Current Reviews in Musculoskeletal Medicine (2019) 12:291–299
https://doi.org/10.1007/s12178-019-09575-1

FEMOROACETABULAR IMPINGEMENT/LABRAL TEARS (A ZHANG, SECTION EDITOR)

Surgical Treatment of Labral Tears: Debridement, Repair, Reconstruction

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Published online: 26 July 2019

Abstract

Purpose of Review With the rapid growth of hip arthroscopy over the past decade, new treatment paradigms as well as recognition of new disease states have sprung forth. The ability to perform complex arthroscopic procedures of the hip such as labral augmentation and reconstruction is essential for hip arthroscopists in the revision setting, with patient selection and indications for various labral treatments the key driver for improved short- and mid-term clinical outcomes.

Recent Findings Current techniques have been developed to address disease states where the labrum is either unstable, torn, deficient, or otherwise incompetent. Many early reports focused on the description of these techniques with new literature reporting short- and mid-term outcomes. A few of these have demonstrated improved outcomes with a contemporary arthroscopy with emphasis on capsule preservation and repair.

Summary Studies have demonstrated that labral repair has improved outcomes over labral debridement, with results of labral reconstruction in a revision approaching those of labral repair. In addition, newer reports have shown significantly improved outcomes and survivorship with capsule repair and therefore should be included in every hip arthroscopy.

Keywords Hip labral repair · Labral reconstruction · Labral augmentation · Hip capsule repair

Introduction

Hip arthroscopy was first described when it was used to assist with a dislocated total hip [1]. It began to gain traction in the late 1990s and early 2000s and today an initial PubMed search for "hip arthroscopy" yields nearly 3000 results with over half of those being published in the last 5 years. This rapid expansion of the knowledge base necessitates timely and frequent reviews to help keep clinician's knowledge current. Much of the recent literature and evolution in hip arthroscopy has been focused on treatment of the acetabular labrum. During the past decade, the treatment of hip labral tears has transitioned from debridement of pathologic labral tissue only to a complex decision tree based on labral tissue viability, joint instability, and bony morphology. A recent systematic review reflects this paradigm shift reporting increased utilization of labral repair (19 to 81%) between 2009 and 2017 [2]. This review will summarize recent trends in the treatment of labral tears and detail below our decision analysis for labral management.

This article is part of the Topical Collection on *Femoroacetabular Impingement/Labral tears*

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Role of Acetabular Labrum

The labrum is a triangular shaped fibrocartilage structure that surrounds the majority of the acetabulum, aside from its transition into the transverse acetabular ligament [3]. It has an important role in hip function that continues to be better understood. The labrum appears to contribute to hip stability, maintenance of fluid dynamics, and proprioception. Cadaveric studies have shown that the labrum is a heavily innervated structure with noci- and proprioceptive fibers which can lead to significant pain when the labrum is torn or mechanically unstable [4]. An incompetent or torn labrum can lead to hip microinstability which has recently gained recognition as a pathologic entity [5•]. Biomechanical evidence supports the role of restoring labral anatomy and architecture in reestablishing a more stable hip joint [6, 7].

An important question within hip preservation is what impact does arthroscopic labral repair and treatment of associated bony pathology have on the health of the articular cartilage. Two studies thus far have evaluated the change of cartilage biochemistry at 1-year and 2-year follow-ups [8, 9•]. Unfortunately these studies have conflicting results. Both varied their treatments for femoroacetabular impingement (FAI) with surgical hip dislocation and arthroscopy and more importantly different methods of measuring cartilage biochemistry. In their 1-year follow-up study, Schmaranzer et al. found that the dGEMERIC indices were actually lower after surgical management when compared with a non-operative cohort of FAI patients [8]. Conflictingly, Beaulé et al. showed significantly decreased T_1 rho relaxation times at 2-year follow-up which nearly approximates that of a "normal" hip. In addition, they found decrease bone mineral density of the subchondral bone at the anterosuperior acetabular rim at 2-year follow-up [9•]. And while variance in pre-operative cartilage imaging has been shown to be predictive of outcomes, it appears that the jury is still out on the effectiveness of surgical intervention to alter the biochemistry and subchondral bone density and will require long-term data [10].

