criteria included history, physical examination, and radiographic findings consistent with FAIS among patients who failed nonoperative management and underwent femoroplasty, acetabuloplasty, and labral repair. Exclusion criteria included the following: unwillingness to participate in the study, symptomatic contralateral hip FAIS requiring surgery, revision surgery, ipsilateral knee and ankle injury/surgery, history of any hip surgery, history of pediatric deformities (developmental dysplasia of the hip [lateral center-edge angle <20°], slipped capital femoral epiphysis, and Perthes disease), and osteoarthritis or joint space narrowing (Tönnis grade >1). Patient factors and outcomes were analyzed with univariate and correlation analyses to identify predictors of labral tear length.

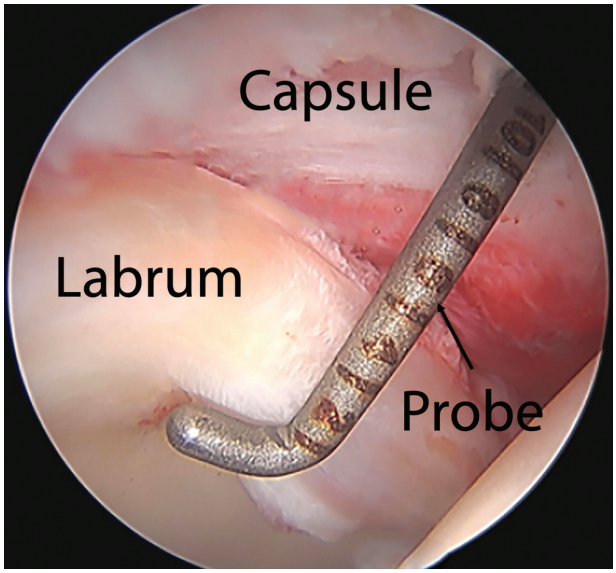

Figure 1. Intraoperative image of the graduated probe used to measure the labral tear length.

Surgical Technique

Our preferred surgical technique has been previously described,[9,12,30] which incorporates labral repair or labral debridement, femoral osteochondroplasty, acetabular rim trimming, and capsular closure. All surgical procedures were performed with the patient under general anesthesia in the supine position on a standard traction table. Anterolateral, midanterior, and distal anterolateral accessory portals were created to address the central compartment pathology, and a T-capsulotomy was performed for visualization of the peripheral compartment. Labral refixation was performed in all cases as previously described. At the time of surgery, labral tear characteristics were documented for all patients, with traditional acetabular clock face nomenclature to determine the location of the tear and with a graduated probe to measure the extent of the tear (Figure 1). Hip traction was released immediately after work was concluded in the central compartment, and the peripheral compartment was addressed after a dynamic examination to identify the zones of the impingement. Closure of the capsulotomy via repair of the interportal and T-capsulotomy incisions was performed in all cases.

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Postoperative Rehabilitation

Rehabilitation started on postoperative day 1 for all patients as previously described.[14,15,18] Patients went through a 4-phase rehabilitation protocol that lasted a mean 16 to 18 weeks. Rehabilitation phase 1 prioritized joint protection and soft tissue mobilization techniques. Phase 2 focused on the reestablishment of normal gait maintenance, full range of motion, improvement of neuromuscular control, and maintenance of pelvic and core stability. Phase 3 included single-legged squats and strengthening, soft tissue and joint mobilization, and cardiovascular fitness. Phase 4 emphasized return to preinjury level of sports participation or daily physical activity in non-athletes. Patients were cleared to return to sports if they were able to participate in sports without pain, had full dynamic functional control, and passed all return-to-sports tests.

Radiographic Measurements

Radiographs were taken preoperatively and at the time of latest follow-up. All patients underwent anteroposterior pelvis, false profile, and Dunn lateral views in the supine position. The lateral center-edge angle of Wiberg was assessed on the anteroposterior pelvis radiographs, and the alpha angle was assessed on Dunn lateral radiographs.[4] Additionally, femoral neck shaft angle, posterior wall sign, and crossover sign were assessed to determine whether they were associated with labral tear length.

