

# Femoroacetabular Impingement

## Diagnosis and Treatment

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Kevin M. Kaplan, M.D., Mehul R. Shah, M.D., and Thomas Youm, M.D.

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### Abstract

*Femoroacetabular impingement results from an abnormal contact between the femur and the pelvis. This abnormal contact leads to developmental changes in the femoral neck, labrum, and acetabulum. Secondary to the altered hip joint mechanics, chondral damage occurs and initiates the degenerative process, eventually leading to osteoarthritis. Numerous etiologies have been implicated in femoroacetabular impingement, and a variety of treatment algorithms have been established, with no definitive gold standard. However, the treatment of this disorder with joint preserving techniques offers a viable option between the extremes of nonoperative treatment and total joint arthroplasty.*

In 1974, Stulberg<sup>1</sup> noted the association between subtle anatomic abnormalities of the hip and the development of osteoarthritis (OA). This report was one of the earliest descriptions of what is now referred to as femoroacetabular impingement (FAI). Stulberg described decreased head-neck offset and found that the subset of patients with this finding developed early OA. Harris<sup>2</sup> reviewed 75 patients with idiopathic OA in 1986 and showed that 80% had a subtle

femoral or acetabular abnormality. It was not until more recently, after 2000, that the majority of literature regarding FAI was published. Although the association between anatomic abnormalities and OA is not a novel concept, previous studies did not attempt to delineate the mechanism and implications of the morphologies.

Ganz and colleagues<sup>3</sup> summarized the mechanism of FAI, in which morphologic abnormalities of the acetabulum and proximal femur lead to anterosuperior soft tissue damage and continued bony contact. At terminal ranges of hip motion, abnormal contact can occur between the femoral neck and acetabular rim, creating developmental lesions in the labrum and adjacent acetabular cartilage. With continued loading, these lesions will progress and lead to the development of a degenerative joint.

### Etiology

FAI is considered an abnormal contact between the femur and acetabulum, with numerous potential etiologies that include but are not limited to prior femoral neck fracture, prior periacetabular or femoral osteotomy, acetabular retroversion, and slipped capital femoral epiphysis. However, many patients do not have a clear history predisposing them to the development of FAI.