Evaluation and Diagnosis

The hip is a complex unit of static and dynamic stabilizers and is a key link between the axial and appendicular skeleton. Thus, "hip pain" and more specifically labral tears can have various and sometimes multiple etiologies such as trauma, osteoarthritis, instability, and most commonly femoroacetabular impingement syndrome (FAIS). It is important to determine the underlying cause of the labral tear as it will dictate the appropriate treatment of the underlying etiology. A multifaceted approach is utilized beginning with basic imaging and a detailed history and physical exam.

Physical Exam

A comprehensive physical exam of the hip is important to determine the possible etiology of hip pain and the labral tear [11]. Labral tears can result from one or more processes including femoroacetabular impingement, instability, degenerative joint disease, and trauma. One of the more difficult pathologies to assess is instability and the physical exam can help identify the role of instability in the pathology of the labral tear [12]. Many patients can have normal to increased range of motion of the hip but may be painful either in the groin or laterally. The FABER position can provide useful information through the presence of anterior pain with the knee close to the table. The log-roll test has been suggested to evaluate the iliofemoral ligament competency but this test is influenced significantly by femoral version with femoral retro-torsion leading to false positives. Dynamic tests of instability include increased pain when walking with feet externally rotated. Rotation of the femur in both the prone position and 90° of flexion can provide information about femoral and acetabular version respectively.

Imaging

AP pelvis, false profile, and Dunn lateral are obtained to assess for femoral head undercoverage (dysplasia) and overcoverage (pincer lesion, coxa profunda, acetabular protrusio) and CAM morphology [13]. It is important to identify those individuals that lack bony stability or have pre-existing degenerative joint disease [14]. Magnetic resonance imaging (MRI) offers visualization and characterization of the labral tear. While MRI arthrogram is the gold standard, the arthrogram generates additional morbidity and cost. Thus, we prefer high-resolution (3 T) non-contrast MRI. In addition to identifying and characterizing the labral tear, the MRI can identify associated or alternative pathology such as gluteal tendinopathy, ischiofemoral impingement, stress fractures, hamstring tendinopathy, or neoplasms. Computed tomography (CT) scans offer the advantage of three-dimensional imaging of the bony morphology of FAI. This becomes a useful tool with both pre-operative planning and intra-operative bone resection. Additionally, with MRI and CT scan both acetabular version and femoral torsion can be measured if additional imaging is obtained through the distal femur. Newer CT protocols have been shown to further reduce the radiation exposure in those patients undergoing hip preservation procedures [15•]. Measuring and synthesizing all of these factors are time consuming and complicated. Software that produces advanced analysis of hip morphology is emerging to facilitate this part of the evaluation (Fig. 1).

Diagnostic Injections

If the etiology of hip pain is unclear, a diagnostic intra-articular injection is first line to determine if the source of the patients' symptoms is their hip joint. It has been demonstrated that diagnostic hip injections are both sensitive and specific when differentiating hip pain from extra-articular, intra-articular, and spinal etiologies [16]. Diagnostic hip injections are more cost-effective than advanced imaging and could possibly predict a poorer outcome in a patient with a negative response to injection. We recommend performing the injection in the clinic setting under ultrasound guidance with a pre- and post-injection exam to maximize diagnostic value [17, 18].

