Arthroscopic acetabular labral reconstruction: a review

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ABSTRACT

The function and importance of the acetabular labrum in hip biomechanics have been determined. A labral tear is one of the most common findings in the hip preservation field, commonly associated with femoroacetabular impingement (FAI) syndrome. It has been established that the restoration of labral anatomy and function are key factors to improve patient-reported outcome measurements (PROMs) and psychometric tools following arthroscopic hip arthroscopy in the context of FAI syndrome. Labral repair or refixation is currently the gold-standard surgical option when facing labral tears, with clinical mid to long-term data supporting its use. Labral selective debridement has proven to be a valid alternative in selective patients. Acetabular labral reconstruction has risen as an alternative to labral excision or resection when repair is not an option due to labral tissue deficiency. Restoring the labral sealing mechanism is the goal behind the acetabular labral reconstruction. It has been proven that labral reconstruction leads to superior PROMs when compared with resection. This review presents an analysis of the indications, techniques, and outcomes for arthroscopic acetabular labral reconstruction.

INTRODUCTION

Hip arthroscopy is a unique field, characterized by an exponential evolution in concepts, understanding, surgical techniques and technology [1]. In the last decade, there has been a tremendous advance in the arthroscopic management of femoroacetabular impingement (FAI) syndrome and labral tears [2–4], with exponential improvements in surgical techniques [5]. Meticulous bone-morphology correction [6, 7], appropriate capsular management involving preservation and closure [8, 9] and labral function restoration are among the most meaningful advances in modern contemporary hip preservation arthroscopic surgery [10, 11].

While labral preservation with repair is the gold-standard treatment for labral tears [3, 12–14], labral selective debridement has yielded favorable outcomes in some earlier hip arthroscopy series for FAI syndrome [10, 15–18]. Selective debridement is defined as excision of only peripheral labral tearing that, when performed, will not compromise the labral sealing mechanism [19]. To accomplish this, the labrum must be of functional size after selective debridement and stable at its chondrolabral junction [17, 20]. Differently, labral excision or resection implies complete debridement of the labral tissue with entire loss of suction sealing mechanism [21]. With tool modernization, labral reconstruction has become a reproducible option for irreparable labral acetabular tears or insufficient labral tissue, Fig. 1 [22–24]. Superior patient-reported outcome measurements (PROMs) have been reported following arthroscopic labral reconstruction compared to labral resection for patients with irreparable labra [22]. Two alternatives for labral reconstruction have been described [25]. The first alternative is the segmental labral reconstruction, for which most available data have reported favorable © The Author(s) 2021. Published by Oxford University Press. This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/4.0/), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact journals.permissions@oup.com
PROMs for short and long-term follow-up [24, 26–29]. Second, arthroscopic circumferential labral reconstruction has been recently advocated [20, 30, 31], as good to excellent results have been reported at short-term follow-up [32–37]. This review presents an analysis of the indications, options and outcomes for arthroscopic acetabular labral reconstruction.

INDICATIONS

In the hip preservation setting, irreparable and non-viable labral tears have been suggested as the main indicators for labral reconstruction, a situation that mostly manifests in revision cases (Fig. 1). Herickhoff and Safran [38] reported that the intraoperative appearance of the labrum is the single most important factor for labral treatment decisions. Trivedi et al. [29] systematically reviewed the indications for labral reconstruction and concluded that the most common indication was a ‘deficient labrum’ on intraoperative evaluation. A hypotrophic labrum (<2 mm) or a dysfunctional hypertrophic labrum (>8 mm) has also been considered [39]. Wolff and Grossman [20] listed the following as intraoperative findings of an irreparable labral tear and therefore indications for labral reconstruction:

1. Insufficient labral tissue: defined as <2 mm. In this situation, the labrum lacks the surface area to heal and labral repair may not create a sufficient fluid.
2. Labral defect.
3. Severe labral intrasubstance damage.
4. Labral calcification.