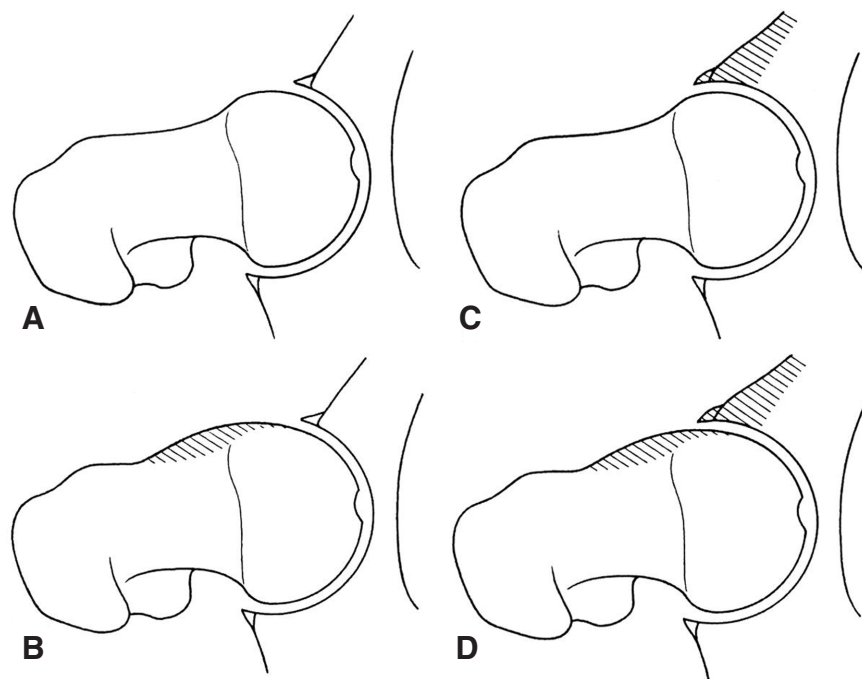
### Classification

The most common classification system is based on a review of 600 surgical dislocations performed by Ganz and coworkers.<sup>4</sup> They classified FAI as either cam or pincer type (Fig. 1). Cam impingement is typical in young, active male patients (Fig. 1B). Radiographically, these patients will have a prominence on the femoral neck, which, when forced into the acetabulum, will result in a tearing or avulsion of the labrum; the damage then progresses with continued loading of the joint, notably in the anterosuperior cartilage, as previously stated.

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Kevin M. Kaplan, M.D., was an Administrative Chief Resident, Department of Orthopaedic Surgery, NYU Hospital for Joint Diseases and currently is Orthopaedic Surgeon, Jacksonville Orthopaedic Institute, Jacksonville, Florida. Mehul Shah, M.D., is Assistant Professor, NYU School of Medicine, Hospital for Joint Diseases and within the Division of Sports Medicine, Department of Orthopaedic Surgery, NYU Hospital for Joint Diseases. Thomas Youm, M.D., is Clinical Assistant Professor of Orthopaedic Surgery, New York University School of Medicine, and within the Division of Adult Reconstructive Surgery, Department of Orthopaedic Surgery, NYU Hospital for Joint Diseases, NYU Langone Medical Center, New York, New York.

*Correspondence:* Thomas Youm, M.D., 1056 5th Avenue, New York, New York 10028; thomas.youm@med.nyu.edu.



**Figure 1** Anterior femoroacetabular impingement. **A**, Normal hip. **B**, Cam impingement. **C**, Pincer impingement. **D**, Mixed. (Reproduced from: Lavigne M, Parvizi J, Beck M, et al. Anterior femoroacetabular impingement: part I. Techniques of joint preserving surgery. *Clin Orthop Relat Res.* 2004;418:61-6. Copyright © 2004 The Association of Bone and Joint Surgeons. With permission.)

Pincer impingement presents more commonly in middle-aged athletic females (Fig. 1C). The femoral head may be normal; however, acetabular over-coverage is the mechanism responsible for the abnormal contact. This over-coverage may be a result of conditions such as coxa profunda or abnormal acetabular version.

With pincer impingement, failure occurs first in a limited area of the labrum that appears benign. With continued abutment of the femoral neck against the rim, patients will exhibit degenerative changes in the labrum. As a result, the acetabulum may deepen, causing worsening of the over-coverage. Thus, chondral injury will ensue, leading to acetabular degeneration.

The common final pathway for both types of impingement involves a morphologic abnormality that leads to abnormal contact. As a result of abnormal contact, the labrum and cartilage become damaged. McCarthy and associates<sup>5</sup> reviewed 463 hip arthroscopies in patients with reproducible mechanical symptoms and no evidence of OA on radiographs. The prevalence of labral tears was 55%. Additionally, 94% of the patients had chondral damage in continuity with the labral pathology. They concluded that in young, healthy patients strenuous activity may lead to recurrent microtrauma and eventual attrition of the labrum, with associated chondral injury. This, in turn, leads to abnormal contact and deterioration, which predisposes these patients to end stage OA.

## History

FAI typically presents in active young or middle-aged patients.<sup>6</sup> These patients typically begin to have symptoms insidiously or after minor trauma. Pain is localized to the

groin and is often unilateral. They may complain of intermittent pain that worsens with activity or prolonged sitting and, occasionally, the symptoms are bilateral. Patients may describe mechanical symptoms, such as locking, catching, and giving way. These findings are pathognomonic for labral pathology. Burnett and colleagues<sup>7</sup> reviewed 66 patients with pain from FAI; 91% of their cohort had activity-related pain, and 47% had night pain. Jager and coworkers<sup>8</sup> reported a mean delay of greater than 5 years between the onset of symptoms and a definitive diagnosis of labral tears, while Burnett and associates<sup>7</sup> reported a mean delay of 21 months, with an average of greater than three doctor visits prior to diagnosis.