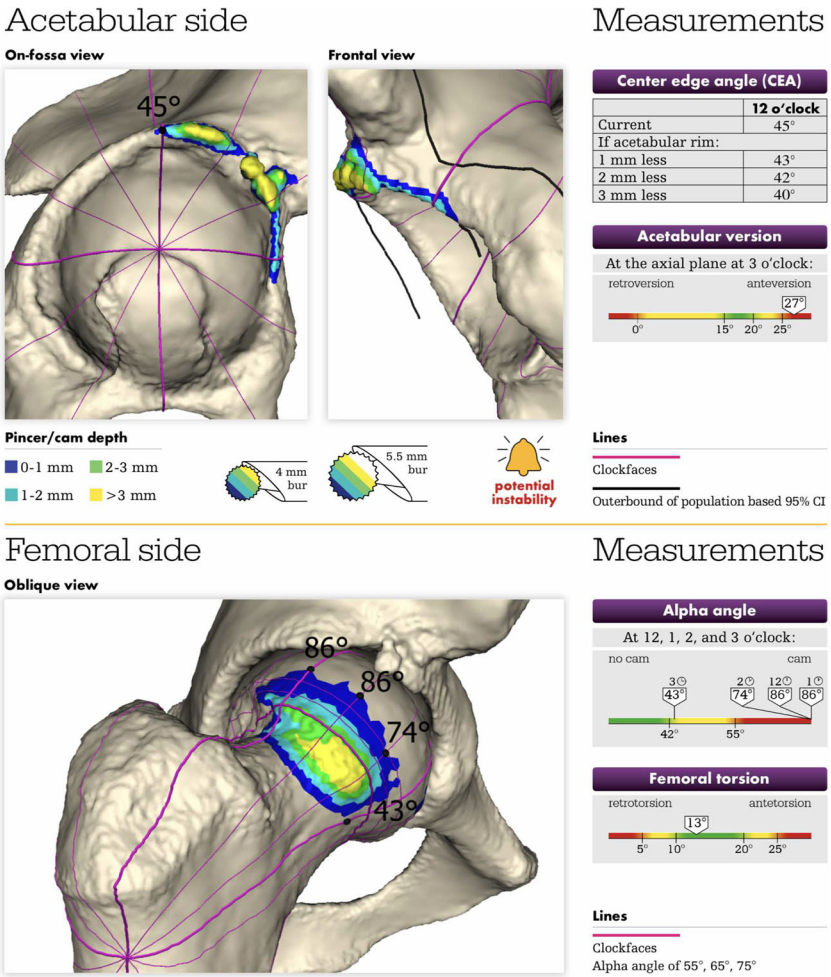

Fig. 1 CT Hip Map of a right hip with color map overlay demonstrating both pincer and CAM impingement. Acetabular version and femoral torsion also depicted

Non-operative Treatment

If the plain films and physical exam highly correlate with the likely diagnosis of FAIS and labral tearing, then an intra-articular injection is considered for therapeutic reasons, as this can assist with pain control and advancement of physical therapy. Once the diagnosis is established, a trial of non-operative management with NSAIDs and focused physical therapy is attempted for 4 to 6 weeks. There are limited downside and risk to this approach as it can also serve as pre-habilitation prior to arthroscopy [19]. While physical therapy has its role in FAIS and patients do demonstrate improvement in their symptoms, it has been shown with randomized controlled trials that arthroscopic management of FAI can exceed the minimum clinically significant difference when compared with physiotherapy [20••, 21••]. At this time, there is limited evidence to support the routine use of platelet-rich plasma or hyaluronic acid in the hip joint for FAIS. If the patient fails non-operative management or would like to proceed with operative management, advanced imaging is obtained at that time for pre-operative planning.

Operative Management

Arthroscopic management can be considered if consistent with the patient's goals and risk-benefit framework. Early in the history of hip arthroscopy, most patients were treated with labral debridement only, while today the vast majority of patients, if diagnosed and treated early will have labral tissue that can be repaired primarily. However, partial or complete labral reconstruction or augmentation techniques have recently been developed as treatment options for irreparable tears and specific subgroups.

Debridement

In the early development of hip arthroscopy, most labral lesions were treated with selective debridement. The goal of debridement is to relieve a moderate amount of pain and return a patient to their activities of daily living while ensuring joint stability. Byrd and Jones published their 10-year results of labral debridement in 26 patients. They showed a median Harris Hip Score (HHS) improvement of 29 points (mean

