[Orthopaedic Surgery]

What's New in Femoroacetabular Impingement Surgery: Will We Be Better in 2023?

Anil K. Gupta, MD, MBA,[†] Geoffrey D. Abrams, MD,[‡] and Shane J. Nho, MD, MS*[§]

Context: Femoroacetabular impingement (FAI) has been described as a common cause of hip pain in young adults. This leads to abnormal hip joint mechanics and contact pressures. The associated pathomechanics can lead to the development of early osteoarthritis. Better understanding of the anatomy and pathophysiology, biomechanics, and diagnostic and therapeutic advances has led to improved clinical outcomes. A growing body of evidence has set the foundation for future progress in the treatment of this commonly encountered condition.

Evidence Acquisition: The PubMed database was searched for English-language articles pertaining to FAI over the past 15 years (1998-2013).

Study Design: Retrospective literature review.

Level of Evidence: Level 4.

Results: The authors evaluated and discussed the current evidence regarding the anatomy, physiology, biomechanics, imaging, and clinical outcomes of surgical intervention for FAI. Based on this information, future directions for improving the diagnosis and management of FAI are proposed.

Conclusion: There remains a diverse approach to the diagnosis and management of cam- and/or pincer-type FAI. Recent advances in clinical diagnosis, imaging, indications, and arthroscopic techniques have led to improved outcomes and have set the foundation for future progress in the management of this condition.

Strength of Recommendation Taxonomy (SORT): B

Keywords: femoroacetabular impingement; surgical; biomechanics; imaging

Femoroacetabular impingement (FAI) is a common cause of hip pain in young adults. FAI can be the result of an acetabular-sided "pincer" deformity or a femoral-sided "cam" deformity. Each type of bony abnormality can be seen in isolation or in combination and can lead to FAI.[11,15,17,23] In the past 2 decades, many advances have been made in the recognition and management of this condition that have led to improved patient outcomes. Despite improved outcomes, there remains the opportunity for future advancements. The purpose of this review is to describe the current evidence and future directions of the anatomy and pathophysiology, imaging, biomechanics, clinical decision making, and clinical outcomes of FAI treatment options.

ANATOMY AND PATHOPHYSIOLOGY

Femoroacetabular impingement can result from a cam deformity,[11,13] where there is loss of sphericity of the femoral head, or from a pincer deformity,[11,52] where there is focal or global acetabular overcoverage of the femoral head. There is a sex-related difference, with cam lesions more prevalent in men and acetabular overcoverage more prevalent in women.[13,42,53] Recent studies, however, have demonstrated that such findings are less likely to be seen in isolation.[11,13] Rather, a combination of these pathologies is more commonly present, and failure to identify and treat this can lead to undesirable outcomes.[11,13,42,52,53]

From †Sports Medicine and Shoulder Surgery, Florida Orthopaedic Institute, Tampa, Florida, ‡Department of Orthopedic Surgery, Stanford University, and Veterans Administration, Palo Alto, California, and §Department of Orthopedic Surgery, Division of Sports Medicine, Rush University Medical Center, Chicago, Illinois
*Address correspondence to Shane J. Nho, MD, MS, Department of Orthopedic Surgery, Division of Sports Medicine, Rush University Medical Center, 1611 West Harrison Street, Suite 300, Chicago, IL 60612 (e-mail: snho@rushortho.com).
The following author declared potential conflicts of interest: Shane J. Nho, MD, MS, is a consultant for Stryker, Pivot Medical, and Ossur. He has grants pending for the Arthroscopic Association of North America, Stryker, and Allosource. He holds stock or stock options in Pivot Medical.
DOI: 10.1177/1941738113513006

Up to 90% of patients with labral pathology have a morphologic abnormality of the femoral head-neck junction or acetabulum.[13,16,19,23] Asphericity of the femoral head can lead to early contact and shear stresses of the anterior-superior acetabular rim as the hip is brought into flexion and internal rotation.[2,6,7] This can lead to prearthritic pain, early chondral delamination, and associated labral pathology.[8] Similarly, acetabular overcoverage, both focal and global, can cause abnormal impaction at the labrum during hip joint motion, as well as a contrecoup injury to the posteroinferior acetabulum.[23]

Bedi et al[8,9] described static and dynamic factors associated with prearthritic hip pain. Static factors include anterior or lateral acetabular undercoverage, femoral anteversion, and femoral valgus. These factors lead to asymmetric joint loading and chondral wear during static activities (ie, stance).[8,9] Dynamic factors include cam-type deformity and acetabular overcoverage. As the hip is dynamically flexed, there is abnormal engagement between the femoral head and acetabulum. This alters the mechanics of the joint and surrounding musculature, leading to pain and early chondrolabral degeneration.[8,9] Dynamic extra-articular impingement factors, including femoral retroversion, femoral varus, trochanteric impingement, and anterior-inferior iliac spine (AIIS) impingement, also occur as the hip is brought into flexion and/or abduction.[8,9]

IMAGING

Radiographs

Radiographic assessment of FAI, including true anteroposterior pelvis, false-profile, cross-table lateral, frog-leg lateral, and 45° lateral Dunn views, provides useful static evaluation for femoral or acetabular-sided bony lesions.[5,12,58] The ability to extrapolate spherical pathology from 2-dimensional imaging, however, can be difficult. For this reason, multiple radiographic views have been suggested to diagnose cam and pincer deformities. In a comparative study, Nepple et al[48] evaluated the sensitivity and specificity of specific radiographic views in predicting cam-type FAI diagnosed by radial-oblique CT reformats (considered gold standard). They found that a complete radiographic series, including an anteroposterior pelvis, 45° lateral Dunn, cross-table lateral, and frog-leg lateral, was 86% to 90% sensitive in detecting abnormal alpha angles on CT. In an evaluation of the alpha angle measured on a cross-table lateral view with the leg in 15° of internal rotation or on the Dunn view, Beaule et al[5] found that patients with an alpha angle greater than 65° had significantly increased risk of cartilage damage.