Using a multivariate analysis, we identified radiographic and demographic preoperative factors and proposed a predictor model for labral arthroscopic reconstruction. This can be useful to surgeons in the early stages of the learning curve to anticipate the need for this complex procedure [40]. This study analyzed 18 variables in a cohort of 1398 primary hip arthroscopies (251 primary reconstructions and 1147 primary repairs) and found that the odds of labral reconstruction were 2.52 times higher in patients with Toennis grade 1 than 0. Each additional degree in the lateral center-edge angle was associated with a 6% increase in the odds of reconstruction and 4% for each additional degree in the alpha angle. Higher age and body mass index also increased the likelihood of reconstruction by 11.29 and 1.03, respectively. Nakashima et al. [41] concluded that age ≥45 years, body mass index ≥23.1 and vertical center anterior angle ≥36° were risk factors for an irreparable labral tear at primary hip arthroscopic surgery for patients with FAI syndrome.

PRIMARY LABRAL RECONSTRUCTION

Labral repair is currently the gold-standard surgical treatment to address labral tears [3, 42]. According to the American Board of Orthopaedic Surgery, nearly 80% of hip arthroscopy procedures include a labral repair [43]. Labral reconstruction can be a useful resource for the irreparable labral tear in the primary setting, but we do not advocate for primary labral reconstruction beyond the specific aforementioned indications [10, 25, 44]. Although systematic primary labral reconstruction has been proposed [45], there is not sufficient data to support this approach.

As we previously reported, primary labral reconstruction reaches PROMs comparable to a benchmark labral repair control group at a minimum 5-year follow-up but has lower patient satisfaction at the latest follow-up. Factors such as cost, operative time and potential complications related to extended hip traction time must be taken into consideration when deciding between labral repair and reconstruction. Additionally, the average number of anchors required for a circumferential labral reconstruction is considerably higher than for a labral repair [45, 46]. While progression along the learning curve of hip arthroscopy leads to reduced complication rates, surgical and traction time [5], and reoperation rates [47], even on experienced hands, it has been reported that the traction time and the total operative time are significantly higher when performing...
labral reconstruction compared to labral repair (94.4 ± 22.0 versus 60.2 ± 16.4 min, \(P < 0.001\); 132.1 ± 20.6 versus 95.1 ± 18.5, \(P < 0.001\), respectively) [32].

LABRAL RECONSTRUCTION IN THE REVISION SETTING

Shapira et al. [48] reported that labral re-tear is the most common cause for revision hip arthroscopy followed by residual bony morphology. Interestingly, labral reconstruction is the most common procedure to address labral pathology in the revision setting. Labral repair is still performed in revision surgery, but the probability of facing irreparable labra seems to be higher. Failed hip arthroscopy is a multifactorial problem that can include capsular insufficiency and adhesions [9], inaccurate bony morphology correction [7] or cartilage damage [49, 50]. As such, clinicians must recognize and understand all of these potentially related pathologies and determine a comprehensive approach that may require surgical procedures beyond labral reconstruction [51]. Makhni et al. [52] reached a similar conclusion and proposed a stepwise algorithm for the management of pain and disability in failed primary hip arthroscopy. They suggested that if the symptoms were similar to those preoperatively, the patient most likely had an incomplete resection of the cam-type or pincer-type morphologies. It has been reported that patients requiring revision hip arthroscopy are 2.6 times more likely to fail with re-repair than with labral reconstruction [53]. The senior author of the current review concluded that labral reconstruction for segmental defects was a strong predictor of improvement for PROMs in revision surgery [54].