post-operative score of 81). However, 88% of patients with arthritis progressed to total hip arthroplasty [22]. There has been a trend to additionally treat bony impingement with resection of CAM and pincer lesions, along with labral repair when possible. Krych et al. published the first prospective study on female patients undergoing hip arthroscopy that were randomized to either labral debridement or repair. At minimum 1-year follow-up, the post-operative hip outcome score activities of daily living (HOS-ADL) were significantly higher in the repair group versus the debridement group (mean 91.2 vs 80.9) [23•]. Additionally, Larson et al. reported their 3.5-year follow-up of patients treated with labral repair versus debridement. The repair group had significantly higher post-operative HHS and short form-12 (SF-12). When comparing overall change, the repair group had a significantly greater increase in both measures [24]. More recently Menge et al. reported their 10-year outcomes of labral debridement versus repair. After controlling for factors related to increased hazard ratio for failure (increased age, microfracture, and joint space ≤ 2 mm), they demonstrated no difference in modified Harris Hip Score (mHHS), HOS-ADL, or HOS-Sport score between debridement and repair groups (mHHS 90 vs 85; HOS-ADL 96 vs 96; HHS-Sport score 89 vs 87). A higher rate of conversion to total hip arthroplasty was found in older patients, those with acetabular microfracture and hips with joint space ≤ 2 mm [25••].

Each study must be taken in context when applied to today's "contemporary hip arthroscopy". Byrd et al. did not address bony impingement and employed labral debridement for all patients and had a broad range of ages (17–84). As well 9/16 had full thickness cartilage damage; despite this, they showed a mean 29-point increase in HHS [22]. Krych et al. found better results with labral repair in their randomized study, but their debridement cohort did improve their mean HOS-Sport (25.3) and HOS-ADL (20.3) [23•]. This effect was also demonstrated in the Larson et al. study, which was not randomized but perhaps had inclusion bias with the debridement cohort comprised of patients treated earlier in the surgeon's career compared with the repair cohort [24]. The most recent study by Menge et al. perhaps provides the best long-term data regarding outcomes of repair versus selective debridement, with debridement being reserved for more pathologic labra that were not amenable to repair. Following careful selection and controlling for risk factors for failure, comparable results were shown for repair versus debridement [25••].

Ultimately, level I studies best control for bias and confounding factors and thus the senior author favors primary repair whenever possible based on this study. Currently the senior author will reserve selective labral debridement for patients that are perhaps older, have low radiographic or clinical risk of instability, and are low demand (Fig. 2). In the rare patient that has higher-grade osteoarthritis, selective debridement may also be performed with the knowledge that there is a greater risk of arthroplasty in the near future.

Repair

In the treatment paradigm of labral tears, arthroscopic labral repair has emerged as the leading treatment option for most tears regardless of etiology. The technique of labral repair has variations of a similar theme. In general, the acetabular rim is prepared with a burr in order to expose a bleeding bone bed to assist with healing of the labrum to bone; additional bone may be removed from the acetabular rim if there is reactive bone or evidence of pincer impingement. There is a deluge of anchors that allows a surgeon to select which anchor design and material fit their needs to restabilize the labral base and restore the hip suction seal. It had been debatable whether it mattered to perform a mattress or looped stitch though recently it has been demonstrated that a mattress stitch better restores normal joint pressures and distractibility versus a looped stitch [6, 7, 26].

Excellent short-term outcomes have been described in athletes with return to sport for recreational and high school or college athletes being 94% and 88% respectively [27]. Additionally there is high rate of return to sport for professional baseball, football, and basketball players [28–30]. Even in workers' compensation patients, nearly 70% are able to return to work without restrictions and demonstrated similar magnitude of improvement in outcome scores to a control cohort [31]. However, there is a paucity of data describing the long-term outcomes of labral repair. Menge et al. demonstrated that the results of hip arthroscopy are durable at a mean 10 years if patients have more than 2 mm of joint space remaining and did not require acetabular microfracture. They also demonstrated that patients older than 31 years of age are at increased risk of conversion to total hip arthroplasty [25••]. Recently the outcomes in patients older than 50 and 60 have been shown to significantly improve at a mean of 22 and 26 months respectively. Importantly, both studies excluded patients with Tönnis grade ≥ 2 and had 100% and 88% survival rates [32, 33].

