Current Concepts Review

Femoroacetabular Impingement

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Both arthroscopic and open operative treatment of femoroacetabular impingement (FAI) can reproducibly relieve hip pain with correction of the underlying osseous deformity and treatment of the associated labral pathology, particularly in patients without substantial articular cartilage injury at the time of surgery.

Between 75% and 90% of athletes undergoing FAI surgery return to sports at their pre-injury level of function. There is no peer-reviewed evidence to date reporting on the efficacy of nonoperative treatment and return to play with FAI.

Successful operative treatment of impingement requires appropriate and complete correction of the mechanical injury that led to the symptomatic labral pathology.

Early intervention prior to the onset of irreversible chondral damage is critical to the long-term success of FAI surgery.

Complex deformities involving combinations of static and dynamic mechanical factors often coexist, so careful preoperative evaluation of the underlying structural anatomy is critical to successful treatment planning.

The development of symptomatic hip disorders in the non-arthritic hip is related to the underlying structural anatomy of the hip joint and the impact of superimposed cyclic mechanical loads and/or acute injuries of daily and athletic activity. Ganz and colleagues have elucidated the complexities of the structural anatomy of the hip joint and the various ways that pathologic hip structure affects the loading characteristics of the hip. Femoroacetabular impingement (FAI) likely represents the most common mechanism that leads to the development of early cartilage and labral damage in the nondysplastic hip. While the combination of dynamic and static factors that impact the mechanics of the hip joint are complex, the most common structural deformities are a loss of femoral head-neck offset (cam-type lesion), focal or global acetabular overcoverage (pincer-type lesion), or combined impingement deformity. These anatomic abnormalities of the proximal part of the femur and/or acetabulum result in the occurrence of repetitive collisions during dynamic hip motion, which leads to regional loading of the femoral head-neck junction against the acetabular rim and precipitate labral injury, chondral delamination, and a degenerative cascade of more extensive, nonfocal intra-articular injuries. These injuries are commonly localized to the anterosuperior region of the acetabular rim and frequently are associated with concomitant cartilaginous injury to the adjacent transition zone of the articular cartilage within the acetabulum. The severity of the labral injury and associated cartilaginous injury often depends on the duration of the untreated injury, suggesting the importance of early diagnosis and treatment. The location of the injury pattern depends highly on the osseous structure, and the ability for labral and chondral healing is compromised by the relative avascularity of the region.

Pathophysiology

Approximately 90% of patients with labral pathology have underlying structural abnormalities in femoral and/or acetabular morphology. Historically, alterations in hip joint mechanics...
1. Dynamic factors
   A. Loss of offset and sphericity of femoral head-neck junction (cam-type lesions)
   B. Acetabular overcoverage
      i. Focal rim impingement lesion
      a. Cephalic retroversion (focal rim lesion)
      b. True acetabular retroversion
      ii. Global overcoverage of acetabulum—profunda and protrusio deformity
   C. Extra-articular impingement
      i. Femoral retroversion
      ii. Femoral varus
      iii. Trochanteric impingement
      iv. Allis impingement

2. Static factors
   A. Anterior or lateral undercoverage of acetabulum (dysplasia)
   B. Femoral anteversion
   C. Femoral valgus
3. Dynamic instability—posterior hip subluxation
4. Common combined patterns
   A. Impingement with femoral retroversion
   B. Paradoxical acetabular dysplasia with FAI

5. Compensatory injury patterns with FAI
   A. Anterior enthesopathy
      i. Hip flexor strains
      ii. Psoas impingement
      iii. Sub-spine impingement
   B. Medial enthesopathy
      i. Athletic pubalgia (adductor tendinopathy and rectus abdominis tendinopathy)
      ii. Osteitis pubis
   C. Posterior compensatory injury
      i. Proximal hamstring strains
      ii. Deep gluteal syndrome
      iii. SJ joint dysfunction
   D. Lateral enthesopathies
      i. Abductor injury
      ii. ITB syndrome

Fig. 1
A list of static and dynamic mechanical factors for prearthritic hip pain.
AIIS = anterior inferior iliac spine, FAI = femoroacetabular impingement,
SI = sacroiliac joint, and ITB = iliobibial band.

have been thought of as a continuum between so-called undercoverage (dysplasia) and overcoverage (FAI). Often, however, there are complex combinations of both dynamic and static mechanical factors.

