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Outcomes for Surgical Treatment of Femoroacetabular Impingement in Adults

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Abstract

Purpose of review To assess the outcomes of modern techniques for arthroscopic surgery in the treatment of femoroacetabular impingement.

Recent findings While initially approached by means of open surgical hip dislocation, recent literature has shown generally good outcomes of arthroscopic treatment for femoroacetabular impingement. Modern advances in hip arthroscopy technique and implants now allow for labral repair or reconstruction when indicated.

Summary Arthroscopic treatment of femoroacetabular impingement results in significant improvements in patient pain and function, with low complication rates and high patient satisfaction. A majority of improvements in these patients occur within 1 to 2 years post-operatively. Hip arthroscopy for femoroacetabular impingement yields the best results in patients without significant arthritis or hip dysplasia.

Keywords Femoroacetabular impingement · Hip impingement · Acetabular labrum · Hip arthroscopy · Hip labral repair

Introduction

Femoroacetabular impingement (FAI) involves dynamic mechanical abutment of the proximal femur and the anterolateral acetabulum, injuring the interposed labrocartilaginous structures. This concept was first described in a small case series published by Smith-Petersen in 1936, with patients treated by means of an open anterior acetabuloplasty [1]. Ganz refined our modern understanding of FAI complete with the definition and pathophysiologic impact of cam and pincer lesions, and advocated for its treatment with surgical hip dislocation to allow for open acetabuloplasty and femoroplasty, labral debridement, and reattachment [2]. As arthroscopic techniques improved, hip arthroscopy became more popular in the treatment of FAI, and saw an 18-fold increase in use among American Board of Orthopedic Surgery candidates from 2003 to 2009 [3]. Studies have generally shown similar outcomes with arthroscopic versus open treatment of femoroacetabular impingement, with the benefit of minimizing morbidity through avoidance of an open surgical hip dislocation [4•]. While physical therapy remains the recommended initial treatment for FAI, recent literature has demonstrated superior outcomes with surgical treatment as compared to conservative care. A 2018 randomized controlled trial of 348 patients with femoroacetabular impingement demonstrated significantly greater improvement in hip-related quality of life in patients undergoing hip arthroscopy as compared to personalized physical therapy [5•]. Similarly, a 2019 randomized controlled trial comparing physical therapy and activity modification to hip arthroscopy for symptomatic FAI in 222 patients demonstrated significantly improved functional outcome scores in the surgical group [6•]. A comprehensive understanding of clinical outcomes after surgery for FAI is thus paramount to effectively counseling patients and guiding appropriate care. Because most cases are now approached arthroscopically, this review will focus on the outcomes of FAI treated with hip arthroscopy.

This article is part of the Topical Collection on *Femoroacetabular impingement/labral tears*

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FAI Outcome Assessment Tools

Functional outcome scores assessed in FAI literature are unfortunately inconsistent, with authors choosing to use a variety of scores including modified Harris hip score (mHHS), non-arthritic hip scale (NAHS), Hip Outcome Score (HOS), Hip Disability and Osteoarthritis Outcome Score (HOOS), International Hip Outcome Tool (iHOT-33), Short Form 12 (SF-12), and Western Ontario McMaster Osteoarthritis Index (WOMAC) [7]. The most commonly cited scores include mHHS followed by HOS, NAHS, and pain on a VAS scale [7, 8, 9•]. The HOOS and iHOT-33 have psychometric properties favorable for use in the younger population undergoing hip arthroscopy, while the mHHS and HOS may prove less valuable in this patient population [10].