Radiographic imaging to detect pincer-type deformity can be challenging. For example, alterations in pelvic tilt and rotation can influence interpretations of acetabular pathomorphology; as a result, pincer deformities can be either unrecognized or falsely identified. In a cadaveric assessment of the normal pelvis, Siebenrock et al[55] demonstrated a correlation between pelvic tilt and acetabular version. At 9° of pelvic inclination, all specimens demonstrated positive crossover and posterior wall signs despite a lack of acetabular retroversion. This study exposed the need for standardized techniques in radiographic imaging to account for this variability. Furthermore, in a recent retrospective study, Nepple et al[47] found that coxa profunda, a commonly accepted radiographic finding demonstrating global acetabular overcoverage, should be considered a normal radiographic finding in women.

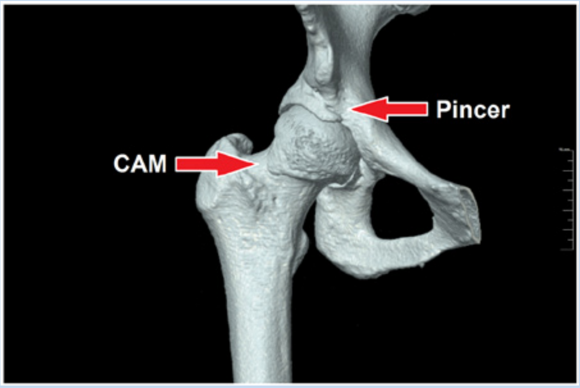

Figure 1. Three-dimensional computed tomography scan demonstrating combined cam and pincer deformities.

Computed Tomography and 3-dimensional Modeling

Inaccurate or inconclusive preoperative assessment of plain radiographs can lead to inadequate or excessive resection of presumed lesions contributing to FAI. Failure to adequately address the offending 3-dimensional (3D) deformity causing FAI is the most common reason for failed arthroscopy and need for revision.[29,52] High-resolution CT allows for precise evaluation of osseous morphology about the hip joint (Figure 1). Three-dimensional modeling is a recent advancement that has demonstrated promise with regard to dynamic hip analysis for preoperative planning (Figure 2). Using a noninvasive 3D CT-based kinematic technique to create a virtual hip model, Kubiak-Langer et al[35] were able to identify the location of impingement and assess the changes in range of motion before and after virtual resection of isolated cam, pincer, or combined lesions. Similarly, Bedi et al[9] performed patient-specific 3D CT modeling of hips with cam and/or pincer deformities. Models were dynamically assessed for location and extent of impingement. The location of impingement was unique in each case and did not correlate with radiographic imaging. Virtual acetabular rim trimming and/or femoral head-neck osteochondroplasty was performed to remove areas of impingement, which improved hip kinematics and range of motion.[9]

Dynamic 3D CT modeling may also help decipher deformities that are symptomatic from those that are asymptomatic. Two recent studies demonstrated the prevalence of cam-type deformities in asymptomatic individuals. In an evaluation of 200 asymptomatic volunteers who underwent MRI, Hack

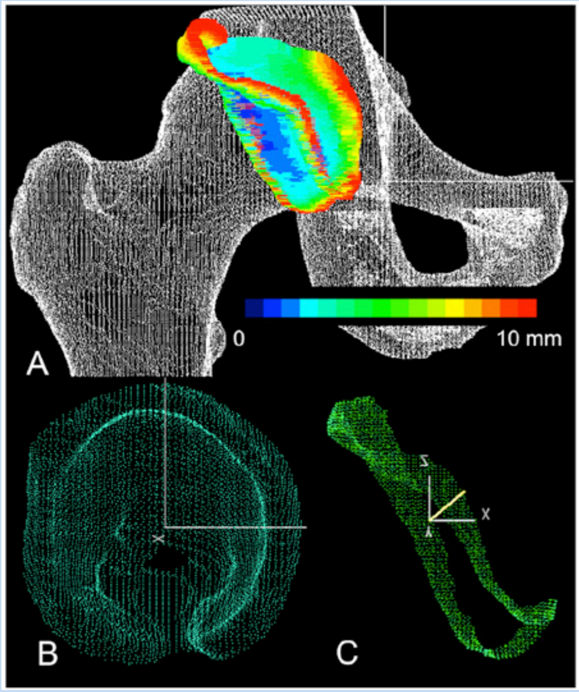

Figure 2. Point cloud model of the acetabulum devised from 3-dimensional computed tomography scan. (A) Joint space width represented on complete hip joint. (B) View of the modeled acetabulum surface. (C) View of the modeled acetabulum rim.

et al[26] found a 14% incidence of cam morphology and 10.5% with an elevated alpha angle. Similarly, Jung et al[31] found a 14.3% incidence of cam-type deformity in asymptomatic male patients and a 5.6% incidence in asymptomatic female patients based on abnormal alpha angle measurements on anterior-posterior CT scout images. Although these patients had evidence of bony abnormality on static imaging, dynamic imaging comparison was not performed.[31] In a study comparing patients with symptomatic FAI, asymptomatic patients with 3D CT evidence of FAI, and asymptomatic controls, Audenaert et al[2] demonstrated increasing hip internal rotation among groups, respectively. They found that cam size, acetabular overcoverage, and decreased femoral anteversion all contributed to the loss of internal rotation.