Static factors result in abnormal stress and asymmetric load between the femoral head and acetabulum in the standing position. These mechanical stresses lead to hip pain related to insufficient congruency between the femoral head and the socket, which leads to asymmetric wear of the chondral surfaces of the acetabulum and femoral head with or without associated instability of the hip. Hip pain related to static overload does not require motion across the hip. In contrast, dynamic factors result in abnormal stress and contact between the femoral head and acetabular rim with terminal motion of the hip. These mechanical stresses result in reactive hip pain with movement of the hip into the flexed position, resulting in abnormal engagement between the femoral head and the acetabulum. These alterations in the mechanics of the hip joint can result in changes in the dynamic muscle forces and strains across the pelvis and typically affect the adductor longus, proximal hamstrings, hip abductors, iliopsoas, and hip flexor muscles (Fig. 1).

Loss of Femoral Head-Neck Offset (Cam-Type Lesions)
Loss of femoral head-neck offset and asphericity commonly contribute to prearthritic hip pain, especially in young athletic males. Cam-type lesions on the femoral head lead to shear forces of the spherical portion of the femoral head against the acetabulum (Fig. 2). Repetitive entry of this cam-type lesion into the hip joint, typically during flexion and internal rotation, results in a characteristic pattern of shear injury to the transition zone and adjacent articular cartilage. Resulting chondral delamination and detachment ensues over time. These cartilage lesions may be treated with simple debridement, reattachment with adhesives (e.g., fibrin glue), abrasion chondroplasty, or microfracture, although the long-term structural outcomes of these treatments remain unknown. The location of the labral tear and cartilage delamination injury is predictable on the basis of the location and topography of the cam-type lesion (Fig. 3).

Labral tears with cam-type impingement result from compression of the labrum between the aspherical femoral head and acetabular rim and more commonly result in detachment at the transition-zone cartilage rather than intrasubstance injury. As compared with intrasubstance tears, these tears have more favorable healing rates after repair because of the improved tissue quality and vascular supply from the capsule at this peripheral location. Beck et al. found that cam-type impingement caused damage to the anterosuperior acetabular cartilage, with separation between the labrum and cartilage. During flexion, the nonspherical femoral head resulted in chondral delamination but was relatively sparing of associated labral injury. Johnston et al. studied the relationship between the size of cam-type lesions, as quantified by the radiographic alpha angle, and the presence of cartilage damage, labral injury, and change in the range of motion in hips with FAI. The alpha angle defines the concavity of the head-neck junction by measuring the point of deviation of femoral-head sphericity relative to a central head-neck axis (Fig. 4, Appendix). In eighty-two patients who underwent operative intervention, a higher offset alpha angle was associated with the presence of chondral defects of the acetabular rim (p ≤ 0.044) and full-thickness delamination of the acetabular cartilage (p ≤ 0.034). Patients with detachment of the base of the labrum had a higher offset alpha angle (p ≤ 0.016).

Cam-type lesions can effectively be addressed with arthroscopy or open surgical dislocation and osteoplasty. Mardones et al. compared these techniques in both cadaveric and clinical studies and found no significant differences in any of...
the measurements of resection. Whether the procedure is performed in an open or arthroscopic fashion, the deformity correction achieved with the osteochondroplasty is maintained and recorticalization occurs in the majority of patients during the first two years. Using preoperative and postoperative alpha-angle measurements on extended-neck lateral radiographs, Bedi et al. identified no significant difference in achieved correction between surgical dislocation (thirty patients) and arthroscopic decompression (thirty patients).