With these variety of scores, it becomes difficult to review existing literature and come to any overarching conclusions. The minimal clinically important difference (MCID), substantial clinical benefit (SCB), and patient acceptable symptomatic state (PASS) values help in providing some context for PROS improvements that are clinically significant. MCID represents the smallest change in outcome that the patient perceives as beneficial, and has been defined for the mHHS, iHOT-33, and the sport and activities of daily living (ADL) HOS subset scores as shown in Table 1 [11•]. SCB represents the threshold of change in outcome score that the patient perceives as considerable improvement from baseline, and has been defined for the same scores as MCID, shown in Table 1 [12•]. PASS refers to the functional score at which patients feel their symptomatic state is manageable, and unlike MCID and SCB is an absolute value, not a pre- to post-operative change in score [9•]. MCID, SCB, and PASS are most often reached within 1 year of hip arthroscopy for FAI [9•, 11•, 12•]. Given that MCID essentially represents the lowest bar while PASS represents the highest, MCID is unsurprisingly achieved in a higher percentage of patients post-operatively, and is met at an earlier time point than is PASS [9•]. PASS standards are met in a majority of hip arthroscopy patients with respect to mHHS, while HOS-ADL and HOS-Sport are much more difficult to achieve. Levy et al. reviewed 81 studies of primary hip arthroscopy (9317 hips) and found that the MCID was met for mHHS, HOS-Sport, and HOS-ADL in 97%, 93%, and 90% of study populations while PASS was met by 88%, 30%, and 25%, respectively [9•].

Table 1 MCID, SCB, and PASS values

	MCID	SCB	PASS
HOS-ADL	8.3	10	87
HOS-Sport	14.5	29.9	75
iHOT-33	12.1	24.5	N/A
mHHs	8.2	19.8	74

Overview: Outcomes of Hip Arthroscopy for FAI

Given its relative infancy, studies reporting long-term outcomes of arthroscopic FAI treatment are sparse, and at a maximum provide 10-year follow-up data [13, 14•, 15]. The first reported arthroscopic hip labral repair outcomes were published in 2009, so studies citing procedures prior to that year primarily represent labral debridement with or without correction of bony impingement sources [16]. Byrd et al. published one of the earliest reports of long-term follow-up with a series of 50 patients at minimum 10-year follow-up after arthroscopic labral debridement [15]. Patients overall saw significant improvement with mHHS improving 29 points from 52 to 81 [15]. Revision arthroscopy was required in 4% of patients, and 31% of patients ($n = 8$) underwent conversion to total hip arthroplasty (THA) at a mean of 62 months after arthroscopy. Similar arthroplasty conversion rates were noted in studies of 10-year follow-up after hip arthroscopy published by McCarthy and Phillipon, reporting THA conversion in 44.1% and 34.0%, respectively [13, 14•]. These studies were helpful in identifying factors predictive of conversion to THA after hip arthroscopy including increased age, femoral and acetabular Outerbridge grade III–IV lesions, and < 2 mm of joint space on pre-operative radiographs, which better defined appropriate indications for hip arthroscopy [13, 14•].

Manuscripts reporting 5-year outcomes more consistently reflect current techniques of labral repair with femoral and acetabular osteochondroplasty, providing better insight into the fate of hips undergoing modern hip arthroscopy [17•, 18, 19•, 20•, 21•, 22•]. Domb et al. reported on 64 hips with minimum 5-year follow-up after hip arthroscopy with labral repair, and saw significant improvements in all collected PROS (ΔmHHS 20.9, ΔNAHS 23.3, ΔHOS-Sport 29.4, ΔVAS −3.9) and high patient satisfaction (8.1 ± 2.0) [19•]. Hip joint survivorship in this study was 96.9% at 2 years and 90.6% at 5 years post-operatively, with revision arthroscopy required by 10.9% and 17.2% of patients at 2- and 5-year follow-up, respectively, and no conversion to THA [19•].

Studies with 1 to 2 years of follow-up are certainly most common, and while they may not fully capture the long-term impact of hip arthroscopy, a majority of improvements in patient-reported outcome scores (PROS) are seen within 1 year of hip arthroscopy [11•, 12•, 23•]. Flores et al. demonstrated that most improvement in PROS occurs within 3 months of hip arthroscopy for FAI, although significant improvements continue to occur in SF-12 physical component score, HOOS-Sport, and HOOS-quality of life subsets up to 2 years post-operatively [23•]. Return to sport after hip arthroscopy is reliably completed within 1 year of surgery and occurs in a majority patients, with reported rates ranging from 87% in professional American football players athletes to 94% in recreational athletes [24•, 25•, 26•]. Runners have a similarly high rate of return to running (94%), but report significantly reduced mileage as compared to pre-operatively, and do not return until a mean of 8.5 months post-operatively [27•].

