Clinical and Morphologic Factors Associated with Suture Anchor Refixation of Labral Tears in the Hip

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Abstract *Background:* The acetabular labrum is critical to hip function. Surgical options for treatment of a damaged labrum include removal, debridement, and refixation using suture anchors. *Questions/Purposes:* The purpose of this study is to determine if certain patient demographic and osseous morphological factors result in increased labral damage requiring refixation. *Methods:* Data was collected prospectively from a consecutive series of 334 procedures performed from August 2010 to June 2011 for femoroacetabular impingement. Demographic data, including age, sex, and race, was collected from patient charts. Three-dimensional (3D) CT scans were reviewed to retrieve alpha angles, acetabular version, femoral version, and lateral center edge angle on the symptomatic hip. *Results:* In 238 (71.3%) of the procedures, the labrum required refixation using suture anchors with a mean of 2.74 anchors being used. Of males, 78.8% required suture anchors and 62.3% of females required suture anchors. Among procedures requiring suture anchors, significantly more suture anchors were used in males (2.92) than females (2.47). Regression analysis showed a positive association between alpha angle, acetabular retroversion at 1 and 2 o'clock, and the number of suture anchors used. The mean alpha angle in the cohort that required suture

anchors (63.1°) was significantly greater than the cohort that did not (59.4°). *Conclusion:* This study found femoral deformities to contribute more to labral damage than acetabular deformities and highlighted the importance of pre-operative 3D CT scans. This study provides demographic and morphologic factors to review preoperatively to evaluate if extensive labral damage is present and if suture anchor refixation will be required.

Keywords femoroacetabular impingement · labral tears · 3D CT scans · labral repair · hip pain

Introduction

Labral tears are the most common pathological finding during arthroscopic hip surgery and are responsible for the majority of mechanical symptoms [10]. Unfortunately, the labrum is often damaged due to an underlying abnormal bony morphology such as femoroacetabular impingement (FAI) that can result in increased stress on the labrum [13]. Studies have suggested that as many as 90% of patients with labral pathology have an underlying bony abnormality [4, 17]. Unique osseous deformities that predispose to FAI such as femoral anteversion and acetabular retroversion have been associated with osteoarthritis of the hip [3]. These distinct pathologic morphologies highlight how unique osseous deformities can result in unique labral damage.

Labral tears vary based on etiology and diagnosis [3]. The form of impingement dictates the type of labral lesion with a cam lesion being associated with early intra-articular cartilage wear and separation of the labrum from the acetabulum and the pincer lesion being associated with labral pathology due to compressive forces [7, 23]. Labral tears also vary by their zone of injury, where the majority of labral tears occur in the anterosuperior region near the chondrolabral junction [25]. In addition, this area is a common site of osseous impingement on the labrum; hence, the zone of maximal labral is damaged [11, 35]. As we further

Level of Evidence: Level II evidence; Development of diagnostic criteria on basis of consecutive patients.

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identify the etiology of the labral tears, the best methods for treatment can be proposed.

Due to our recent understanding of the biomechanical importance of the labrum, which is critical to hip function, there has been an increasing trend in labral preservation and repair [10]. Surgical methods for treatment of labral tears along with FAI include open, arthroscopic, or combined open/arthroscopic procedures [6]. A review of the literature has shown arthroscopic techniques are as effective in treating FAI and labral pathology as open procedures [5]. Treatment options for a damaged labrum include removal, debridement, and refixation using suture anchors.

Debridement was the standard of care until 2001 when emerging scientific evidence as well as advances in surgical techniques began to support labral refixation [9]. Studies suggest that the reason labral refixation is superior to debridement alone or removal is due to a rich vascular supply resulting in the labrum's ability to heal by ways of fibrovascular scar tissue to the acetabulum [22, 27, 32]. Based on these basic science principles, clinical science began supporting labral refixation. Studies have demonstrated superior clinical and radiographic outcomes in patients receiving labral refixation versus removal or debridement [9, 20, 31].

The proper assessment and presurgical planning of a prearthritic hip rely on appropriate imaging. Radiographs are the cornerstone for evaluation for osseous impingement; however, non-contrast MRIs and three-dimensional (3D) CT scans have been used with increased frequency and both have their advantages. MRI being superior for labral tears and is the most commonly used technique for evaluation of labral pathology [25, 28, 30]. 3D CT scans have now been described as an accurate diagnostic tool in defining abnormal morphologies in hips with FAI [2]. 3D CT scans allow views through multiple plains and help outline the femoral head/neck junction [33]. Gu and colleagues identified 3D CT as the superior imaging technique to identify femoral offset [12]. It is also a helpful tool to define femoral and acetabular version. 3D CT scans are now commonly used as a diagnostic tool in defining subjective and objective assessment of both complex and subtle morphological abnormalities in FAI.