Cephalad Retroversion of the Acetabulum (Pincer-Type Lesions)

A focal rim lesion, or cephalad retroversion of the acetabulum, is a distinct dynamic mechanical cause of FAI that is common in females and that results in repetitive contact stresses of a normal femoral neck against an abnormal area of focal acetabular overcoverage (Fig. 2-B). On a well-aligned anteroposterior radiograph with neutral tilt and rotation, this focal anterosuperior overcoverage may present as a crossover and/or ischial spine sign, but this method has limited reliability compared with computed tomography. These findings result from relative or absolute retroversion of the acetabulum anterosuperiorly and more normal anteversion inferomedially. Focal rim lesions need to be distinguished from global overcoverage and impingement, which can result from coxa profunda, coxa protrusio, true acetabular retroversion, or even iatrogenic overcorrection after periacetabular osteotomy.

Repetitive abutment of the femoral head-neck junction on the abnormal acetabular rim in flexion and rotation results in degeneration and tearing of the labrum anterosuperiorly, and the characteristic posteroinferior contrecoup pattern of cartilage loss of the femoral head and acetabulum. Contrecoup chondral injury may result from flexion or rotation of the hip beyond engagement of the focal rim lesion, leading to levering of the femoral head and abnormal shear forces on the posterior chondral surfaces. In contrast to cam-induced injury, rim-impingement lesions typically induce primary, intra-substance labral injury and are often less reparable. Heterotopic bone apposition often occurs on the osseous rim adjacent to the base of the labrum and can progress to ossification of the entire, damaged labrum anterosuperiorly. In later stages, the bone formation cannot be distinguished from the native bone, and the labrum may be absent on imaging. Overall, a focal rim lesion results in relatively limited chondral damage as compared with the deep chondral injury and delamination that are associated with cam-type impingement.

Pincer-type impingement secondary to prominence of the anterior inferior iliac spine below the acetabular margin has been reported as a potential cause of pathologic impingement with direct hip flexion and/or internal rotation. Impingement of the anterior inferior iliac spine on the subspine may be developmental or the result of a prior anterior inferior iliac spine avulsion or pelvic osteotomy. Subspine decompression in these select cases has been reported with satisfactory clinical outcome.

Impingement Patterns

Mixed impingement with both femoral and acetabular deformity is the most common FAI pattern. Allen et al. reported on 113 patients who had a symptomatic cam-type impingement...
deformity of at least one hip. Bilateral cam-type deformity was present in eighty-eight patients (77.9%), while only twenty-three (26.1%) of those had bilateral hip pain. Painful hips had a mean alpha angle that was significantly higher than that of asymptomatic hips (69.9° versus 63.1°, p < 0.001). Among 201 hips with a cam-type impingement deformity, 42% also had a focal rim deformity. Laborie et al. reported on the population-based prospective follow-up of 2081 (874 male and 1207 female) young adults from a larger study cohort of 4006 young adults. The cohort was composed of all 5068 newborns who had been delivered at the primary research institution in 1989; 1062 were excluded from the follow-up because of death or emigration. Cam-type deformities were seen in the 868 male and 1192 female participants, respectively, as follows: pistol-grip deformity, 187 (21.5%) and thirty-nine (3.3%); focal femoral neck prominence, eighty-nine (10.3%) and thirty-one (2.6%); and flattening of the lateral femoral head, 125 (14.4%) and seventy-four (6.2%). Pincer-type deformities were seen in those same 868 male and 1192 female participants, respectively, as follows: posterior wall sign, 203 (23.4%) and 131 (11.0%); and excessive acetabular coverage, 127 (14.6%) and fifty-eight (4.9%) (all p < 0.001, according to sex distribution). The crossover sign was seen on radiographs in 446 (51.4%) and 542 (45.5%) of the male and female participants, respectively (p = 0.004). A high degree of coexistence (odds ratio [OR] > 2) among most FAI findings was reported.

Relative or absolute femoral retroversion can exacerbate symptoms and loss of motion from FAI because reduced hip flexion and/or internal rotation is necessary for engagement of a cam-type or rim-type lesion. Even in the absence of femoral or acetabular deformity, retroversion of the femur increases functional external rotation and reduces internal rotation of the hip. A cam-type lesion in a patient with normal or increased femoral anteverision may not be symptomatic until the terminal range of hip flexion and internal rotation with no substantial restriction in range of motion, whereas this same lesion in a retroverted femur may engage the rim with minimal internal rotation, resulting in substantial pain and loss of internal rotation with daily activities.