Functional Outcome Evaluation

All patients completed hip-specific outcome instruments, including the Hip Outcome Score–Activities of Daily Living (HOS-ADL),[19] Hip Outcome Score–Sports-Specific Subscale (HOS-SS),[20] and modified Harris Hip Score (mHHS),[2] as well as patient-determined pain and satisfaction as measured on a 1-100 visual analog scale (VAS) at a minimum of 2 years postoperatively. Differences in pre- and postoperative outcome scores were compared with the minimal clinically important difference (MCID) for each PRO previously established in literature.[25] The 1-year MCIDs were set at 9, 6, and 8 points for the HOS-ADL, HOS-SSS, and mHHS, respectively. Similarly, the 1-year patient acceptable symptomatic states (PASSs) were set at 87, 75, and 74.[4]

Statistical Analysis

Receiver operating characteristic (ROC) analysis was performed to determine a cutoff value for small versus large labral tears. Given that multiple outcomes were assessed and that ROC curves can be generated with binary outcomes only, the ROC curve for labral tear length was performed by using, as the stated variables, the MCID and PASS for the HOS-ADL, HOS-SS, and mHHS. The acceptable area under the curve chosen was 0.500, and a labral tear length cutoff was chosen with a balance of high specificity and sensitivity. The area under the curve for the PASS for the HOS-ADL, HOS-SS, and mHHS was not used because it fell below 0.500. The labral tear length cutoff value for small versus large tears generated from ROC analyses was 2.5 cm and used to separate groups (Appendix 1, available in the online version of this article).

Patient demographic information is presented as means and SDs. Student *t* tests were used to compare the difference in PROs between patient groups. Chi-square analyses were used to compare the labral tear length group versus the MCID and PASS. All statistical tests were 2-tailed, and the statistical difference was established at a 2-sided α level of .05 ($P < .05$). Binary logistic regression analysis was performed to determine whether having a large tear was predictive of achieving MCID for any of the outcome scores independent of other potential confounders (eg, age, gender, physical activity). Statistical analyses were conducted with SPSS (v 24.0.0; IBM Corp).

TABLE 1
Patient Characteristics by Tear Size[a]

	Small	Large	*P* Value
Age, y	32.4 ± 11.8	34.6 ± 12.0	.027
Sex			<.001
Male	49 (23)	164 (77)	
Female	218 (56.3)	169 (43.7)	
Body mass index	25.0 ± 12.5	25.7 ± 5.1	.380
Smoker	37 (11.6)	53 (13.5)	.478
Workers' compensation	14 (5.2)	22 (6.7)	.479
Physically active	207 (79.3)	225 (70.3)	.049
Runner	195 (61.1)	214 (51.7)	.121

[a]Data reported as n (%) or mean ± (SD), unless otherwise indicated.

RESULTS

Patient Characteristics

A total of 600 (80.3%) eligible patients were included in the analysis. Mean ± SD age and body mass index were 33.5 ± 12.3 years, 25.4 ± 9.2 kg/m^2, respectively. Mean length of labral tears was 2.7 ± 0.7 cm, with 97.7% occurring in the anterosuperior position. The differences in characteristics between the small and large labral tear groups are described in Table 1. Briefly, men had a higher proportion of large tears (≥2.5 cm) when compared with women (77% vs 43.7%, $P < .001$). The mean age among patients with small tears was lower but within 2 years of the mean age of patients with large tears (32.4 ± 11.8 vs 34.6 ± 12.0, respectively; $P = .027$). Physically active patients had a higher frequency of having small tears (79.3% vs 70.3%, $P = .049$). There were no other differences in characteristics of interest, including body mass index, smoking status, workers' compensation, or running for physical activity. Of note, 6 (1.8%) patients underwent total hip arthroplasty in the large tear group and 1 (0.4%) in the small tear group.