The goal of this study is to determine if specific demographic and morphologic factors identified on 3D CT scan result in greater labral damage and instability requiring a greater number of suture anchors for repair. It also aims to identify if femoral or acetabular deformities result in greater labral pathology. Based on previous research, we hypothesize that gender, alpha angle, femoral anteversion, and acetabular retroversion will have a positive association with the number of suture anchors needed [3, 11].

Methods

Since March 1, 2010, all patients presenting to the Center for Hip Preservation with nonarthritic hip pain have been enrolled into a prospective outcomes registry after giving informed consent. Demographic, physical examination, and

radiographic data are collected at the time of the visit and entered into the registry. All patients who undergo open or arthroscopic hip preservation procedures have intraoperative data recorded prospectively by the treating surgeon at the time of surgery. The registry and projects using registry data have approval from the Institutional Review Board. The prospectively collected data was queried for all patients who had hip arthroscopy performed between August 2010 and June 2011 for FAI and labral tear, totaling 334 procedures. For this study, inclusion criteria were males and females between the age of 15 and 45 with radiographic evidence of FAI and positive MRI findings of labral pathology. Exclusion criteria included hip arthroscopy patients with MRI findings not consistent with labral pathology, such as ligamentous teres injuries, loose bodies, or hip dysplasia. Each patient underwent an initial evaluation for hip pain which included physical exam findings consistent with FAI and radiographic, 3D CT, and MRI findings consistent with FAI and labral pathology. Each patient failed conservative management which included 3–6 months of physical therapy and every patient received an intraarticular injection. When labral repair was performed, the acetabular rim was cleared of soft tissue and the bone was abraded for anchor placement for soft tissue healing [10]. Rim trimming was not performed to destabilize any labral tissue any further than what was deemed unstable. The appropriate number of anchors were placed 3–4 mm apart using quality tissue near the acetabular labral junction to repair the defect.

Demographic data including age and sex was collected from patient charts. 3D CT scans were reviewed to retrieve alpha angles, acetabular version, femoral version, and lateral center edge angle on the symptomatic hip. GRYPHON 3.0-mm anchors were used in all cases that required labral refixation.

Alpha angles were measured using both oblique axial and radial sequences to find the largest cam lesion on CT scan at multiple angles to find the area of maximal offset. A circle was then drawn around the femoral head. The alpha angle was measured between the center line of the femoral neck and a line drawn between the center of the femoral head and the point at which the femoral cortex is tangent to the circle drawn (Fig. 1) [16]. Femoral version was measured using the angle between the center line through the femoral neck on the axial images and a horizontal line (Fig. 2c) [26]. Then, the angles between a line drawn along the posterior femoral condyles and a horizontal line were measured and the two angles were added. Lateral center edge angles were measured on a coronal slice through the center of the femoral head with a circle drawn around the femoral head (Fig. 2b) [16]. The coronal center edge angle is the angle between a vertical line and a line between the lateral edge of the acetabulum and the center of the femoral head (Fig. 2a). Acetabular version was measured at 1, 2, and 3 o'clock; normal is 5°, 10°, and 15°, respectively (Figs. 3b–d). The pelvis was assessed for any lateral tilt (Fig. 3a). The acetabular version was then measured between a vertical line and a line connecting the anterior and posterior edges of the acetabulum [33].

Fig. 1. The alpha angle was measured between the center line of the femoral neck and a line drawn between the center of the femoral head and the point at which the femoral cortex is tangent to the circle drawn.

Student's *t* tests were performed to determine if there was a difference in means between the suture cohort and non-suture cohort. A regression model for count data was used to determine any relationships between the number of suture anchors and clinical and morphologic factors. A Poisson

regression model was chosen to control for over-dispersion in the data. The significance codes that were used are .001 “***,” .01 “**,” and .05 “*” (Table 1).

Results

In a consecutive series of 334 procedures, 238 (71.3%) of the labrums required refixation using suture anchors with a mean of 2.74 suture anchors being used. Fifty and a half percent (50.5%) of the sutures were mattress configuration and 49.5% were simple sutures. The average age of the patients who required labral refixation was 30.0 (15.3–54.9±9.4). There were 142 males (59.7%) and 96 females (40.3%). The average of the patients who underwent debridement alone was 31.2 (14.9–56.8±10.4). There were 58 females (60.4%) and 38 males (39.6%). Of males, 78.8% required labral refixation and 62.3% of females required labral refixation. Among procedures requiring labral refixation, significantly more suture anchors were used in males (2.92) than females (2.47) ($p<.05$). A negative association was found between age and the number of suture anchors used ($p<.05$) (Fig. 4).