Dynamic instability occurs with posterior hip subluxation as a result of early contact of the femoral head against the acetabulum. The spectrum of posterior instability of the hip ranges from subluxation to frank dislocation. The most common traumatic mechanism of injury in athletic competition is a fall on a flexed and adducted hip with a posteriorly directed force. Atraumatic and lower-energy mechanisms of hip instability have also been described. It has been proposed that capsular tissue laxity or abnormal osseous morphology may predispose the athlete to hip instability. The arthroscopic management of a traumatic dislocation of a hip that had predisposing anterior impingement pathology has recently been reported. Ilizaliturri et al., who reported on seventeen patients who were surgically treated for mechanical symptoms after traumatic posterior dislocation of the hip, reported the presence of labral tears and chondral injury consistent with anterior impingement in fourteen patients.

The combination of dysplasia and FAI can also occur. Clohisy et al. reported on a series of patients with acetabular dysplasia in association with deformity of the proximal part of the femur, which resulted in hip dysfunction. The authors concluded that a periacetabular osteotomy combined with concurrent femoral procedures can provide comprehensive deformity correction and improved hip function for this complex pattern of FAI and dysplasia.

Etiology

The etiology of the cam-type and rim-type impingement morphology in humans remains controversial and incompletely defined. Evolutionary explanations have been offered. Hogervorst et al. described two stereotypical mammalian hips (i.e., coxa recta and coxa rotunda) as possible adaptations that occurred in response to the activities of running (coxa recta) and climbing and swimming (coxa rotunda). The evolutionary conflict between upright gait and the birth of a large-brained fetus is expressed in the female pelvis and hip, and can explain the pincer-type impingement that occurs in association with coxa profunda. Slipped capital femoral epiphysis or related injury has also been implicated in the etiology of FAI, and the aspherical osteocartilaginous bump could be associated with an extended physis that results from increased loading of the hip during late childhood and early adolescence.

Genetic factors may have a role in the etiology of FAI. Pollard et al. studied ninety-six siblings of sixty-four patients treated for primary impingement and compared them with a spouse control group of seventy-seven individuals. The siblings of patients with a cam-type deformity had a relative risk of 2.8 of having the same deformity, and the siblings of patients with a pincer-type deformity had a relative risk of 2.0 of having the same deformity. Bilateral deformity occurred more often in the sibling group than it did in the spouse control group.

Geographical variation also plays a part in the incidence of FAI. The prevalence is low in the Eastern world, with only six preoperative cases reported among 946 primary hip replacements for osteoarthritis.

Management Options

Nonoperative Treatment

Nonoperative management is often advisable for FAI and typically consists of activity modification, anti-inflammatory medication, abductor strengthening, and hip-motion exercises. The physical therapy program should be individualized on the basis of factors such as athletic demands, restriction in range of motion, and objective weakness in muscle strength-testing. The rehabilitation program must not only improve soft-tissue mobility and restore strength of the hip abductors and perarticular musculature but also emphasize improved neuromuscular control and postural balance. Adjustments in posture and core strength may create subtle changes in the position of the lumbar spine and pelvis to avoid impingement in terminal motion. However, there are no data demonstrating the efficacy of these interventions with regard to achieving functional improvement or altering the
natural history of progressive degenerative changes in patients with symptomatic FAI. The effect of nonoperative management on the natural history and progression of degenerative changes in patients with FAI is also unknown. Hartofilakidis et al. retrospectively examined the outcome of ninety-six asymptomatic hips in ninety-six patients (mean age, 49.3 years) for whom there was radiographic evidence of FAI. Overall, seventy-nine hips (82.3%) remained free of osteoarthritis for a mean of 18.5 years (range, ten to forty years). Only the presence of idiopathic osteoarthritis of the contralateral diseased hip was predictive of development of osteoarthritis on the asymptomatic side.