Comparison of Radiographic Findings. Analysis of radiographic findings demonstrated statistically significant differences in femoral angle measurements. Alpha angles in the false profile and Dunn were all significantly less in the small labral tear group (Table 2). There was

TABLE 2
Radiographic Findings of the Cohort[a]

	Small	Large	*P* Value
Alpha angle			
Anteroposterior	76.2 ± 11.9	77.1 ± 12.4	.443
False profile	62.9 ± 12.0	66.8 ± 13.4	**.019**
Dunn	63.4 ± 10.9	66.6 ± 11.1	**.006**
Femoral neck shaft angle	130.2 ± 5.2	128.7 ± 5.9	.074
Center-edge angle			
Anterior	33.2 ± 5.8	33.2 ± 7.1	.952
Lateral	30.2 ± 5.5	30.9 ± 5.5	.568
Tönnis angle	6.7 ± 4.5	6.5 ± 4.7	.873
Crossover sign	18 (6.8)	21 (6.5)	.872
Posterior wall sign	28 (31.4)	33 (40.7)	.208

[a]Data reported as mean ± (SD) or n (%), unless otherwise indicated. Bold indicates $P < .05$.

TABLE 3
Patient-Reported Outcomes vs Preoperative Expectation Scores[a]

	Small	Large	*P* Value
Preoperative			
HOS-ADL	63.9 ± 18.8	64.8 ± 17.9	.578
HOS-SS	41.6 ± 22.3	42.6 ± 22.9	.609
mHHS	57.5 ± 13.9	57.6 ± 15.6	.926
VAS for pain	66.3 ± 19.4	66.7 ± 20.7	.791
Postoperative			
HOS-ADL	87.3 ± 16.3	84.3 ± 18.1	**.033**
HOS-SS	76.6 ± 23.5	70.5 ± 27.7	**.005**
mHHS	82.5 ± 18.0	78.5 ± 18.2	**.009**
VAS for pain	19.8 ± 23.4	21.4 ± 23.2	.429
VAS for satisfaction	83.5 ± 23.4	77.8 ± 34.9	**.026**

[a]Data reported as mean ± (SD), unless otherwise indicated. Bold indicates $P < .05$. HOS-ADL, Hip Outcome Score–Activities of Daily Living; HOS-SS, Hip Outcome Score–Sports-Specific Subscale; mHHS, modified Harris Hip Score; VAS, visual analog scale.

no statistical difference in the acetabular angle measurements or femoral neck shaft angle.

Reported Outcome Bivariate Analysis. Bivariate analyses were performed to compare 2-year postoperative outcomes between patients with small and large labral tears (Table 3). None of the preoperative PRO means were statistically different between the groups. Analysis of 2-year postoperative PROs demonstrated that patients in the small labral tear group had significantly higher PRO scores than those in the large labral tear group. Furthermore, patients with small tears had a significantly higher satisfaction mean than those with large tears (83.5 ± 23.4 vs 77.8 ± 34.9; $P = .026$). MCID and PASS rates were similar for both groups (Table 4). However, patients with small tears reached the MCID for the HOS-SS and PASS for the mHHS at higher rates than those with large tears (48% vs 36% and 63% vs 52%, respectively; $P < .05$ for both).

Multivariate Regression Analysis. A multivariate regression model incorporating age, sex, physical activity, and tear length was constructed to determine the cumulative effect of these variables on postoperative PROs and satisfaction (Table 5). With postoperative VAS satisfaction as the dependent variable, length of labral tear was the strongest independent predictor of VAS satisfaction score (β, –6.10; 95% CI, –11.4 to –0.58; $P = .03$). Similarly, labral tear length was the strongest independent predictor of the HOS-ADL and HOS-SS. However, being physically active appears to be a stronger predictor than large labral tear (β: 3.623 vs –3.48, respectively) for having a higher mHHS score 2 years after surgery.