Authors Preferred Technique

The vast majority of patients in the primary setting will undergo a labral repair (Fig. 3a), as indications for debridement, augmentation, or reconstruction are relatively small compared with that of repair (Fig. 2). Standard anterolateral (AL) and mid-anterior (MA) arthroscopy portals are utilized. Capsular suspension sutures are used to elevate the capsule and help delineate the capsulolabral junction. A radiofrequency ablator is used to elevate the capsule from the bony acetabular rim. Using pre-operative imaging and intra-operative fluoroscopy, a rim resection is performed if needed; otherwise, the rim is minimally burred to produce a bleeding bone bed for labral healing. Sutures are passed from either the MA or the AL portals in a mattress fashion started anteriorly and continuing posteriorly spaced approximately 7–10 mm apart. A distal

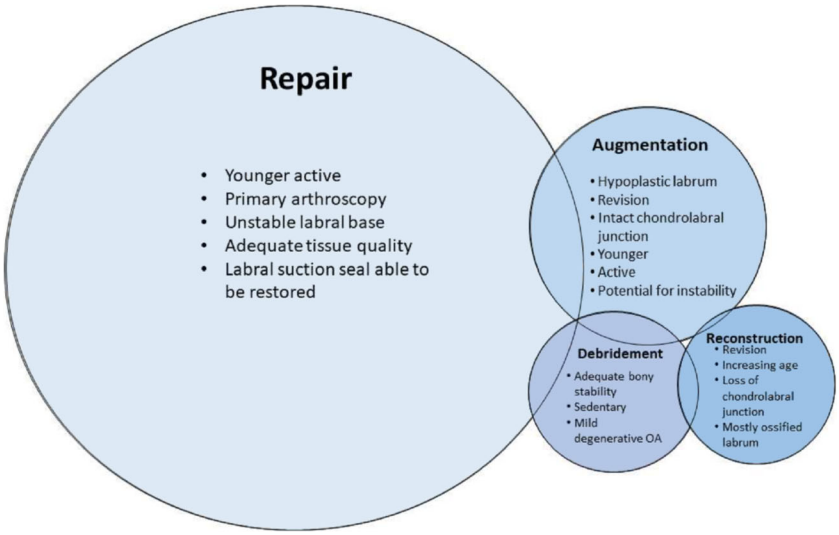

Fig. 2 Decision bubble. Pre-operative and intra-operative decision-making for surgical management of labral pathology can be complex and many times indications overlap and are dependent on surgeon skill and experience. Linear decision algorithms do not capture the interaction of multiple variables and may underestimate the complexity of decision-making. This figure best captures our decision-making approach illustrating treatment of labral pathology as overlapping circles or bubbles; the largest of which is labral repair. This is the recommended treatment for most patients presenting for hip arthroscopy in the primary setting. Rarely would a debridement, augmentation, or reconstruction need to be undertaken in the primary setting. While if a surgeon is willing to take on revision hip arthroscopy, augmentation and reconstruction are tools necessary to treat patients that require restoration of a labral seal and who are at risk for instability without a labrum. The criterion for reconstruction is narrower than augmentation and the indications for reconstruction do not overlap those of repair and should be considered substitutive of repair. Labral debridement in our opinion is reserved for a select group of patients that are low demand, have adequate bony stability, and perhaps have mild degenerative changes and/or would be at risk for not healing/incorporating a labral graft

anterolateral accessory (DALA) portal is established for drilling and anchor placement. We prefer an anchor that allows tensioning of both limbs of the suture as to prevent excessive eversion of the labral edge.

Reconstruction and Augmentation

First described by Philippon et al. in 2010, arthroscopic labral reconstruction has become an essential tool in the armamentarium of the more experienced hip arthroscopist [34]. While they described using fascia lata autograft, additional techniques have been described using various autografts and allografts [35–37]. Both segmental and circumferential techniques have been described with good to excellent outcomes, approaching those of a primary repair in the setting of more severe labral deficiency [38, 39•, 40, 41]. However, in a cadaveric hip model, it has been shown that labral repair more effectively restores the hip joint fluid seal compared with reconstruction [42]. While there has been great success with labral reconstruction, the appropriate indications remain a topic of debate [39•]. Rarely is a circumferential reconstruction necessary in a primary setting but possible in a revision situation with large amounts of capsulolabral adhesions. If there is an intact chondral labral junction, then we prefer a labral