Outcomes based on patient demographics

Age is classically the patient demographic most suspicious for correlation to poor outcomes after hip arthroscopy. Horner et al. supported this idea, reporting similar improvements in PROS but increased risk of total hip arthroplasty conversion after hip arthroscopy with increasing age, from 18.1% in patients over 40 years old to 23.1% in those over 50 years and 25.2% after 60 years of age [28•]. Studies standardizing for cartilage status, however, do not appear to uphold this trend. Capogna et al. reported on the outcomes after hip arthroscopy in 42 patients over the age of 60 with Tonnis grade 0 or 1 hips, and found THA conversion rate of only 7.1%, with improvements in mHHS exceeding MCID, SCB, and PASS at 2 years [29•].

Obese patients can expect significant short-term improvement in PROS after hip arthroscopy, but tend to have lower absolute scores both pre- and post-operatively as compared to normal weight patients [30•]. Obesity also creates a twofold risk of conversion to total hip arthroplasty, and 11 times the complication risk of normal weight patients [30•, 31].

The impact of patient sex on hip arthroscopy PROS is poorly studied, with conflicting reports of similar or inferior scores in females in the few studies that analyze sex as an independent variable [32•, 33•, 34, 35•, 36]. Indisputable, however, is the fact that need for revision hip arthroscopy is significantly higher in females [37–40]. The Academic Network of Conservative Hip Outcome Research (ANCHOR) group found that 71% of the 359 hips undergoing revision hip preservation surgery were female [40]. Similarly, Ricciardi et al. found that while 52% of patients undergoing primary hip arthroscopy are female, 64% of revisions are female [39]. The reasons for this discrepancy are poorly understood, with hormonal differences, proximal femoral anatomy (increased coxa valga and anteversion in females) creating extra-articular impingement, and hypermobility or increased soft tissue laxity all potentially playing a role [39].

Outcomes of Labral Debridement, Repair, and Reconstruction

The suction seal maintained by the intact labrum is chondroprotective and contributes to hip joint stability [41]. Labral repair and reconstruction have been shown to restore intra-articular fluid pressurization and suction seal restoration to the native state, while debridement does not, leading to the general belief that labral preservation with repair rather than excision or debridement is preferable [42•]. This is supported clinically by a 2012 randomized controlled trial demonstrating that patients treated with labral repair as compared to selective debridement for pincer or mixed-type FAI are significantly more likely to report a normal to near-normal hip post-operatively, and score significantly higher post-operatively on the HOS-ADL (91.2 versus 80.9, $p < 0.05$) and HOS-Sport (88.7 versus 76.3, $p < 0.05$) [43]. This difference in between groups in HOS subset scores exceeds the MCID for HOS-ADL but not for HOS-Sport. A review by Ayeni et al. similarly reported greater post-operative improvements in functional scores after labral repair as compared to debridement in all six included studies, and pooled analysis of change in mHHS confirmed significantly greater improvement after labral repair, with the mean difference between groups (7.4) exceeding the MCID [8]. Perets et al. identified a significant increase in conversion to THA after labral debridement (14.0% converted to THA) rather than repair (5.3% converted to THA, $p = 0.02$) [22•].

Literature does not unanimously support superiority of labral repair over debridement; however, Menge et al. in 2017 reported on minimum 10-year follow-up of 79 hips undergoing labral repair and 75 labral debridement. They found no significant difference in any measured outcome scores (HOS-ADL, HOS-Sport, mHHS, SF-12) nor in the rate of revision hip arthroscopy (2.7% debridement, 6.3% repair) or conversion to THA [14•]. In a study of 101 hips with minimum 5-year follow-up after either labral repair or selective debridement, Chen et al. found no difference in a multitude of PROS (mHHS, NAHS, HOS, VAS, iHOT-12, satisfaction) nor revision arthroscopy or THA conversion rates [20•]. Notably, this study had stringent criteria for pathology deemed appropriate for selective debridement, including a stable labral base with at least 4-mm remnant labrum and no disruption of the suction seal [20•].

Overall, these findings suggest that truly selective debridement in cases which allows for sufficient remnant labrum to retain suction seal may be acceptable, but excision or debridement of large segments of labrum yields unfavorable results.