TABLE 4
Frequency of Achieving MCID/PASS by Labral Tear Size[a]

	Small	Large	*P* Value
MCID			
HOS-ADL	104 (55)	121 (58)	.567
HOS-SS	86 (48)	63 (36)	**.019**
mHHS	123 (68)	131 (69)	.958
PASS			
HOS-ADL	84 (32)	29 (29)	.495
HOS-SS	64 (26)	77 (25)	.819
mHHS	158 (63)	165 (52)	**.010**

[a]Data reported as n (%), unless otherwise indicated. Bold indicates $P < .05$. HOS-ADL, Hip Outcome Score–Activities of Daily Living; HOS-SS, Hip Outcome Score–Sports-Specific Subscale; MCID, minimal clinically important difference; mHHS, modified Harris Hip Score; PASS, patient acceptable symptomatic state.

Binary Logistic Regression Analysis. A binary logistic regression analysis was performed to determine whether the small tear group was more likely to achieve the MCID and PASS. The analysis demonstrated that patients in the small tear group were more likely to achieve both the MCID for the HOS-SS (odds ratio, 1.61; $P = .02$) and PASS for the mHHS (odds ratio, 1.56; $P = .038$) (Table 6). Labral tear length size did not predict any of the other MCID or PASS categories.

DISCUSSION

The main finding of this study was that patients with labral tears ≥2.5 cm in length demonstrated inferior 2-year outcomes and patient satisfaction in comparison with patients with labral tears <2.5 cm. A multivariate regression analysis demonstrated that labral tear length was an independent predictor of 2-year PROs and satisfaction. Last, patients with labral tears <2.5 cm were more likely to achieve the MCID for the HOS-SS and PASS for the mHHS than those ≥2.5 cm.

Prior literature largely focused on identifying predictors of the presence of a labral injury at the time of hip arthroscopy. Nepple et al[23] retrospectively reviewed 338 patients undergoing hip arthroscopy by a single surgeon. After performing a regression analysis, the group reported a significant association between male sex and multiple markers of more severe hip disease. Of these, males were significantly more likely to have larger labral tears and more severe acetabular chondromalacia. Similarly, Redmond et al[28]

TABLE 5
Multivariate Regression Analysis for Age, Sex, and Labral Tear Length vs Patient-Reported Outcomes and VAS for Satisfaction[a]

	β	95% CI	*P* Value
HOS-ADL			
Age	–0.82	–0.21 to 0.04	.948
Sex	–0.1	–3.2 to 2.9	.172
Physically active	3.02	–0.35 to 6.39	.078
Large labral tear	–2.87	–5.85 to –0.097	**.048**
HOS-SS			
Age	–0.146	–6.4 to 3.1	.504
Sex	–1.63	–0.33 to 0.04	.117
Physically active	4.135	–1.07 to 9.35	.120
Large labral tear	–6.2	–10.7 to –1.6	**.009**
mHHS			
Age	–0.098	–0.23 to 0.03	.129
Sex	1.102	–2.2 to 4.4	.512
Physically active	3.623	0.02 to 7.224	.049
Large labral tear	–3.48	–6.60 to –0.33	**.031**
VAS for satisfaction			
Age	0.1	–0.23 to 0.09	.35
Sex	–0.43	–0.63 to 9.21	.88
Physically active	2.92	–3.245 to 9.093	.352
Large labral tear	–6.1	–11.4 to –0.58	**.030**

[a]Bold indicates $P < .05$. HOS-ADL, Hip Outcome Score–Activities of Daily Living; HOS-SS, Hip Outcome Score–Sports-Specific Subscale; mHHS, modified Harris Hip Score; VAS, visual analog scale.

TABLE 6
Binary Logistic Regression Analysis for Labral Tear Size and MCID/PASS Rates[a]

	Odds Ratio	*P* Value
MCID		
HOS-ADL	0.89 (0.60-1.33)	.567
HOS-SS	1.61 (1.39-1.92)	**.02**
mHHS	0.96 (0.64-1.53)	.958
PASS		
HOS-ADL	1.13 (0.80-1.61)	.496
HOS-SS	0.82 (0.71-1.53)	.819
mHHS	1.56 (1.11-2.2)	**.038**