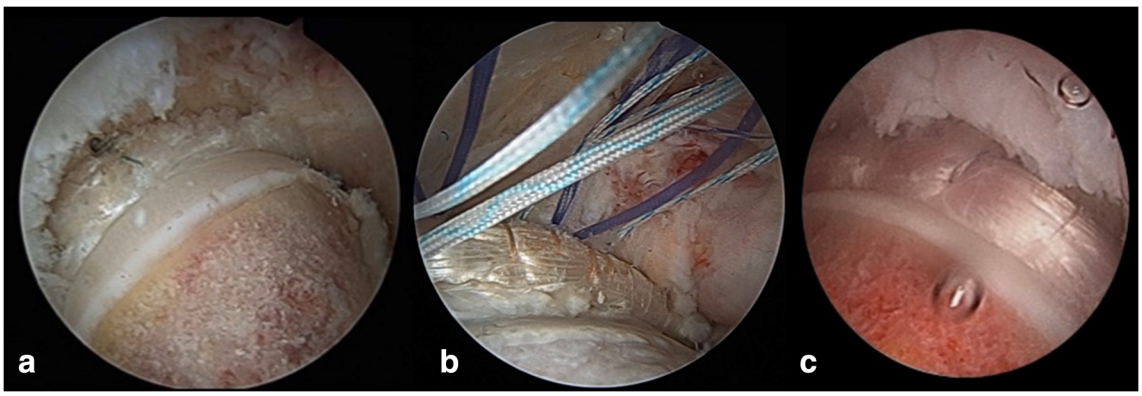

Fig. 3 Labral repair (**a**), labral augmentation (**b**), and autograft labral reconstruction (**c**)

augmentation utilizing tensor fascia lata allograft over labral reconstruction [43]. Philippon et al. recently compared labral augmentation (LA) with labral reconstruction (LR) with a significantly higher percentage of patients reaching the minimum clinically important difference for HOS-ADL and HOS-Sport in the augmentation group. However, both groups had similar rates of revision (LA—18%, LR—14%) and conversion to THA (LA—3%, LR—4.5%) [44].

Authors Preferred Technique

If repair is not possible or Labral tissue is inadequate and the patient factors and goals suggest an intact labrum is necessary to achieve an excellent outcome, we favor augmentation (Fig. 3b) whenever possible over reconstruction. This decision is influenced by the substantial difference in outcome between labral reconstruction and augmentation as well as the importance of the native labrum in proprioception and neuroendocrine function [44]. Thus, we prefer to keep the chondral labral junction and circumferential fibers of the labrum intact if possible. Labral reconstruction (Fig. 3c) is reserved for relatively young patients in a revision setting with deficient or incompetent labral tissue where repair is not possible and there is disruption of the chondral labral junction (Fig. 2). The senior author does not utilize primary labral reconstruction except in cases of complete labral ossification in a young, active patient with minimal degenerative disease.

Maximizing Outcomes

The learning curve for the arthroscopic treatment of hip labral pathology can be very demanding [45•]. Hip arthroscopy is made difficult by limited residency training in hip preservation, the use of a 70° arthroscopic lens, and the complexity of hip pathology [46]. Those surgeons wishing to treat labral lesions should do so with care and caution. Failures and revisions occur for various reasons: capsulolabral adhesions, poor post-op therapy, unrecognized excessive femoral torsion, unrecognized acetabular dysplasia, inadequate restoration of capsule integrity, and most commonly under-resection of CAM or pincer deformity [47, 48]. While adhesions are difficult to control, we believe that capsular repair helps avoid higher incidence of adhesions. Additional pharmacological adjuncts are being investigated as well [49]. Careful evaluation both clinically and radiographically can avoid missteps in the dysplastic patient as well as version studies when warranted. And while good to excellent results are achievable in patients that undergo femoral osteotomy for excessive torsion, it is unknown which patients are appropriate for osteotomy [50]. Utilizing modern surgical techniques focusing on appropriate labral treatment and capsular management, Nho et al. reported a low overall failure rate at 2 years post-operatively [51•].