Hips with insufficient remnant labrum to restore suction seal thus warrant consideration of labral reconstruction. This procedure, first described arthroscopically by Philippon et al. in 2010, utilizes autograft or allograft tissue to substitute for the native labrum in cases of segmental defect or circumferential disease [44]. Neither biomechanical nor clinical studies have shown superiority of any one graft choice, and ultimately even autograft converts into fibrocartilage [45•, 46, 47]. While post-operative change in PROS are similar between patients undergoing arthroscopic labral reconstruction and revision labral repair, the absolute scores are higher in the repair group both pre- and post-operatively [48•]. Logically, hips with severely compromised labra requiring reconstruction may concomitantly have worse chondral damage, which could provide an explanation for this difference. Regardless, in the case of a labrum with severe intrasubstance damage, segmental defect, insufficient girth to restore suction seal, or otherwise deemed irreparable, labral reconstruction demonstrates significantly better PROS than segmental resection [49].

Impact of Capsular Management on Hip Arthroscopy Outcomes

Access to the hip arthroscopically requires violation of the capsule for placement of at least two portals. Classically, an interportal capsulotomy connecting the entry points for an anterolateral portal and a mid-anterior or direct anterior portal has been used [50•]. T-capsulotomy, with an additional longitudinal capsular incision along the anterior femoral head-neck junction starting from the interportal capsulotomy, can improve access to large and distal cam lesions [51•]. More recently, periportal capsulotomy, utilizing dilation of the anterolateral and midanterior portals without interconnecting them, has been advocated due to its preservation of the midsubstance of the stabilizing iliofemoral ligament [52•, 53•].

Concerns regarding post-operative instability with either frank dislocation or, more commonly, microinstability presenting as continued pain, have sparked debate as to the necessity of capsular closure or plication at the end of hip arthroscopy procedures [54]. Cadaveric studies have demonstrated hip hypermobility after T-capsulotomy or large (4 to 6 cm) interportal capsulotomies, with restoration of mechanics after side-to-side capsular repair [55•, 56•, 57, 58•]. Some clinical studies report improved PROS with closure of interportal and T-capsulotomies compared to patients without capsular closure, though these differences remain below the minimally clinically important difference (MCID) [50, 59]. Frank et al. reported on 32 hips with complete closure of T-capsulotomy and 32 with partial closure (no closure of interportal limb), noting significant improvements in pre- to post-operative PROS within both groups which remained stable up to 2.5 years after surgery [59]. They found that the complete repair group had significantly higher post-operative HOS-Sport and satisfaction scores, but these differences were of questionable clinical significance, with HOS-Sport differing by only 3.7 points and satisfaction by 0.2 points at final follow-up [59]. Other studies have shown equivalent PROS, revision arthroscopy, and total hip arthroplasty conversion rates with or without capsular closure for interportal capsulotomies at up to 5-year follow-up [60•, 61]. A study of bilateral hip arthroscopies randomized to closure of small interportal capsulotomy on one hip, and no closure contralaterally revealed healing of all unclosed capsules in a similar fashion to those surgically closed by 24 weeks post-operatively, with no capsular defect or disruption and similar capsular dimensions on MRI in both groups [43].

While no firm conclusions can be drawn regarding the necessity for routine capsular closure, there are cases in which this should be more seriously considered. Hips with borderline dysplasia (lateral center edge angle 20–25), patients with generalized joint hypermobility (Beighton > 4), and revision cases should likely be treated with capsular closure [52•, 53•].

Outcomes Based on Bony Morphology

Borderline or mild acetabular dysplasia can occur concurrent with FAI, and needs to be approached cautiously. Hip arthroscopy is generally not recommended for patients with lateral center edge angle (LCEA) under 18° (Fig. 1a) or Tonnis angle over 10 to 15° (Fig. 1b) due to high failure and reoperation rates [62•, 63, 64•]. Parvizi et al. reported that hip arthroscopy failed to improve symptoms in 80% of dysplastic hips (24 of 30), with accelerated arthritis and/or migration of the femoral head seen post-operatively in 46.7% and 43.3% of hips, respectively [63]. More than half of the hips in the study (53.3%, 14 of 30) required additional surgery including periacetabular osteotomy, femoroacetabular osteoplasty, or total hip