Dynamic 3D CT analysis has also recently shed light on potential extra-articular causes of impingement. In a dynamic CT model of 53 hips of patients with impingement, Hetsroni et al[28] described varying AIIS morphology based on the relationship between the AIIS and the acetabular rim. They demonstrated that a prominent AIIS can lead to "subspine impingement" with loss of hip flexion and internal rotation. Evaluation of contact points also showed varied sites of contact on the femoral neck depending on the relative extent of the prominence.[28] Thus, along with intra-articular evaluation, 3D dynamic CT has tremendous future potential for identifying additional causes and locations of extra-articular impingement, including dysplasia, malunion, and heterotopic ossification. This will allow for a more comprehensive surgical approach in treating patients with FAI.

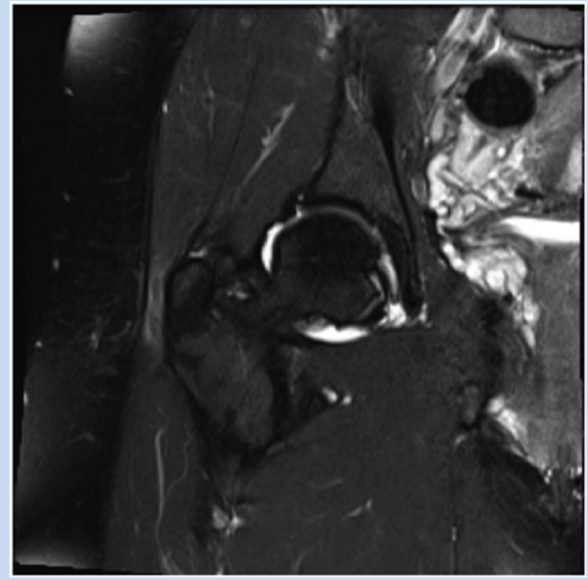

Figure 3. Coronal magnetic resonance arthrogram demonstrating anterior-superior labral tear with chondral delamination.

Magnetic Resonance Imaging

Magnetic resonance imaging is considered the most sensitive and specific modality to diagnose labral pathology and associated bony and soft tissue abnormalities associated with FAI (ie, subchondral cysts, bony edema, capsular thickening, synovitis, paralabral cysts, gluteus medius tendinopathy, adductor longus strain) as well as those independent of FAI (ie, osteonecrosis of the femoral head, bone tumors, synovial chondromatosis). Abnormal head-neck morphology and anterior-superior chondrolabral lesions can been seen in up to 90% of cases of FAI.[32] For the best results, a 1.5- or 3.0-T magnet with a 2-part shoulder coil, small field-of-view wrap coil, or multiple-channel cardiac coil should be used.[25] Axial-oblique images oriented along the femoral neck are typically utilized in the evaluation of a cam deformity, labral tears, and partial- and full-thickness cartilage defects.[25]

Cartilage delamination is the early result from focal cam-type FAI.[25] This is commonly seen at the chondrolabral junction of the anterior-superior acetabulum. It is diagnosed by fluid extravasation deep to the cartilage (Figure 3). Magnetic resonance arthrography, which is typically performed to improve visualization of labral tears, has a 22% sensitivity and 100% specificity in detecting chondral delamination.[1,25] Delamination was most commonly identified on sagittal T1-weighted and proton-density sequences with fat saturation.[1] Recently, delayed gadolinium-enhanced MRI of cartilage (dGEMRIC) has been used to evaluate proteoglycan depletion to predict early cartilage degeneration. Contrast uptake correlates inversely to the amount of glycosaminoglycan content present.[25] dGEMRIC in symptomatic FAI shows promise for detecting early cartilage degeneration.[1,25]

BIOMECHANICS

Abnormal contact resulting from FAI leads to labral damage and a cascade of events resulting in the development of osteoarthritis. Finite element modeling has demonstrated that the absence of a functioning labrum results in an increase (up to 92%) in contact stress of the acetabular cartilage.[21] In addition, the contact area of the femoroacetabular cartilage shifts laterally toward the acetabular rim. Labral tearing and/or deficiency can lead to instability.[17,18,57] Three-dimensional motion analysis of cadaveric hips with simulated labral tears has shown increased distraction.[18]

The altered contact pressures, eccentric loading, and loss of stability that results from labral dysfunction may contribute to the development of osteoarthritis. In a cadaveric study, Smith et al[57] demonstrated that removal of 2 cm or more of the labrum reduced hip stability. In addition, strain in the anterior-superior labrum was increased with a circumferential-type tear.[57] In an in vitro biplanar fluoroscopy study, Myers et al[44] demonstrated that the labrum served as a secondary stabilizer to the iliofemoral ligament in limiting external rotation and anterior translation.

The labrum may also contribute to the suction-seal effect of the joint.[17,57] Loss of the suction-seal can lead to subclinical instability and abnormal articular cartilage contact loading.[17,44,57] In a cadaveric study, Cadet et al[17] demonstrated that labral repair results in lower capsular fluid efflux than do partial labral resection and/or iliotibial band autograft reconstruction. Repair, however, was not as effective as the intact labral state.