AUTOGRAPH VERSUS ALLOGRAFT

The use of an autograft and allograft has been described for labral reconstruction [55]. There are multiple options: iliobibial band autograft/allograft, hamstring tendon autograft/allograft, indirect head of rectus femoris autograft, peroneus brevis tendon allograft, labrum allograft, posterior and anterior tibialis tendon allograft [25, 39, 55]. The factors that determine graft choice include patient and surgeon preference, surgeon experience, operative time, morbidity and cost [28]. No significant differences in outcomes have been found based on graft type alone. We reported comparable clinical outcomes for labral reconstruction with both graft alternatives; however, in our series, patient satisfaction was higher in the allograft group due to the avoidance of donor site morbidity [56]. Our current preference is the anterior or posterior tibialis tendon allograft because of its length, shape and width [32]. Nevertheless, there are limitations related to the allograft use, including the high-cost and the allograft availability. Based upon the operative room cost per minute, allograft use would reduce costs by hundreds or thousands of dollars due to shorter operative times. However, allograft tissue alone can cost between $1392 and $1417 on average which could offset the savings from decreased operative room time [28]. These are important variables to include in the progress of graft selection [56, 57].

SEGMENTAL AND CIRCUMFERENTIAL LABRAL RECONSTRUCTION

With segmental labral reconstruction, only the irreparable ‘segment’ is reconstructed therefore the remaining healthy labrum is preserved (Fig. 2). The superiority of one alternative over the other has not been proven yet. Proponents of the segmental technique argue that healthy labra native tissue can be unnecessarily sacrificed. Additionally, most of the available outcomes data on reconstruction, even in the long-term follow-up, comes from the segmental alternative [26, 27]. In the circumferential or total labral reconstruction, the whole native labrum is taken down and reconstructed with the graft (Fig. 3). Advocators of the circumferential labral reconstruction state that segmental reconstruction may result in incomplete removal of damaged native labral tissue, which may then act as a pain generator [58]. This scenario can be particularly true in the revision setting with labral re-tearing in patients who underwent prior repair or debridement since labral tissue can be even further compromised [20]. Nonetheless, the evidence is scarce regarding the effect of the alternative labral reconstruction techniques on PROMs and secondary surgeries. We recently performed a systematic review on this matter and found, most notably, that favorable outcomes were reported at short-term follow-up regardless of
the reconstruction technique used (manuscript accepted for publication).

Through analysis of the senior author’s database, we found patients who underwent primary hip arthroscopy for either circumferential or segmental labral reconstruction in the context of irreparable labra and FAI syndrome. Forty-seven hips (46 patients) who underwent circumferential labral reconstruction were compared to a propensity-matched segmental labral reconstruction group of 47 hips (46 patients). At the minimum 2-year follow-up, both groups achieved significant and comparable improvement for the modified Harris Hip Score, Non-Arthritic Hip Score, Hip Outcome Score-Sports Specific Subscale and the International Hip Outcome Tool 12 and rates of secondary surgeries. Moreover, no differences were found between groups for the achievement of the minimal clinically important difference (MCID) and the patient acceptable symptomatic state (PASS). Based on these results, we concluded that a customized approach, using the extent of the irreparable labral tear, should be utilized to determine whether circumferential or segmental primary labral reconstruction is performed. Both, circumferential and segmental labral reconstruction are useful surgical techniques in hip preservation, and the choice between the two depends on the extent of labral pathology in the individual case.

LABRAL AUGMENTATION

Not all irreparable labral tears share the same characteristics or intraoperative findings. In some scenarios, the inner circumferential labral fibers are well preserved and identifiable arthroscopically, Fig. 4. In such cases, adding a graft reinforcement via tissue augmentation is suitable to preserve those fibers and the chondrolabral junction, Fig. 5 [59–61]. A hypoplastic labrum may also warrant an augmentation, in which case the diminutive native labrum would similarly be reinforced by the graft tissue [59, 61].
Philippon et al. [61] reported favorable short-term PROMs using labral augmentation. Further, they compared patients who underwent labral augmentation versus reconstruction by matching 33 labral augmentations in a 1:2 ratio to labral reconstruction. The authors found higher PROMs in the labral augmentation group with comparable secondary surgery rates.