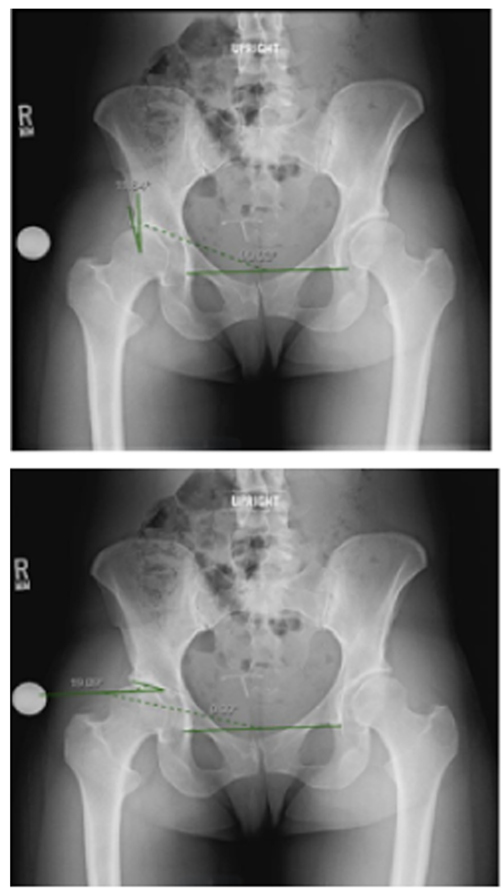

Fig. 1 Anterior-posterior pelvis radiograph in a patient with hip dysplasia demonstrating measurement of **a** lateral center edge angle, measured as the angle between a line from the center of the femoral head to the lateral edge of the acetabular sourcil and a vertical line from the center of the femoral head, perpendicular to an inter-teardrop line; **b** Tonnis angle, measured between a line from the medial to lateral edge of the acetabular sourcil and a horizontal line extending from the medial edge of the sourcil, parallel to an inter-teardrop line

arthroplasty [63]. It is important to note, however, that this study only included hips with LCEA < 20°, just 7 (23.3%) hips had concurrent FAI, and all were treated with labral debridement. Subsequent studies have demonstrated the importance of labral preservation in borderline dysplastic hips, with a 44% reoperation rate after labral debridement as compared to 16% after labral repair in this population [65]. Acetabular rim resection of more than 3 mm in dysplastic hips is also associated with high failure rates [64•]. Looking specifically at borderline hip dysplasia (LCEA > 18°) with concurrent FAI treated with hip arthroscopy including minimal acetabular rim resection, repair of all unstable labral tears, and capsular plication, Domb et al. noted excellent satisfaction, improvement in VAS pain scores from 5.6 to 1.8 after surgery, and significant improvements in mHHS (70.3 ± 9.8 to 85.9 ± 12.1), NAHS (68.3 ± 13.2 to 87.3 ± 9.8), and HOS-SSS (52.1 ± 15.9 to 70.8 ± 19.5) at minimum 5-year follow-up [66•]. There were no THA conversions, but has a 19% revision arthroscopy rate in this cohort. Hip arthroscopy therefore may do well in mildly dysplastic hips with concurrent FAI and conscious efforts to avoid iatrogenic destabilization through labral preservation, minimal acetabular rim resection, and capsular plication.

Acetabular retroversion, identified radiographically by the presence of a crossover sign, posterior wall sign, and ischial spine sign on an AP pelvis (Fig. 2), produces anterolateral femoroacetabular overcoverage and posterior undercoverage [67•]. While classically treated with anteverting or "reverse" periacetabular osteotomy (PAO), the morbidity can be significantly reduced, and intra-articular labrocartilaginous pathology more readily treated arthroscopically [29, 32]. Flores et al. compared hips with acetabular retroversion to those with focal pincer lesion and found no significant difference in PROS improvement after hip arthroscopy between groups [67•]. Similarly, Hartigan et al. found that arthroscopic treatment for global acetabular retroversion had a 99% survivorship at 2 years with a minor complication rate of only 3.6% [68•]. Hip arthroscopy thus represents a valid and successful treatment for FAI symptomatology caused by global acetabular retroversion.