CLINICAL DECISION MAKING

Nonoperative management of symptomatic FAI can help alleviate pain and restore function.[3,15,23] In a prospective observational study of patients with symptomatic prearthritic intra-articular hip disorders, 44% of patients treated conservatively had a satisfactory outcome at 1 year.[30] In comparing the nonoperative versus operative groups, both groups demonstrated improved outcomes without a significant difference.[30] The impact of these nonoperative modalities on the natural history of the development of degenerative osteoarthritis from FAI is not known, largely because there is no consensus at this time on the natural history of asymptomatic and symptomatic FAI.

Intra-articular cortisone injection is often performed to decipher intra-articular from extra-articular pathology. In a retrospective review comparing physical examination, MRI, magnetic resonance arthrography, and intra-articular injection of anesthetic, Byrd and Jones demonstrated that injection was 90% accurate at diagnosing intra-articular pathology.[15] In a retrospective review of patients who underwent injection before arthroscopy, Kivlan et al[34] found that patients with acetabular chondral damage had significant pain relief compared with those without chondral damage. The presence and severity of FAI and labral pathology did not influence the percentage relief from injection.[34] Therefore, in patients with isolated FAI, there is a possibility that they may not obtain significant benefit from injection if there is no associated chondrolabral pathology.

The decision to pursue open versus arthroscopic intervention depends on the pathomorphology as well as surgeon experience. Open surgical dislocation may be the best treatment option for posterior cam deformities or global pincer deformities in the event that appropriate access to the joint cannot be attained through traction only. Studies have demonstrated improved outcomes at midterm follow-up with this technique, including return to play in high-level athletes.[45,46] This technique, however, is technically demanding, with complications including trochanteric nonunion, heterotopic ossification, and avascular necrosis of the femoral head with acetabular retroversion and/or posterior wall insufficiency; open reverse periacetabular osteotomy is effective at reorienting the acetabulum. This is a technically difficult procedure with risk of neurovascular injury, symptomatic hardware, and nonunion.[8] Studies have demonstrated improved pain relief, function, and range of motion when performed effectively.[56]

Recent technical advances in hip arthroscopy have enabled surgeons to address osseous and soft tissue pathologies that were once managed by open surgery. In a comparative series, Bedi et al[10] demonstrated that arthroscopic osteochondroplasty has similar efficacy to open surgical dislocation for restoring head-neck offset, depth, and arc of resection for anterior and anterior-superior cam and focal pincer pathology. Similarly, Buchler et al[12] demonstrated similar efficacy of osseous correction of cam-type deformity between the 2 techniques. Success of arthroscopy, however, depended on surgeon experience.[12]

Current limitations of arthroscopy for FAI, including posterior-superior cam and acetabular lesions, may become routinely manageable via arthroscopy and mitigate the morbidity associated with open procedures.

CLINICAL OUTCOMES

Long-term Follow-up Studies

Unfortunately, there is a paucity of level 1 or 2 data available. In a cohort of 50 consecutive patients with 100% follow-up at 10 years, Byrd and Jones[16] reported improved functional outcome scores in patients who were younger and had a shorter duration of symptoms and a normal center-edge angle.

Investigations Examining Outcomes Following FAI Treatment

With some exceptions, studies examining outcomes for patients undergoing treatment for FAI are mostly limited to smaller patient populations with short- to mid-term follow-up (Table 1). In one of the larger studies on FAI treatment, Larson et al[39] investigated the effect of radiographic arthritis on clinical outcomes in cohorts with FAI only and those with FAI and radiographic osteoarthritis. A total of 210 patients were included and followed for a minimum of 1 year (mean, 27 months). Improvements in Harris Hip Score (HHS), SF-12 (Short Form–12), and visual analog scale (VAS) for pain were greater in the group without osteoarthritis so that those with less than 50% joint space narrowing or more than 2 mm of joint space remaining fared better. Chondral damage noted on MRI and longer duration of preoperative symptoms were associated with worse clinical outcomes.[39]

Byrd and Jones[14] studied the results of FAI surgery in athletes, including 23 professional and 56 intercollegiate athletes. A total of 200 patients was followed for a minimum of 1 year, with a majority of patients having cam pathology. There was significant improvement in the modified HHS (to a mean of 96 postoperatively) as compared with preoperative values, and 95% of professional athletes and 85% of intercollegiate athletes were able to return to sports.[14]

Philippon et al[51] examined clinical outcomes in 112 patients following arthroscopic treatment for FAI. Mean patient age was 40.6 years, and mean follow-up was 2.3 years. Most patients underwent treatment for mixed (cam and pincer) impingement, 23 underwent osteoplasty only, and 3 had acetabuloplasty alone. The mean modified HSS improved from 58 preoperatively to 84 postoperatively, with 10 patients undergoing total hip arthroplasty at an average of 16 months. The preoperative HHS, joint space greater than 2 mm, and repair of labral pathology rather than debridement were predictors for a more favorable outcome.[51]

Malviya et al[41] prospectively followed a cohort of 80 patients (40 professional athletes and 40 recreational athletes) to examine differences in return to sport and activity following arthroscopic treatment for FAI. Compared with preoperative values, there was a 2.6-fold improvement in training time and a 3.2-fold increase in time spent competing in the patients' desired sport 1 year following surgery. Overall, mean time to return to sport was 5.2 months, with professional athletes returning at an average of 4.2 months and recreational athletes at 6.8 months. Professional athletes also returned to their preinjury level of sport at a higher rate than that of recreational athletes at the 1-year mark.[41]

Studies Examining Arthroscopic Treatment of Labral Pathology in FAI

When intrasubstance tears of the labrum are present, some favor debridement while others prefer maintaining labral tissue and refixation (Table 2).[22,33,36]

Larson et al,[38] in a cohort study of 94 patients undergoing either labral debridement or refixation, showed that postoperative HHS, SF-12, and VAS were all significantly better in the refixation group at a mean follow-up of 42 months. Good to excellent results were noted in 68% of the debridement group versus 92% of the refixation group.[37] Limitations of this investigation include the use of a historical control population.