Radiographs in young to middle-aged patients with hip pain are consistently nondiagnostic. These patients may be subject to unnecessary general surgery procedures, as well as an extensive orthopaedic work-up, in an attempt to determine the location of the pathology.

## Physical Examination

Examination of patients with FAI will demonstrate a normal neurovascular examination, with no deficit in motor strength.<sup>9</sup> Range of motion will be limited in internal rotation and adduction, which is unlike the globally restricted motion found in advanced cases of OA.

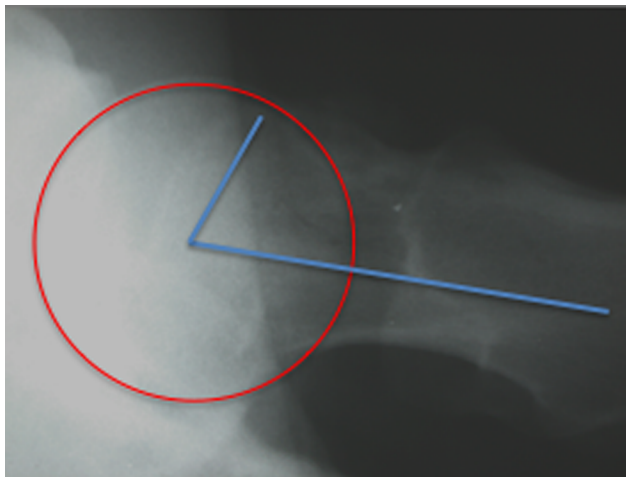
Several tests can be performed to identify FAI in patients with hip pain. The anterior impingement test (Fig. 2) is performed with the patient in the supine position. The hip is internally rotated as it is passively flexed to 90°. Flexion and adduction results in contact between the femoral neck and labrum, which leads to the aforementioned degenerative cycle of chondral damage.



**Figure 2** Anterior impingement test.



**Figure 3** Posteroinferior impingement test.



**Figure 4** Alpha angle.

The posteroinferior impingement test (Fig. 3) is also performed with the patient in the supine position; however, the patient slides to the edge of the examination table and extends the hip, while the examiner passively externally rotates the hip. A reproduction of symptoms is considered a positive sign. In patients with positive impingement tests, MacDonald and colleagues<sup>10</sup> found a significant association with acetabular rim lesions on specific MRI arthrograms. Burnett and coworkers<sup>7</sup> also found that 95% of their cohort with labral pathology had positive impingement signs and lower rates of symptoms,

such as a limp or a Trendelenburg sign.

**Radiographic Evaluation**

Radiographic evaluation of these patients include a true anteroposterior view of the pelvis, defined as the coccyx pointing toward the symphysis pubis, with no greater than a 2 cm distance between them.<sup>9</sup> This is important in order to determine the acetabular version. Additional radiographs include a cross-table lateral and a false profile view. The false profile view is an additional aid for assessing the anterior coverage of the femoral head.

The alpha angle<sup>11</sup> can be determined on the lateral view of the hip or on an oblique MRI section (Fig. 4). A line is drawn from the center of the femoral head through the femoral head-neck junction. Normal alpha angles are typically 45°, whereas patients with FAI have alpha angles of approximately 70°. Notzli and associates<sup>12</sup> found that all patients in the series with confirmed FAI had alpha angles of greater than or equal to 55°, whereas controls had alpha angles of less than 48°. They concluded that an alpha angle of 55° should be used as a cutoff for impingement.