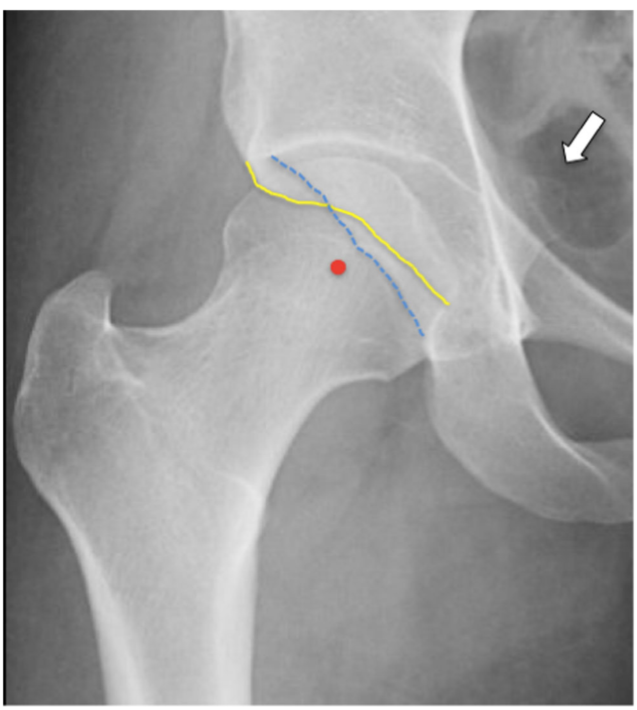

Fig. 2 Anterior-posterior hip radiograph demonstrating the three radiographic indicators of global acetabular retroversion. Crossover sign: the acetabular posterior wall (dashed blue line) crosses over the anterior wall (solid yellow line) superiorly; posterior wall sign: the posterior wall lies medial to the center of the femoral head (red dot); ischial spine sign: the ischial spine (white arrow) is visible medial to the pelvic brim

Mild to moderate femoral malversion does not appear to have a significant impact on PROS after hip arthroscopy. Ferro et al. found no significant difference in post-operative mHHS, SF-12, or WOMAC scores after hip arthroscopy in 180 patients with < 5°, 5–15°, or > 15° of femoral version [69]. Conversely, Fabricant et al. found that while patients with relative femoral anteversion, retroversion, and normal version all improved significantly after hip arthroscopy, the femoral retroversion group saw lesser magnitude of improvement and was less likely to achieve the MCID for mHHS, HOS-ADL, HOS-Sport, and iHOT-33 as compared to normal or anteverted patients [70]. Severely abnormal femoral version, defined as retroversion < 0° or anteversion > 35°, is seen in 8–9% of hips with cam, pincer, or mixed FAI and in 43% of patients with hip pain, labral tear, and no radiographic abnormality [71•]. Complete symptomatic relief in these patients may require derotational osteotomy. Overall, improvements can be expected after hip arthroscopy for FAI regardless of femoral version, but severe malversion or moderate retroversion may impart lesser symptomatic change.

Hip Arthroscopy for the Prevention of OA in FAI

FAI has long been known to correlate with early degenerative changes in the hip joint [2, 72•]. While short to mid-term improvement in pain and function as denoted by increased PROS is well-established after hip arthroscopy for FAI, the question of its role in preventing arthritis remains. Current literature allows only inferences based on conversion to total hip arthroplasty after hip arthroscopy, with multiple contributing variables and a wide range of reported THA conversion rates. Unsurprisingly, pre-existing arthritis is the strongest predictor of conversion to THA with < 2-mm radiographic joint space increasing THA conversion rate by 12 times (86% THA conversion at 5-year follow-up) [73], and Tonnis grade 2 or higher increasing the rate by eight times compared to Tonnis grade 0 [74•]. Redmond et al. analyzed nearly 800 patients in an attempt to identify predictors of conversion to THA after hip arthroscopy [75•]. They found that revision surgery (rate ratio 2.4), femoral outerbridge grade (II, RR 2.23; III, RR 2.17; IV, RR 2.96), performance of acetabuloplasty (RR 1.83), lack of femoral osteoplasty (RR 1.83), older age (RR 1.06), lower pre-operative mHHS (RR 0.98), and decreased femoral anteversion (RR 0.97) were associated with conversion to THA within 27 months of surgery, and created a weighted risk calculator for patient counseling purposes [75•].