Schilders et al[54] investigated labral resection versus refixation in 96 patients at a mean 2.4 years postoperatively. HHS in the labral repair group improved from 60 to 94 and from 63 to 89 in the labral resection group. Based on a regression model, the mean benefit of performing labral fixation over resection was 7.3 points on the HHS grading system.[54] Preserving labral tissue when possible seems reasonable because of the sealing function of the labrum; the decision to perform labral debridement/resection versus refixation typically depends on a variety of factors: the type and location of the tear, healing capacity, the size of the labrum, the status of the articular cartilage, and the skill of the surgeon.[33,53] Outcomes following refixation versus debridement/resection may be more dependent on the status of the labrum at the time of arthroscopy rather than the treatment provided.

When the labrum is not salvageable, some surgeons turn to labral reconstruction.[50] Philippon et al[50] reported clinical results of labral reconstruction using autograft iliotibial band in patients with advanced labral degeneration or labral deficiency. The mean HHS significantly improved preoperatively to postoperatively in the 47 patients, with a mean patient satisfaction score of 8 (scale, 1-10) over the 18-month follow-up. Four patients went on to total hip arthroplasty, with age being a significant independent predictor of patient outcome.[50] In a cohort of 19 patients undergoing labral reconstruction, 3 underwent total hip arthroplasty within the 3 years, and 14 of 16 patients had improved subjective functional scores.[59]

Open Versus Arthroscopic Treatment of FAI

Treatment of FAI was initially performed through an open surgical dislocation.[23] Treatment for FAI now includes open surgical dislocation,[23] all-arthroscopic,[10-12] and combined mini-open and arthroscopic techniques.[40] Comparison between techniques is difficult because of the varying outcome measures.

In a group of patients with FAI, 23 underwent arthroscopy and 15 open dislocation.[60] Ten patients were randomly allocated to a treatment group while the others made their own decision. The arthroscopy group had a significantly better follow-up, up to 1 year postoperatively. Shorter hospital stay and time off work were noted in the arthroscopy group; additionally, there was overcorrection of morphologic abnormalities at the head-neck junction in the arthroscopy group.[60]

A systematic review of outcomes and complications of arthroscopic, mini-open, and surgical dislocation techniques showed that all 3 methods were effective in the treatment of FAI.[43] The arthroscopic group had a lower rate of complications (0%-5% major complication rate).[43] The open dislocation group had a relatively high rate of postoperative complications (0%-20% major complication rate), mostly related to trochanteric osteotomy-related issues.[43] The mini-open group had a lower complication rate than the open group (0%-17% major complication rate) but a higher incidence of lateral femoral cutaneous nerve injury versus the arthroscopic group.[43]

Table 1. Selected studies investigating arthroscopic treatment of FAI

Study	Patients, No.	Follow-up	Main Outcomes	Complications/ Failures	Other Findings
Malviya et al[42]	612	3.2 y	QoL score improved 1 year postoperative; 77% of patients showed QoL improved by at least 1 grade	NR	Mean change in QoL not significantly different for men vs women, age > 50 vs < 50 y; associated pathologies not associated with QoL score
Larson et al[38]	210	27 mo	HHS, SF-12, VAS better for patients without radiographic joint space narrowing	12% FAI and 52% FAI/OA, no sustained HHS improvement	MRI chondral damage and longer duration of symptoms led to lower scores
Byrd and Jones[16]	200	16 mo	HHS improvement of 20 points with cam impingement, 19-point improvement for pincer	0.5% THA, 1.5% repeat arthroscopy	Patient with microfracture had average 20-point HHS improvement
Philippon et al[51]	122	2.3 y	HHS improved from 58 preoperatively to 84 postoperatively; patient satisfaction was 9 (1-10 scale)	NR	Preoperative HHS, lack of joint space narrowing, and labral repair associated with improved outcome following surgery
Byrd and Jones[13]	116	2 y	HHS improved from 72 preoperatively to 96 postoperatively	10% not able to RTS (5% professional, 15% collegiate), 0.5% THA, 2% repeat scope	Microfracture and bipolar cartilage lesion RTS 92%
Gedouin et al[24]	110	10 mo	WOMAC improved from 60 preoperatively to 83 postoperatively; 77% satisfied or very satisfied with result	4% THA or resurfacing arthroplasty	Patients with early OA had significantly lower WOMAC scores than those without OA
Malviya et al[41]	80	1.4 y	HHS improved from 61 preoperatively to 84 postoperatively; NAHS improved from 68 to 88	NR	Lower mean time to RTS for professional versus recreational athletes
Nho et al[49]	47	27 mo	HHS improved from 69 preoperatively to 85 postoperatively; HOS improved from 79 preoperatively to 91 postoperatively	7% unable to return to same level of play	Alpha angle correction from 76 degrees preoperatively to 51 postoperatively
Fabricant et al[20]	21[a]	1.5 y	HHS improved by 21 points and HOS improved by 16 points; all self-reported athletic participation improved	No intra- or postoperative complications or reoperations	No difference in final scores for labral debridement versus refixation

FAI, femoroacetabular impingement; HHS, Harris Hip Score; HOS, Hip Outcome Score; NAHS, Non-Arthritic Hip Score; NR, not reported; OA, osteoarthritis; QoL, quality of life; RTS, return to sport; SF-12, Short Form–12; THA, total hip arthroplasty; VAS, visual analog scale.
[a]Age < 20 y.