Operative Treatment
Operative treatment of symptomatic FAI should primarily address all contributory mechanical factors to the symptomatic impingement and secondarily address the resultant intra-articular pathology. The specific approach must be individualized and depends on the pattern and extent of pathology.

Independent of approach, the goals of surgery are to relieve pain, improve function and return to activity, and prevent degeneration of the hip joint. 

Open surgical approaches include surgical dislocation of the hip, the Smith-Petersen approach or Heuter anterior arthrotomy, and anteversion periacetabular osteotomy. Surgical dislocation, described by Ganz et al., utilizes a trochanteric slide osteotomy and protects the short external rotators to preserve the blood supply to the femoral head, allowing for direct, circumferential visualization of the acetabular rim and femoral head-neck junction to address osseous deformity and chondral and labral pathology. Naal et al. reported on twenty-two male athletes (mean age plus standard deviation, 19.7 ± 2.2 years) at a mean of 45.1 months after surgical hip dislocation for the treatment of symptomatic hip impingement. At the time of follow-up, twenty-one of twenty-two patients (95%) were still competing professionally and eighteen (82%) were satisfied with their hip surgery. Surgical dislocation can safely achieve an extensile...
exposure to the native hip, but complications of this technically demanding procedure may include trochanteric osteotomy non-union, osteonecrosis of the femoral head, heterotopic ossification, and persistent weakness of the hip abductor musculature.

The anteversion periacetabular osteotomy is an uncommonly performed treatment for pincer-type rim impingement secondary to global acetabular retroversion and posterior-wall insufficiency. Siebenrock et al. reported on twenty-nine hips in twenty-two patients who underwent periacetabular osteotomy for symptomatic anterior impingement secondary to acetabular retroversion. Arthrotomy was performed in twenty-six hips to visualize intra-articular lesions and improve a low

Fig. 3-C

**Fig. 3-C** Intraoperative arthroscopic images of the central compartment, demonstrating the labral tear and delaminating chondral injury.

Fig. 4

Anteroposterior (Fig. 4-A) and Dunn lateral (Fig. 4-B) radiographic images depicting alpha (α), beta (β), and center-edge (CE) angles as well as the femoral head-neck offset.
femoral head-neck offset. At a mean follow-up of thirty months, the average ranges of internal rotation, flexion, and adduction increased significantly. The mean Merle d’Aubigné-Postel score increased 2.9 points ($p < 0.001$), and the result was good or excellent for twenty-six hips$^{60}$. The return to competitive athletic play after periacetabular osteotomy for symptomatic impingement, however, has not been reported. Periacetabular osteotomy is also very technically demanding. Complications may include inadequate correction of deformity, intra-articular osteotomy, nonunion of the superior pubic ramus, loss of fixation and correction, symptomatic implants, and neurovascular injury$^{120}$.

Arthroscopic techniques have evolved to allow for effective and comprehensive treatment of various impingement patterns. Techniques for extensive arthroscopic capsulotomies have allowed for improved central and peripheral compartment exposure and access for labral takedown, refixation, treatment of chondral injury, and osteochondroplasty of the femoral head-neck junction and acetabular rim (Fig. 5)$^{60,74,121}$. The management of the capsule can be critical and must allow for an improved exposure without compromising stability and kine-ematics of the hip. If an extensive capsulotomy to address peripheral compartment pathology is necessary, it should be made between the lateral and medial synovial folds and parallel with the femoral neck to avoid injury to the retinacular perfusing branches of the medial and lateral femoral circumflex arteries. At the conclusion of the procedure, the medial and lateral capsular flaps are anatomically reduced, restoring the tension and stabilizing function of the iliofemoral ligament$^{120}$.