Al Mana et al. [39] reported mid-term follow-up on patients who underwent labral reconstruction through open, mini-open, and arthroscopic techniques. The authors included 9 studies with a total of 234 patients and concluded that labral reconstruction with autograft or allograft showed short and mid-term improvement in functional scores and PROMs. Rahl et al. [28] performed another systematic review with 537 hips and concluded that arthroscopic hip labral reconstruction results in clinically significant improvements in PROMs with a mean follow-up of 29 months. At mid-term follow-up, we found durable and improved PROMs at a minimum 5-year follow-up. Moreover, 65% of patients achieved PASS for the modified Harris Hip Scores, and 70% achieved PASS for the Hip Outcome Score–Sports Specific Subscale. Philippon et al. [27] concluded that segmental labral reconstruction with an iliobial band autograft yield excellent results and high patient satisfaction at 10-year follow-up. Labral reconstruction, even in the context of severe chondral damage, has shown favorable results. In the setting of primary arthroscopic for FAI syndrome, irreparable labral tears and acetabular chondral lesions of Outerbridge III/IV, two groups of matched patients who underwent labral reconstruction versus labral resection were compared. Although both groups experienced a significant and comparable improvement in PROMs at a minimum 2-year follow-up, the relative risk and rate to total hip arthroplasty conversion were significantly higher in the resection group. Patients who

**Fig. 5.** Intraoperative arthroscopic left hip image with the same patient in the supine position and under traction is shown. The native labrum (L) is reinforced with a graft (*). The overlapping between graft and L is marked by the black arrow. A, acetabulum; F, femoral head.

**Fig. 6.** Algorithm for the arthroscopic management of labral tear. CLJ, chondrolabral junction. *Circumferential intrasubstance tearing, and/or calcification, and/or circumferential prior debridement/resection.
underwent labral reconstruction were four times less likely to convert to total hip arthroplasty [44].

**AUTHORS’ ALGORITHM FOR LABRAL TEAR RESTORATION**

The decision to proceed with a labral reconstruction is made by the authors intraoperatively. Labral reconstruction is performed when the labral tissue is considered non-viable or irreparable [25]. An irreparable labrum is characterized by severe or complete calcification or non-viable tissue that is not amenable for repair [26, 41, 62]. In the primary or revision setting, the segmental reconstruction option is used for segmental defects [26, 27]. On the other hand, the circumferential option is selected for complete labral intrasubstance tearing, complete labral calcification and previously complete labral resection [26, 32].

Labral augmentation is our current preferred choice for labral restoration when facing an irreparable labral tear with preserved inner circumferential labral fibers [60]. This also applies to diminutive labra that do not ensure...
labral suction seal restoration with labral repair [63]. The author's labral restoration algorithm is presented in Fig. 6.

Fig. 9. All the images corresponds to the left hip of the same patient after circumferential labral reconstruction (R) using allograft and the knotless pull-through technique. View was from the anterolateral (12 O'clock) portal with the 70° arthroscope. (A) Under traction, the most medial point of fixation of R, beyond the 3 O’clock position (*), can be noticed. (B) The arthroscope was moved laterally, the 12 O’clock position was marked (*). R from this perspective was recorded. (C) The most posterior point of fixation of R can be seen at the level of the 6 O’clock position (#). (D) Hip traction was released, and restoration of labral seal is noted, the 12 O’clock was marked (*). A, acetabulum; F, femoral head.

LABRAL RECONSTRUCTION TECHNIQUE

Labral reconstruction is highly technical and challenging; even an experienced hip arthroscopist can be considered a ‘novice labral reconstructionist’ [64]. The authors of the current investigation performed a labral reconstruction consensus among high-volume hip arthroscopic surgeons, and only 8.3% of them were categorized as a ‘very high-volume reconstructionist’ [25].

Several labral reconstruction techniques have been described, but the superiority of one over the other has not been established. Accurate acetabular measurement defect is a critical step. Ellman et al. [65] described the ‘kite’ technique, which offers a reproducible and accurate measurement of a segmental labral reconstruction graft, mitigating the risk of a graft-defect mismatch. Acetabular defect measurement using a superior capsular reconstruction guide has been proposed [66]. White and Herzog [31] described the ‘front to back’ technique, which requires measurement of the acetabular labral defect and an overestimation of graft length to prevent the graft from being too short.