Table 2. Selected studies investigating arthroscopic treatment of labral pathology in FAI

Study	Patients, No.	Follow-up	Main Outcomes	Complications/ Failures	Other Findings
Schilders et al[54]	96	2.4 y	HHS in the labral repair group improved more than in the labral resection group	No patient went on to THA	No significant effect of cartilage lesions on HHS
Larson et al[39]	94	42 mo	HHS, SF-12, and VAS all improved in labral refixation group versus labral debridement group	2 patients revision surgery for HO, 2 revision arthroscopy, 1 THA	No difference in reduction of alpha angle between groups
Haviv and O'Donnell[27]	81	3 y	HHS and NAHS improved by 18 and 17 points postoperatively, respectively; synovitis and cartilage lesions had negative effect on postoperative outcome	3 patients THA	No effect of labral tear type on outcome
Larson and Giveans[37]	75	19 mo	Labral refixation group with improved HHS versus labral debridement	HHS < 70, revision surgery, THA—11% debridement, 8% refixation ($P > 0.05$)	No difference in SF-12 or VAS postoperatively
Espinosa et al[19]	52[a]	2 y	Merle d'Aubigne score better at 1 and 2 years for labral reattachment group versus labral resection group	NR	Radiographic arthritis more prevalent in labral resection group at 1 and 2 years

FAI, femoroacetabular impingement; HHS, Harris Hip Score; HO, heterotopic ossification; NAHS, Non-arthritic Hip Score; NR, not reported; SF-12, Short Form–12; THA, total hip arthroplasty; VAS, visual analog scale.
[a]Open dislocation.

FUTURE DIRECTIONS

One of the main controversies among different treatment centers is whether young, asymptomatic patients with the anatomy of FAI should undergo prophylactic surgical treatment.[11] Identification of patients who may benefit from prophylactic surgery may be aided by new methods of advanced imaging. Standard magnetic resonance sequences cannot detect the biochemical changes that precede morphologic changes. Furthermore, dGEMRIC imaging can quantify the spatial variations in glycosaminoglycans, the main constituent of articular cartilage besides water, which heralds the onset of cartilage degradation.[3,4]

CONCLUSION

The treatment of FAI is a moving target currently under debate and unresolved. Only rigorous scientific investigation in well-designed biomechanical and clinical investigations can enhance our knowledge and ultimately improve the treatment of FAI.

REFERENCES

1. Anderson LA, Peters CL, Park BB, Stoddard GJ, Erickson JA, Crim JR. Acetabular cartilage delamination in femoroacetabular impingement: risk factors and magnetic resonance imaging diagnosis. *J Bone Joint Surg Am.* 2009;91:305-313.
2. Audenaert E, Van Houcke J, Maes B, Vanden Bossche L, Victor J, Pattyn C. Range of motion in femoroacetabular impingement. *Acta Orthop Belg.* 2012;78:327-332.
3. Bashir A, Gray ML, Boutin RD, Burstein D. Glycosaminoglycan in articular cartilage: in vivo assessment with delayed Gd(DTPA)(2-)-enhanced MR imaging. *Radiology.* 1997;205:551-558.
4. Bashir A, Gray ML, Hartke J, Burstein D. Nondestructive imaging of human cartilage glycosaminoglycan concentration by MRI. *Magn Reson Med.* 1999;41:857-865.
5. Beaule PE, Hynes K, Parker G, Kemp KA. Can the alpha angle assessment of cam impingement predict acetabular cartilage delamination? *Clin Orthop Relat Res.* 2012;470:3361-3367.