[a]Bold indicates $P < .05$. HOS-ADL, Hip Outcome Score–Activities of Daily Living; HOS-SS, Hip Outcome Score–Sports-Specific Subscale; MCID, minimal clinically important difference; mHHS, modified Harris Hip Score; PASS, patient acceptable symptomatic state.

investigated 392 hips and reported that male sex and preoperative alpha angle were predictive of increased labral tear length. However, the group noted no correlation between lateral center-edge angle and labral tear length. These findings are in agreement with the results of the current study, which also indicates that male sex and increasing preoperative alpha angles are independently associated with larger labral tears. The current study represents the largest correlation of arthroscopic, radiographic, and patient-specific risk factors for labral tears in the literature. While it is expected that increasing lateral center-edge angles would result in more severe labral damage at the time of arthroscopy, this relationship is not yet fully understood in nondysplastic hips. Domb et al[5] recently reviewed 39 patients with increased lateral center-edge angles, coxa profunda, and symptomatic labral tears and reported a higher incidence of more severe labral pathology at the time of surgery than a matched control group with normal acetabular coverage. As described by Beck et al,[1] acetabular overcoverage results in a specific pattern of intra-articular derangement and reduced hip range of motion owing to compression of the labrum as the femoral neck abuts the overcovering acetabular rim. While this mechanism is well established, no current studies have successfully independently correlated increasing lateral center-edge angle and preoperative hip range of motion with labral tear size. The degree to which radiographic and physical examination findings correlate with intra-articular hip degeneration has not been well established; however, the current study suggests several objective predictors of increased labral tear size that should be considered by the treating surgeon and used clinically to counsel patients preoperatively.

There has been increased emphasis in the hip arthroscopy literature on the use of PRO measurements and intraoperative variables to identify independent predictors of postoperative outcomes and patient satisfaction.[5,21,22] While several patient-specific variables have been identified to negatively affect such outcomes, relatively few intrinsic factors at the time of surgery, such as labral tear length, have been identified. The current study is the first to examine the effect of labral tear size at the time of hip arthroscopy for FAIS on 2-year PROs. While all patients showed improvement at 2-year follow-up consistent with other large cohort studies in the literature, patients with labral tears $\geq$2.5 cm reported significantly lower 2-year outcome scores than those with tears $<$2.5 cm.[31] The relationship among chondrolabral damage, FAIS impingement, and early degenerative changes of the hip have been well established.[1,6,10,29] The current study adds to this understanding by correlating larger labral tear sizes with more severe intra-articular pathology and lower outcome scores at 2 years. As demonstrated in the regression analysis, more severe chondral damage was associated with labral tears $\geq$2.5 cm. This study suggests that larger labral tears may signify more overall severe hip degeneration, resulting in decreasing patient function and satisfaction at 2 years. In addition, patients and surgeons should understand that labral tears $\geq$2.5 cm are independently associated with inferior outcomes.

Limitations

The current study is not without limitations. First, a single fellowship-trained surgeon (S.J.N.) from 1 institution operated on all patients. However, the patient population is diverse, making it a unique sample to study and adding value to the findings. Second, while this study used a regression analysis to limit confounders that influence PROs after hip arthroscopy for FAIS, other factors potentially play a large role, including chondromalacia, alpha angle, acetabular version, and acetabular volume (or overall rim length),

which we were unable to control for. In addition, there are likely other radiographic variables that influence labral pathology and tear size in FAIS that went unidentified in the current study. Next, the mean differences between changes in pre- and postoperative outcomes were relatively small and may not be clinically meaningful. Furthermore, the CIs in the statistically significant values were wide; therefore, future studies with a greater number of patients are warranted to validate our results. Finally, there has been no validated methodology to the intra-articular measurement of labral tear size to date.

CONCLUSION

Labral tear length is influenced by numerous preoperative factors, which were found to be predictive of injury pathology and outcomes after hip arthroscopy for FAIS. Furthermore, patients with smaller tears (<2.5 cm) had better outcomes and a higher likelihood of achieving an MCID at 2-year follow-up. However, the mean differences between changes in pre- and postoperative outcomes were relatively small and may not be clinically meaningful.

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