The knotless pull-through technique was described by the senior author to overcome some of the challenges in arthroscopic acetabular labral reconstruction surgery, providing a reproducible and efficient procedure [30]. These advantages include the use of knotless suture-anchor technology and, most importantly, the elimination of length defect-graft mismatch. Although this technique was initially described for circumferential labral reconstruction, Fig. 7, it can be performed for segmental reconstruction and augmentation [63].
We perform hip arthroscopy in the modified supine position on a traction extension table without a perineal post. Four portals are used: anterolateral, modified mid-anterior, distal anterolateral accessory (DALA) and posterolateral [10, 22, 32]. Once an irreparable labral tear is identified, Fig. 8, a 6–7-mm single-stranded fresh-frozen anterior or posterior tibialis allografts are prepared [8, 55]. Graft length can be a concern, particularly for circumferential reconstruction. We prefer the abovementioned options because it provides the length necessary (>200 mm) for any labral restoration scenario. After acetalbar rim preparation, the appropriate number of knotless suture-anchors are placed from medial to posterolateral. The allograft is ‘pulled-through’ from the modified mid-anterior portal to the posterolateral portal and graft fixation begins in the same order that the suture-anchors were placed. The graft excess is amputated with radiofrequency, Fig. 9 [30].

CONCLUSION
Within the arthroscopic sports medicine field, hip arthroscopy represents a unique area characterized by an exponential evolution in concepts, understanding, surgical techniques, and technology. Although labral reconstruction is perhaps one of the most challenging procedures in hip arthroscopy, with the appropriate indications, it is a reasonable alternative to restore labral function when a labral repair is not possible, with supportive data from the short to long-term follow-up.

CONFLICT OF INTEREST STATEMENT
BGD reports grants and other from American Orthopedic Foundation, during the conduct of the study; personal fees from Adventist Hinsdale Hospital; personal fees and non-financial support from Amplitude; grants, personal fees and non-financial support from Arthrex; personal fees and non-financial support from DJO Global; grants from Kaufman Foundation; grants, personal fees, non-financial support from Medacta; grants, personal fees, non-financial support and other from Pacira Pharmaceuticals and Stryker; grants from Breg; personal fees from Orthomerica; grants, personal fees, non-financial support and other from Mako Surgical Corp; grants and non-financial support from Medwest Associates; grants from ATI Physical Therapy; grants, personal fees and non-financial support from St. Alexius Medical Center; grants from Ossur, outside the submitted work; In addition, BGD has a patent 8920497—Method and instrumentation for acetabular labrum reconstruction with royalties paid to Arthrex, a patent 8708941—Adjustable multi-component hip orthosis with royalties paid to Orthomerica and DJO Global, and a patent 9737292—Knotless suture anchors and methods of tissue repair with royalties paid to Arthrex and BGD is the Medical Director of Hip Preservation at St. Alexius Medical Center, the Clinical Instructor at the University of Illinois College of Medicine, a board member for the American Hip Institute Research Foundation, AANA Learning Center Committee, the Journal of Hip Preservation Surgery, the Journal of Arthroscopy; has had ownership interests in the American Hip Institute, Hinsdale Orthopedic Associates, Hinsdale Orthopedic Imaging, SCD#3, North Shore Surgical Suites and Munster Specialty Surgery Center. DRM reports non-financial support from Arthrex, non-financial support from Stryker, non-financial support from Smith & Nephew, non-financial support from Ossur, outside the submitted work; and DRM is an editorial board member of the Journal of Arthroscopy. RMG has nothing to disclose.

ETHICS APPROVAL
This study was performed in accordance with the ethical standards in the 1964 Declaration of Helsinki. This study was carried out in accordance with relevant regulations of the US Health Insurance Portability and Accountability Act (HIPAA). Details that might disclose the identity of the subjects under study have been omitted. This study was approved by the IRB. (IRB ID: 5276).

Data Availability
The data analyzed during the current study will be shared by the corresponding author upon reasonable request.

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