6. Bedi A, Dolan M, Hestroni I, et al. Surgical treatment of femoroacetabular impingement improves hip kinematics: a computer-assisted model. *Am J Sports Med.* 2011;39:43S-49S.
7. Bedi A, Galano G, Walsh C, Kelly BT. Capsular management during hip arthroscopy: from femoroacetabular impingement to instability. *Arthroscopy.* 2011;27:1720-1731.
8. Bedi A, Kelly BT. Femoroacetabular impingement. *J Bone Joint Surg Am.* 2013;95:82-92.
9. Bedi A, Kelly NH, Baad M, et al. Dynamic contact mechanics of the medial meniscus as a function of radial tear, repair, and partial meniscectomy. *J Bone Joint Surg Am.* 2010;92:1398-1408.
10. Bedi A, Zaltz I, De La Torre K, Kelly BT. Radiographic comparison of surgical hip dislocation and hip arthroscopy for treatment of cam deformity in femoroacetabular impingement. *Am J Sports Med.* 2011;39:20S-28S.
11. Brockenbrough G. Many patients with FAI may benefit from hip arthroscopy. *Orthopedics Today.* http://www.healio.com/orthopedics/arthritis/news/print/orthopedics-today/%7B6d4b4704-01bd-427e-8f07-18fa9378f0e6%7D/many-patients-with-fai-may-benefit-from-hip-arthroscopy.
12. Buchler L, Neumann M, Schwab JM, Iselin L, Tannast M, Beck M. Arthroscopic versus open cam resection in the treatment of femoroacetabular impingement. *Arthroscopy.* 2013;29:653-660.
13. Byrd JW, Jones KS. Arthroscopic femoroplasty in the management of cam-type femoroacetabular impingement. *Clin Orthop Relat Res.* 2009;467:739-746.
14. Byrd JW, Jones KS. Arthroscopic management of femoroacetabular impingement in athletes. *Am J Sports Med.* 2011;39:7S-13S.
15. Byrd JW, Jones KS. Diagnostic accuracy of clinical assessment, magnetic resonance imaging, magnetic resonance arthrography, and intra-articular injection in hip arthroscopy patients. *Am J Sports Med.* 2004;32:1668-1674.
16. Byrd JW, Jones KS. Prospective analysis of hip arthroscopy with 10-year followup. *Clin Orthop Relat Res.* 2010;468:741-746.
17. Cadet ER, Chan AK, Vorys GC, Gardner T, Yin B. Investigation of the preservation of the fluid seal effect in the repaired, partially resected, and reconstructed acetabular labrum in a cadaveric hip model. *Am J Sports Med.* 2012;40:2218-2223.
18. Crawford MJ, Dy CJ, Alexander JW, et al. The 2007 Frank Stinchfield Award: the biomechanics of the hip labrum and the stability of the hip. *Clin Orthop Relat Res.* 2007;465:16-22.
19. Espinosa N, Rothenfluh DA, Beck M, Ganz R, Leunig M. Treatment of femoro-acetabular impingement: preliminary results of labral refixation. *J Bone Joint Surg Am.* 2006;88:925-935.
20. Fabricant PD, Heyworth BE, Kelly BT. Hip arthroscopy improves symptoms associated with FAI in selected adolescent athletes. *Clin Orthop Relat Res.* 2012;470:261-269.
21. Ferguson SJ, Bryant JT, Ganz R, Ito K. The acetabular labrum seal: a poroelastic finite element model. *Clin Biomech.* 2000;15:463-468.
22. Freehill MT, Safran MR. The labrum of the hip: diagnosis and rationale for surgical correction. *Clin Sports Med.* 2011;30:293-315.
23. Ganz R, Parvizi J, Beck M, Leunig M, Notzli H, Siebenrock KA. Femoroacetabular impingement: a cause for osteoarthritis of the hip. *Clin Orthop Relat Res.* 2003;417:112-120.
24. Gedouin JE, May O, Bonin N, et al. Assessment of arthroscopic management of femoroacetabular impingement: a prospective multicenter study. *Orthop Traum Surg Res.* 2010;96:S59-S67.
25. Gold SL, Burge AJ, Potter HG. MRI of hip cartilage: joint morphology, structure, and composition. *Clin Orthop Relat Res.* 2012;470:3321-3331.
26. Hack K, Di Primio G, Rakhra K, Beaule PE. Prevalence of cam-type femoroacetabular impingement morphology in asymptomatic volunteers. *J Bone Joint Surg Am.* 2010;92:2436-2444.
27. Haviv B, O'Donnell J. Arthroscopic treatment for acetabular labral tears of the hip without bony dysmorphism. *Am J Sports Med.* 2011;39:79S-84S.
28. Hetsroni I, Poultsides L, Bedi A, Larson CM, Kelly BT. Anterior inferior iliac spine morphology correlates with hip range of motion: a classification system and dynamic model [published online February 15, 2013]. *Clin Orthop Relat Res.*
29. Heyworth BE, Shindle MK, Voos JE, Rudzki JR, Kelly BT. Radiologic and intraoperative findings in revision hip arthroscopy. *Arthroscopy.* 2007;23:1295-1302.
30. Hunt D, Prather H, Harris Hayes M, Clohisy JC. Clinical outcomes analysis of conservative and surgical treatment of patients with clinical indications of prearthritic, intra-articular hip disorders. *PM R.* 2012;4:479-487.
31. Jung KA, Restrepo C, Hellman M, AbdelSalam H, Morrison W, Parvizi J. The prevalence of cam-type femoroacetabular deformity in asymptomatic adults. *J Bone Joint Surg Br.* 2011;93:1303-1307.
32. Kassarjian A, Belzile E. Femoroacetabular impingement: presentation, diagnosis, and management. *Semin Musculoskelet Radiol.* 2008;12:136-145.
33. Kelly BT, Weiland DE, Schenker ML, Philippon MJ. Arthroscopic labral repair in the hip: surgical technique and review of the literature. *Arthroscopy.* 2005;21:1496-1504.
34. Kivlan BR, Martin RL, Sekiya JK. Response to diagnostic injection in patients with femoroacetabular impingement, labral tears, chondral lesions, and extra-articular pathology. *Arthroscopy.* 2011;27:619-627.
35. Kubiak-Langer M, Tannast M, Murphy SB, Siebenrock KA, Langlotz F. Range of motion in anterior femoroacetabular impingement. *Clin Orthop Relat Res.* 2007;458:117-124.
36. Lage LA, Patel JV, Villar RN. The acetabular labral tear: an arthroscopic classification. *Arthroscopy.* 1996;12:269-272.
37. Larson CM, Giveans MR. Arthroscopic debridement versus refixation of the acetabular labrum associated with femoroacetabular impingement. *Arthroscopy.* 2009;25:369-376.
38. Larson CM, Giveans MR, Stone RM. Arthroscopic debridement versus refixation of the acetabular labrum associated with femoroacetabular impingement: mean 3.5-year follow-up. *Am J Sports Med.* 2012;40:1015-1021.
39. Larson CM, Giveans MR, Taylor M. Does arthroscopic FAI correction improve function with radiographic arthritis? *Clin Orthop Relat Res.* 2011;469:1667-1676.
40. Laude F, Sariali E, Nogier A. Femoroacetabular impingement treatment using arthroscopy and anterior approach. *Clin Orthop Relat Res.* 2009;467:747-752.
41. Malviya A, Paliobeis CP, Villar RN. Do professional athletes perform better than recreational athletes after arthroscopy for femoroacetabular impingement? [published online March 1, 2013]. *Clin Orthop Relat Res.*
42. Malviya A, Stafford GH, Villar RN. Impact of arthroscopy of the hip for femoroacetabular impingement on quality of life at a mean follow-up of 3.2 years. *J Bone Joint Surg Br.* 2012;94:466-470.
43. Matsuda DK, Carlisle JC, Arthurs SC, Wierks CH, Philippon MJ. Comparative systematic review of the open dislocation, mini-open, and arthroscopic surgeries for femoroacetabular impingement. *Arthroscopy.* 2011;27:252-269.
44. Myers CA, Register BC, Lertwanich P, et al. Role of the acetabular labrum and the iliofemoral ligament in hip stability: an in vitro biplane fluoroscopy study. *Am J Sports Med.* 2011;39:85S-91S.
45. Naal FD, Miozzari HH, Schar M, Hesper T, Notzli HP. Midterm results of surgical hip dislocation for the treatment of femoroacetabular impingement. *Am J Sports Med.* 2012;40:1501-1510.
46. Naal FD, Miozzari HH, Wyss TF, Notzli HP. Surgical hip dislocation for the treatment of femoroacetabular impingement in high-level athletes. *Am J Sports Med.* 2011;39:544-550.
47. Nepple JJ, Lehmann CL, Ross JR, Schoenecker PL, Clohisy JC. Coxa profunda is not a useful radiographic parameter for diagnosing pincer-type femoroacetabular impingement. *J Bone Joint Surg Am.* 2013;95:417-423.
48. Nepple JJ, Martel JM, Kim YJ, Zaltz I, Clohisy JC. Do plain radiographs correlate with CT for imaging of cam-type femoroacetabular impingement? *Clin Orthop Relat Res.* 2012;470:3313-3320.
49. Nho SJ, Magennis EM, Singh CK, Kelly BT. Outcomes after the arthroscopic treatment of femoroacetabular impingement in a mixed group of high-level athletes. *Am J Sports Med.* 2011;39:14S-19S.
50. Philippon MJ, Briggs KK, Hay CJ, Kuppersmith DA, Dewing CB, Huang MJ. Arthroscopic labral reconstruction in the hip using iliotibial band autograft: technique and early outcomes. *Arthroscopy.* 2010;26:750-756.
51. Philippon MJ, Briggs KK, Yen YM, Kuppersmith DA. Outcomes following hip arthroscopy for femoroacetabular impingement with associated chondrolabral dysfunction: minimum two-year follow-up. *J Bone Joint Surg Br.* 2009;91:16-23.
52. Philippon MJ, Stubbs AJ, Schenker ML, Maxwell RB, Ganz R, Leunig M. Arthroscopic management of femoroacetabular impingement: osteoplasty technique and literature review. *Am J Sports Med.* 2007;35:1571-1580.
53. Safran MR. The acetabular labrum: anatomic and functional characteristics and rationale for surgical intervention. *J Am Acad Orthop Surg.* 2010;18:338-345.
54. Schilders E, Dimitrakopoulou A, Bismil Q, Marchant P, Cooke C. Arthroscopic treatment of labral tears in femoroacetabular impingement: a comparative study of refixation and resection with a minimum two-year follow-up. *J Bone Joint Surg Br.* 2011;93:1027-1032.