Recent advances in magnetic resonance imaging (MRI) compositional sequences may help to better understand the role of surgical FAI correction in osteoarthritis prevention. These sequences assess cartilage collagen and water content (T2 mapping, T2* mapping) or extracellular matrix proteoglycan and glycosaminoglycan content (T1rho, dGEMRIC, gagCEST) [76]. This allows for earlier identification of cartilage degeneration and potentially regeneration than is possible with current morphologic MRI sequences. Beaule et al. reported significant decreases in T1rho values after surgical resection of femoral cam lesions, suggesting stabilization of previously abnormal cartilage [77•]. Further utilization of these compositional MRI sequences is certainly needed to better define the role of hip arthroscopy for FAI in articular cartilage preservation.

Conclusions

Hip arthroscopy as a treatment for FAI results in significant improvements in patient pain and function, with high satisfaction and relatively low revision surgery rates in appropriately indicated patients. The majority of symptomatic and functional improvements occur within 1 to 2 years of hip arthroscopy. A repaired or reconstructed labrum is best able to restore the suction seal of the hip, which plays a crucial role in chondroprotection and joint stability. The role of hip arthroscopy in preventing osteoarthritis in patients with FAI is not yet clear, and may be better understood in the future as compositional MRI sequences are further investigated, and long-term follow-up of modern labral repair techniques become available. Patients with moderate to severe hip dysplasia or arthritis should not undergo isolated hip arthroscopy due to high failure rates.

Compliance with Ethical Standards

Conflict of Interest Caitlin Chambers declares that she has no conflict of interest. Alan Zhang is a consultant for Stryker, outside of the submitted work.

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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19.• Domb BG, Yuen LC, Ortiz-Declet V, Litrenta J, Perets I, Chen AW. Arthroscopic labral base repair in the hip: 5-Year minimum clinical outcomes. Am J Sports Med. 2017;45(12):2882–90 **Minimum 5-year outcome data after labral repair is uncommon; this manuscript demonstrated high satisfaction, maintenance of post-operative improvement in patient-reported outcome scores at 5 years, and over 90% hip survivorship**.

20.• Chen AW, Yuen LC, Ortiz-Declet V, Litrenta J, Maldonado DR, Domb BG. Selective debridement with labral preservation using narrow indications in the hip: minimum 5-year outcomes with a matched-pair labral repair control group. Am J Sports Med. 2018;46(2):297–304 **An interesting paper which suggests that selective debridement of stable labral tears in appropriately indicated, non-arthritic hips, can yield equivalent outcomes to hips undergoing labral repair**.

21.• Perets I, Chaharbakhshi EO, Mu B, Ashberg L, Battaglia MR, Yuen LC, et al. Hip arthroscopy in patients ages 50 years or older: minimum 5-year outcomes, survivorship, and risk factors for conversion to total hip replacement. Arthroscopy. 2018;34(11):3001–9 **This prospective study found significant post-operative improvements and high satisfaction in patients over 50 years of age and 72% survivorship at 5-years after hip arthroscopy. Subgroup analysis of hips requiring THA identified an increase in BMI, alpha angle, lateral center edge angle, and more hips with Tonnis grade I, femoral and acetabular Outerbridge 2 or higher within this group**.

22.• Perets I, Chaharbakhshi EO, Shapira J, Ashberg L, Mu BH, Domb BG. Hip arthroscopy for femoroacetabular impingement and labral tears in patients younger than 50 years: minimum five-year outcomes, survivorship, and risk factors for reoperations. J Am Acad Orthop Surg. 2018. **Midterm results of hip arthroscopy in patients under 50, demonstrating significantly improved functional and pain scores, high satisfaction, low complication rate, and 92% survivorship at 5 years.**

23.• Flores SE, Sheridan JR, Borak KR, Zhang AL. When do patients improve after hip arthroscopy for femoroacetabular impingement? A prospective cohort analysis. Am J Sports Med. 2018;46(13):3111–8 **A unique study which found that a majority of improvement after hip arthroscopy occurs within 3 months of surgery, although return to sport, quality of life, and pain can continue to see improvements up to 2 years post-operatively**.

24.• Weber AE, Kuhns BD, Cvetanovich GL, Grzybowski JS, Salata MJ, Nho SJ. Amateur and recreational athletes return to sport at a high rate following hip arthroscopy for femoroacetabular impingement. Arthroscopy. 2017;33(4):748–55 **This retrospective study found high rates of return to sport in both recreational and high-level amateur athletes**.