Capsular Management

Perhaps one of the most overlooked aspects of labral repair is appropriate capsular management. The majority of hip arthroscopists are utilizing a standard hip distraction technique which incorporates some amount of capsular disruption via an interportal capsulotomy, an “outside-in” technique or more minimally invasive [52–54]. Conversion of an interportal capsulotomy to a T-capsulotomy is surgeon dependent but can increase ease of viewing and subjectively ease of femoral osteochondroplasty. It has been our experience that performing a T-capsulotomy can allow for a more modest interportal capsulotomy which can result in increased inherent stability by preserving more of the iliofemoral ligament [55]. Much focus has been placed on the management of the hip joint capsule including whether or not to repair, as well as capsular plication in individuals at risk for instability. A recent biomechanical study demonstrated the importance of capsular closure in restoring the rotational profile of the hip back to its native condition [56]. Kraeutler et al. performed a double-blinded randomized controlled trial to compare repaired and unrepaired capsulotomy patients via MRI. While a significant difference was found in the rate of healing at 6 weeks, favoring repaired capsules (43.4% vs 15.4%), at 24 weeks, there was no significant difference found in MRI evidence of capsular healing between the two groups [57]. However, clinical significance may be more apparent and vastly more important. Domb et al. in a 5-year matched cohort study found deterioration of mHHS and increased conversion to total hip arthroplasty in unrepaired patients compared with patients where the hip capsule was repaired [58]. Recently Bolia et al. demonstrated in a matched cohort study of capsule repair versus a non-repaired group a greater percentage of patients reaching minimal clinically importance difference in the repaired group. And perhaps most staggering, the non-repair group was 6.8 times more likely to undergo total hip arthroplasty [59••].

Authors Preferred Technique

We believe that the capsular repair begins with the initial capsulotomy, taking care to not make multiple passes through the capsule with the capsulotomy knife and keeping the capsulotomy modest to preserve as much iliofemoral ligament as possible. Additionally, we minimize our use of radiofrequency and arthroscopic shaver against the capsule. Use of capsular suspension sutures will allow for more visibility, protect the capsule from damage, and minimize the need for an extensive capsulotomy [60]. Not only has it been shown to restore more normal hip motion and stability we believe that by repairing the hip capsule it decreases the incidence of

capsulolabral adhesions by suspending the capsular tissue above the labrum. We therefore repair capsule in all hip arthroscopy patients. In select patients such as those with borderline hip dysplasia or ligamentous laxity, we will additionally plicate the capsule. We have also evolved into utilizing a figure of eight technique for all of our capsular stitches [61]. For those patients who have failed capsular repair or have thin anteromedial capsule, we will place an anchor in the anterior subspine region to reinforce the capsular repair. In patients with large capsular defects or multiple capsular repair failures, we consider capsular reconstruction with a 3–5-mm dermal allograft.

Conclusion

The past decade has brought a renaissance to hip arthroscopy with thousands of publications of new techniques and long-term outcomes. Of great interest is the growing number of randomized control trials and large multi-center studies [20, 21••, 23•]. It should be the goal of any surgeon to hopefully restore function and allow a patient to resume activities of daily living. Many patients with labral tears anticipate return to higher levels of activity such as sports, dancing, and/or vigorous exercise. Every arthroscopist should make extreme effort to preserve and restore normal anatomy. An overarching goal while performing hip arthroscopy should be to restore the labral suction seal and normal hip distractibility. We believe this can be accomplished with a "contemporary hip arthroscopy" that is centered around favoring labral repair over debridement, preserving the chondral labral junction, to perform a labral augmentation over reconstruction if possible, and avoiding overuse of labral reconstruction. A significant effort is made to preserve as much capsular tissue as possible via minimal capsulotomies and capsular suspension sutures. And while it may comprise a third of the overall procedural time, careful capsular management and preservation with closure should be carried out on every individual with plication reserved for patients with or at risk for instability. In rare cases of thin capsule, additional anchors into the subspine region can be used to ensure capsular stability and healing.

Compliance with Ethical Standards

Conflict of Interest Dustin Woyski declares that he has no conflicts of interest.

Richard Mather is a Board or committee member for Arthroscopy Association of North America and the North Carolina Orthopaedic Association, is a paid consultant for Stryker and KNG Health Consulting, and has received research supports from Zimmer and Reflexion Health.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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