55. Siebenrock KA, Kalbermatten DF, Ganz R. Effect of pelvic tilt on acetabular retroversion: a study of pelves from cadavers. *Clin Orthop Relat Res.* 2003;407:241-248.
56. Siebenrock KA, Schoeniger R, Ganz R. Anterior femoro-acetabular impingement due to acetabular retroversion: treatment with periacetabular osteotomy. *J Bone Joint Surg Am.* 2003;85:278-286.
57. Smith MV, Panchal HB, Ruberte Thiele RA, Sekiya JK. Effect of acetabular labrum tears on hip stability and labral strain in a joint compression model. *Am J Sports Med.* 2011;39:103S-110S.
58. Tannast M, Kubiak-Langer M, Langlotz F, Puls M, Murphy SB, Siebenrock KA. Noninvasive three-dimensional assessment of femoroacetabular impingement. *J Orthop Res.* 2007;25:122-131.
59. Walker JA, Pagnotto M, Trousdale RT, Sierra RJ. Preliminary pain and function after labral reconstruction during femoroacetabular impingement surgery. *Clin Orthop Relat Res.* 2012;470:3414-3420.
60. Zingg PO, Ulbrich EJ, Buehler TC, Kalberer F, Poutawera VR, Dora C. Surgical hip dislocation versus hip arthroscopy for femoroacetabular impingement: clinical and morphological short-term results. *Arch Orthop Trauma Surg.* 2013;133:69-79.