Recent studies have established that open surgical dislocation and an arthroscopic approach may have comparable efficacy in achieving a surgical correction of impingement deformity. Bedi et al.$^{83}$ reported on sixty active, male patients who underwent either open (surgical hip dislocation) or arthroscopic surgery for symptomatic FAI. Thirty patients underwent arthroscopic osteochondroplasty with labral debridement and/or refixation for the treatment of cam-type impingement deformity and/or rim defects; and thirty underwent open surgical dislocation, osteochondroplasty for the treatment of cam-type impingement deformity and/or rim defects, and labral debridement or refixation. In the arthroscopic group, the extended-neck lateral alpha angle was reduced by a mean of 17.2° ($28.3\%$, $p < 0.05$), the anterior femoral head-neck offset was improved by 5.0 mm ($111\%$, $p < 0.05$), and the beta angle was increased by a mean of 23.1°. In the open dislocation group, the extended-neck lateral alpha angle was reduced by a mean of 21.2° ($30.7\%$, $p < 0.05$), the anterior femoral head-neck offset was improved by 6.56 mm ($108\%$, $p < 0.05$), and the beta angle was increased by a mean of 18.35°. There were no significant differences in deformity correction between the two treatment groups$^{83}$. Botser et al.$^{123}$ recently assessed differences in outcomes after arthroscopic, open, or combined surgical approaches for symptomatic hip impingement (1462 hips in 1409 patients). Labral repair was performed more frequently in open surgical dislocation (45%) and combined approach (41%) procedures than in arthroscopies (23%). Mean improvement in the modified Harris hip score after surgery was 26.4 points for arthroscopy, 20.5 points for open surgical dislocation, and 12.3 points for the combined approach. A higher rate of return to sport was reported for arthroscopy in professional athletes than for open surgical dislocation. The overall rate of complication was highest in the combined approach group (16%)$^{123}$.

**Outcomes**

Numerous studies have established, on the basis of available short-term to midterm follow-up (Appendix), that open surgical dislocation, mini-open approaches, and arthroscopy are all effective methods to treat symptomatic FAI$^{113,124-130}$. To our knowledge, there is no peer-reviewed literature available to date on the efficacy of nonoperative management for symptomatic FAI. On the basis of a systematic review of the literature from 1980 to 2008, Bedi et al.$^{13}$ reported that open surgical dislocation with labral debridement and osteochondroplasty was a successful treatment for FAI, with a good correlation between patient satisfaction and favorable outcomes (at a mean of forty months after surgery) as defined by the Harris hip score or Merle d’Aubigné-Postel score. A common finding in all series was an increased incidence of failure among patients with substantial preexisting osteoarthritis. Patients treated arthroscopically for a labral tear and associated FAI did well$^{13}$. The substantial range and variation in clinical outcome reflect the heterogeneous patient populations, inclusion criteria, and surgical techniques that were utilized.

Additional systematic reviews and analyses of the literature have reported similar results. Clohisy et al.$^{7}$ reviewed eleven level-III or level-IV studies of FAI that together had a mean follow-up of 3.2 years. The Merle d’Aubigné-Postel score was most commonly utilized, and improvement ranged from 2.4 to 5
points. Reduced pain and improvement in hip function were reported in 68% to 96% of patients. Poor prognostic factors included advanced preoperative osteoarthritis, advanced chondral degeneration, and older age. Ng et al. reported on twenty-three case studies (970 cases) on the surgical treatment of FAI. Although treatment of FAI consistently improved mean hip function, patient satisfaction was not universally positive, and worse outcomes were noted in patients with Tönnis grade-2 osteoarthritis on preoperative imaging and/or Outerbridge grade-3 or 4 cartilage damage noted intraoperatively.

Matsuda et al. recently performed a comparative systematic review of the open surgical dislocation, mini-open, and arthroscopic surgical approaches for FAI (six, four, and eight studies, respectively), concluding that all approaches were effective in pain relief and improvement in function with short-term to midterm follow-up. Open surgical dislocation was found to have a higher incidence of major complications related to the trochanteric osteotomy and associated implants, and mini-open approaches had a greater incidence of lateral femoral cutaneous nerve injury. The arthroscopic approach had equivalent clinical outcomes with a lower rate of major complications when performed by experienced surgeons.

The literature consists of only level-III and level-IV evidence, and, to our knowledge, no prospective or randomized controlled trials have been performed to compare the efficacy of nonoperative management with that of operative management, or open approaches with that of arthroscopic approaches (Table I).