The mean alpha angle in the cohort that required labral refixation (63.1°) was significantly greater than the cohort that did not (59.4°) ($p<.05$) (Table 2). Regression analysis showed a positive association between alpha angle and the number of sutures used ($p<.05$) (Fig. 5). There was no association found with femoral anteversion or retroversion

Fig. 2. The coronal center edge angle is the angle between a vertical line and a line between the lateral edge of the acetabulum and the center of the femoral head (a). Lateral center edge angles were measured on a coronal slice through the center of the femoral head with a circle drawn around the femoral head (b). Femoral version was measured using the angle between the center line through the femoral neck on the axial images and a horizontal line (Fig. 2c).

Fig. 3. The pelvis was assessed for any lateral tilt (a). The acetabular version was then measured between a vertical line and a line connecting the anterior and posterior edges of the acetabulum. Acetabular version was measured at 1, 2, and 3 o'clock; normal is 5°, 10°, and 15°, respectively (b–d).

($p=.606$) and the number of sutures used. Femoral version was not significantly different between the refixation and debridement cohorts ($p=.756$). There was no significant difference in retroversion at 1, 2, or 3 o'clock between the

refixation and debridement cohorts ($p=.236$, $p=.815$, $p=.974$). The lateral center edge angle was not significantly different between the refixation and debridement cohorts

Table 1 Regression analysis of suture counts based on alpha angle, acetabular retroversion at 1 and 2 o'clock, and age. The Poisson regression was used to model count data. Significance codes: .001 (***), .01 (**), and .05 (*). Models represent the respective angle measured and predicted number of suture anchors required. Intercept represents the log of the number of sutures in the sample population when the predictor is zero

	Coefficient	Std. error	<i>p</i> value
Model 1			
(Intercept)	-.232	.223	.298
Alpha angle	.015***	.003	1.90×10^{-5}
Model 2			
(Intercept)	.729***	.044	<.001
Acetabular retroversion	.011*	.005	.026
Model 3			
(Intercept)	.801***	.063	2.00×10^{-16}
Acetabular retroversion	.009*	.004	.039
Model 4			
(Intercept)	.847***	.111	7.62×10^{-13}
Acetabular retroversion	.009	.006	.161
Model 5			
(Intercept)	1.04***	.136	2.65×10^{-13}
Age	-.012*	.005	.011

Fig. 4. Regression analysis was performed demonstrating the negative association between age and the total number of suture anchors used ($p<.05$). Hashes on the x-axis represent the raw data.

Table 2 Results of Student's *t* tests comparing morphologic factors between the cohort that required suture anchors and the cohort that did not require suture anchors. The alpha angle in the cohort that required suture anchors was significantly larger than in the cohort that did not require suture anchors ($p < .05$)

	Suture cohort (deg)	Non-suture cohort (deg)	<i>p</i> value
Alpha angle	63.1	59.4	<.05
Femoral version	16.49	15.95	.756
Lateral center edge angle	35.1	36.1	.566
Acetabular retroversion 1 o'clock	2.82	4.12	.236
Acetabular retroversion 2 o'clock	11.25	11.52	.815
Acetabular retroversion 3 o'clock	16.25	16.22	.974

($p = .566$). There was a positive association between acetabular retroversion at 1 and 2 o'clock and the number of sutures used ($p < .05$) (Figs. 6 and 7). There were 128 patients with alpha angles greater than 60° who also had acetabular retroversion. No association was found between lateral center edge angle ($p = .651$) or acetabular retroversion at 3 o'clock ($p = .161$) and the number of sutures used.

Discussion

The acetabular labrum is often damaged from abnormal bony morphologies such as FAI [3]. With the high incidence of abnormal bony morphologies underlying torn labrums, these are often treated simultaneously [5]. With the increased risk of early osteoarthritis from FAI and chondrolabral injuries, early detection and reliable imaging are crucial to hip preservation [11]. Of the different approaches to repair the labrum, refixation using suture

Fig. 6. Regression analysis was performed demonstrating the positive association between acetabular retroversion at 1 o'clock and the total number of suture anchors used ($p < .05$). Hashes on the *x*-axis represent the raw data.

anchors has been demonstrated to be the superior method [20]. This study looked at a large population of patients treated for FAI with labral damage. We found our hypothesis to be correct that alpha angle had a positive association with labral injury, highlighting the importance of femoral deformities in labral damage. Also, acetabular retroversion at 1 and 2 o'clock had a positive association with greater labral injury and hence a greater number of sutures used in

Fig. 5. Regression analysis was performed demonstrating the positive association between alpha angle and the total number of suture anchors used ($p < .05$). Hashes on the *x*-axis represent the raw data.