25.• Mohan R, Johnson NR, Hevesi M, Gibbs CM, Levy BA, Krych AJ. Return to sport and clinical outcomes after hip arthroscopic labral repair in young amateur athletes: minimum 2-year follow-up. Arthroscopy. 2017;33(9):1679–84 **The authors found high rate of return to sport after hip arthroscopy with labral repair, with greater functional score improvements after arthroscopic labral repair with chondrolabral preservation as compared to labral repair with takedown and reattachment**.

26.• Menge TJ, Bhatia S, McNamara SC, Briggs KK, Philippon MJ. Femoroacetabular impingement in professional football players: return to play and predictors of career length after hip arthroscopy. Am J Sports Med. 2017;45(8):1740–4 **This study demonstrated a high rate of return to sport in NFL players undergoing hip arthroscopy, with no effect of acetabular microfracture on return to sport rates**.

27.• Levy DM, Kuhns BD, Frank RM, Grzybowski JS, Campbell KA, Brown S, et al. High rate of return to running for athletes after hip arthroscopy for the treatment of femoroacetabular impingement and capsular plication. Am J Sports Med. 2017;45(1):127–34 **Greater than 90% return to running rates were demonstrated in both recreation and competitive runners after hip arthroscopy in this series, although with fewer weekly miles at up to 2 years post-operatively**.

28.• Horner NS, Ekhtiari S, Simunovic N, Safran MR, Philippon MJ, Ayeni OR. Hip arthroscopy in patients age 40 or older: a systematic review. Arthroscopy. 2017;33(2):464–75.e3 **This review demonstated clinically significant improvements in patients over 40 years of age undergoing labral repair but not labral debridement. Rate of conversion to THA after hip arthroscopy increases with every decade of life beyond 40**.

29.• Capogna BM, Ryan MK, Begly JP, Chenard KE, Mahure SA, Youm T. Clinical outcomes of hip arthroscopy in patients 60 or older: a minimum of 2-year follow-up. Arthroscopy. 2016;32(12):2505–10 **This study showed significant early improvement in outcome scores after hip arthroscopy was reliably achieved in patients 60 years or older with Tonnis grade 0 or 1 radiographic changes**.

30.• Perets I, Rybalko D, Chaharbakhshi EO, Mu BH, Chen AW, Domb BG. Minimum five-year outcomes of hip arthroscopy for the treatment of femoroacetabular impingement and labral tears in patients with obesity: a match-controlled study. J Bone Joint Surg Am. 2018;100(11):965–73 **While significant clinical improvements**

were seen in obese patients after hip arthroscopy, obese patients were twice as likely to require conversion to THA within 5 years as compared to a matched control group.
31. Collins JA, Beutel BG, Garofolo G, Youm T. Correlation of obesity with patient-reported outcomes and complications after hip arthroscopy. Arthroscopy. 2015;31(1):57–62.
32.• Joseph R, Pan X, Cenkus K, Brown L, Ellis T, Di Stasi S. Sex differences in self-reported hip function up to 2 years after arthroscopic surgery for femoroacetabular impingement. Am J Sports Med. 2016;44(1):54–9 **Unique in its assessment of sex as an independent variable, this prospective study found that while females had poorer pre-operative PROs, this difference was no longer significant 2 years post-operatively, with both female and male patients seeing maximal improvement in the first 6 months after surgery**.
33.• Frank RM, Lee S, Bush-Joseph CA, Salata MJ, Mather RC 3rd, Nho SJ. Outcomes for hip arthroscopy according to sex and age: a comparative matched-group analysis. J Bone Joint Surg Am. 2016;98(10):797–804 **This prospective analysis of hip arthroscopy patients found that those over 45 years of age has lesser post-operative improvements, with women over 45 years old performing worse than any other sex/age group**.
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52.• Chambers CC, Monroe EJ, Flores SE, Borak KR, Zhang AL. Periportal capsulotomy: technique and outcomes for a limited capsulotomy during hip arthroscopy. Arthroscopy. 2019. **The authors present their outcomes with use of periportal dilation capsulotomy, with no incidences of post-operative instability and overall favorable outcomes in line with those reported by studies utilizing routine capsular closure.**
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capsulotomy which is restored to a native state with capsular repair.

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