The impact of surgery on long-term clinical results, the natural history of FAI, or the prevention of or delay in the onset of osteoarthritis has not been established. The current literature supports surgical intervention for the treatment of FAI to provide pain relief and improved function in active patients in whom osteoarthritis is not severe, but it does not support prophylactic surgical intervention in asymptomatic individuals to prevent degenerative changes of the hip (Table I).

Recent studies have reliably demonstrated improved in vivo hip kinematics after surgical correction of FAI. Bedi et al. reported on ten patients with symptomatic, focal cam-type and/or pincer-type impingement lesions who underwent high-resolution computed tomography scans and computer-assisted three-dimensional modeling of the involved hip before and after corrective FAI surgery. The mean alpha angle improved from 59.8° to 36.4°. Corrective femoral and rim osteochondroplasty resulted in significant improvements in both hip flexion (3.8°; p = 0.002) and internal rotation (9.3°; p = 0.0002), and was correlated with significant improvement in the mean Harris hip score from 65.86 ± 6.66 to 89.1 ± 13.02, at a mean follow-up of 10.9 ± 7.4 months. Rylander et al. recently completed an in vivo motion capture analysis of preoperative and postoperative sagittal-plane hip kinematics in eleven patients with FAI during level walking. Overall sagittal-plane range of motion of the hip increased on the affected side from 27.6° ± 5.0° to 30.7° ± 4.3° (p = 0.02). Additionally, pain decreased and activity level increased postoperatively. Kennedy et al. also quantified the effect of cam-type FAI on the in vivo three-dimensional kinematics of the hip and pelvis during walking. A unilateral cam-type impingement group (n = 17) had significantly lower peak hip abduction (p = 0.009), frontal range of motion (p = 0.003), and attenuated pelvic frontal range of motion (pelvic roll) (p = 0.004) as compared with matched controls (n = 14) during level gait.

**Conclusion**

Both open and arthroscopic hip preservation surgery have grown exponentially in popularity over the past ten years as interventions for early hip disease. FAI is the most common indication for hip preservation surgery and is the most common mechanism that leads to the development of early cartilage and labral damage in the nondysplastic hip. However, a careful physical examination and radiographic assessment are critical to define strict surgical indications that reproducibly achieve favorable clinical outcomes. The anatomic abnormalities of the proximal part of the femur and/or the acetabulum are more complex than the originally described cam-type and pincer-type lesions that provided the foundation for the development of this field. The precise osseous anatomy and mechanics of the hip joint lead to a predictable pattern of injury to the labrum and cartilage during dynamic hip motion, with regional loading of the femoral head-neck junction against the acetabular rim. The resulting abnormal kinematics can precipitate not only direct intra-articular damage, but also compensatory injury patterns to the surrounding musculature about the hip joint. Both the direct intra-articular damage and the compensatory injuries lead to pain and loss of function and may result in early osteoarthritic changes and periaricular muscular dysfunction.

**Appendix**

Tables showing important radiographic findings and considerations in the evaluation of femoroacetabular impingement, participant demographics for studies evaluating operative treatment of femoroacetabular impingement, and clinical outcomes

| TABLE I Grades of Recommendation for Femoroacetabular Impingement (FAI) |
|-----------------------------|-----------------------------|
| Pathophysiology             | B                           |
| Injury patterns             | B                           |
| Etiology                    | C                           |
| Nonoperative treatment      | I                           |
| Surgical treatment          | B                           |
| Open versus arthroscopic approach | I                   |
| Improvement in hip kinematics | C                        |
| Prevention of osteoarthritis | I                           |

*A = good evidence (level-I studies with consistent findings) for or against recommending intervention, B = fair evidence (level-II or level-III studies with consistent findings) for or against recommending intervention, C = poor-quality evidence (level-IV or level-V studies with consistent findings) for or against recommending intervention, and I = insufficient or conflicting evidence, therefore not allowing a recommendation for or against intervention.*
reported from studies evaluating FAI are available with the online version of this article as a data supplement at jbs.org.

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References