Fig. 7. Regression analysis was performed demonstrating the positive association between acetabular retroversion at 2 o'clock and the total number of suture anchors used ($p < .05$). Hashes on the *x*-axis represent the raw data.

refixation. Of note, 128 of the patients had alpha angles greater than 60° and acetabular retroversion, demonstrating that the cam and pincer deformities frequently occur together [10]. This is consistent with studies that have demonstrated that certain morphologies are predisposed to impingement [11].

There are many limitations of this paper. It uses suture anchors as a predictor of labral damage and hip instability. However, the use of an anchor depends on other factors besides labral damage and instability including age, activity level, sex, comorbid conditions, and other confounding variables. There is also little research in the hip suggesting that more suture anchors indicate more labral instability. Yet, this notion has been well described in the shoulder [34]. Also, one could speculate that the labrums that were not fixed were done so for too much damage, but in our experience, we have a very low threshold to repair a damaged labrum with suture anchors indicating the majority of these were not unstable enough to require repair. In most cases, labrums are too small or diminutive not to benefit from repair rather than too damaged. There may also be variability among surgeons. This study evaluated procedures from a single attending orthopedic surgeon. This study also highlights the importance of preoperative 3D CT scans which some argue against due to radiation exposure. However, this CT protocol uses adaptive statistical iterative reconstruction which has been shown to reduce radiation exposure up to 57% without compromising image quality [29].

Other studies have demonstrated that cam impingement, which radiographically is determined by a large alpha angle over time, results in labral detachment [1, 7, 23]. This is consistent with our results that showed the larger the alpha angle the more suture anchors required and hence the importance of femoral deformities in labral pathology. Cam impingement tends to affect large labrums and results in chondral–labral separation and these tears are more amenable to repair with suture anchors [10]. Likewise, acetabular retroversion at 1 and 2 o'clock is anatomically located inferior to the anterior inferior iliac spine, which is now considered a potential site of impingement [21]. Pincer type impingement tends to result in fraying and intrasubstance degeneration of the labrum, making it more difficult to repair with suture anchors [10]. Ellis and colleagues found excessive femoral anteversion to limit impingement-free motion, suggesting decreased femoral version may be protective to the labrum [8]. In this study, decreased femoral anteversion did not show an association with the number of suture anchors used. This study also found males to require more suture anchors than females for labral refixation. The femoral head–neck ratio has been shown to decrease in men as they age making them more susceptible to cam type impingement than females [15]. Males have also been shown to have a higher rate of bilateral FAI compared to females, requiring bilateral surgery more frequently [18].

This study also highlights the importance of 3D CT scans as an imaging modality to assess osseous deformities as a tool to aide in preoperative hip planning. 3D CT scans have now been described as an accurate diagnostic tool in defining abnormal morphologies in hips with FAI and as the

superior method to identify femoral head–neck offset [2, 33]. Up to 50% of crossover signs indicating acetabular retroversion on plain AP radiographs have shown not to be present on 3D CT scans [36]. Intraoperative findings of labral damage have been positively correlated with preoperative alpha angles measured on 3D CT scans, which is consistent with our study [14]. Konan found the frog lateral plain radiograph to significantly underestimate the alpha angle when compared to 3D CT scans [19]. Milone et al. used a software-based approach which generated a 3D image based on 3D CT scans and found the measured alpha angle to be significantly larger than plain radiographs [24]. These studies all demonstrate the importance and improved accuracy of 3D CT scans in defining the bony morphology of the femoral head–neck junction.

To the authors' knowledge, this is the first study to analyze the factors that influence the number of suture anchors used. This study identifies specific demographic and morphologic factors which may influence the extent of labral damage and which labral injuries may require suture anchor refixation. The alpha angle was found to have a positive association with the number of suture anchors used. This demonstrates that femoral deformities play a more significant role in labral pathology than acetabular deformities. It also highlights the importance of preoperative 3D CT scans in the surgical planning of FAI treatment.

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Disclosures

Conflict of Interest: John A. Ruder, BS and Erin Magennis, BA have declared that they have no conflict of interest. Bryan T. Kelly, MD received grant funding from Mitek Sports Medicine for the study.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5).

Informed Consent: Informed consent was obtained from all patients for being included in the study.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

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