Eijer and colleagues<sup>13</sup> describe measuring the head-neck offset as an alternative for diagnosis of FAI. Utilizing a cross-table lateral radiograph, a line is drawn that bisects the longitudinal axis of the femoral neck. Two lines are then drawn parallel to the initial line: one as a tangent to the anterior femoral neck and one as a tangent to the anterior femoral head. The measured head-neck offset refers to the

perpendicular distance between the two lines. An abnormal distance, as defined by Eijer and coworkers,<sup>13</sup> is less than 9 mm. The same investigators also described the offset ratio, which is determined as the ratio of the head-neck offset distance relative to the diameter of the femoral head. Values of less than 0.17 are considered abnormal.<sup>13</sup>

In addition to the aforementioned radiographic criteria, there are numerous other pathologic findings that may assist in the diagnosis of FAI. These include bony prominences, congruent nonspherical heads, short femoral necks, small head-to-neck ratios, flattened head-neck junctions, and pistol-grip deformities.<sup>5</sup>

Regarding the acetabulum, retroversion is a significant finding that may cause FAI. An anteroposterior radiograph may demonstrate that the anterior wall is lateral to the posterior wall proximally. This so-called “cross-over” sign is indicative of a retroverted acetabulum.<sup>9</sup> Furthermore, the posterior wall may lie medial to the center of the femoral head, another radiographic finding consistent with a retroverted acetabulum.

Additional imaging includes three-dimensional reconstructed CT scans, which can be utilized to further delineate the abnormal morphology of the femoral neck or acetabulum. However, there have been no conclusive studies regarding their effectiveness.

MRI is considered the most specific and sensitive imaging study in the diagnostic work-up in patients with FAI.<sup>14</sup> Typical findings include abnormal sphericity of the femoral head, a low head-neck offset, herniated pits, and ossification of the acetabular rim. Kassarijan<sup>15</sup> described a triad of anomalies as seen on MRI in patients with cam impingement. Abnormal head-neck morphology, anterosuperior cartilage abnormality and anterosuperior labral pathology were found in 88% of patients with a diagnosis of FAI. The main limitation in regard to the efficacy of this imaging modality is the detection of an undetached chondral lesion.

## Nonoperative Treatment

Restriction of activities that incite the patient’s symptoms should be part of nonoperative therapy. Unless contraindicated, patients can be started on a trial of nonsteroidal antiinflammatory drugs. Injections can also be introduced, serving both a diagnostic and therapeutic role in some patients. Physical therapy with emphasis on muscle strengthening and patient education to avoid extremes of range of motion can alleviate symptoms. However, it is important to avoid passive range of motion or stretching, as these maneuvers may exacerbate the symptoms.

Understanding that FAI is a mechanical problem, nonoperative measures will not eliminate the pathomechanics of structural deformities unless the patient refrains from rigorous activities. Thus, orthopaedic surgeons are faced with the task of relieving the pain, while understanding that these patients would likely benefit from joint sparing

rather than joint sacrificing procedures.

## Operative Treatment

In managing patients with confirmed FAI, advocates of operative treatment believe that early intervention is paramount to prevent the development of OA. Jager and associates<sup>8</sup> stated that nonoperative treatment is successful if the cause is overuse without structural deformity; otherwise, operative intervention was favored. Peters and Erickson<sup>16</sup> established patient criteria to proceed with surgical intervention in patients diagnosed with FAI and included patients with symptoms for longer than 6 months, but with no severe articular damage; those who have failed conservative treatment; and those with radiographically confirmed abnormalities. They believed that most failures occurred because of surgery performed on patients with advanced OA.

The goals of operative treatment include improvement of hip motion and alleviation of abnormal contact areas. In addition to addressing morphologic abnormalities on the femoral neck responsible for the initial FAI insult in cam impingement, surgeons should address the pathologic changes present in the labrum and articular cartilage. The three most common surgical options include arthroscopy alone, arthroscopy with a limited open approach, and surgical dislocation. Each treatment regimen has its advantages and disadvantages.

## Arthroscopy

Arthroscopic procedures are minimally invasive, can be both diagnostic and therapeutic, are utilized in the treatment of labral tears, and able to address pathology in both cam and pincer types of impingement.

In the arthroscopic cam procedure, the goal is to restore femoral head and neck offset, thereby simultaneously decompressing the FAI. In addition to the known risk of hip arthroscopy, which include iatrogenic damage to the labrum and cartilage and neurapraxia, risks specific to this procedure include but are not limited to damage to the retinacular blood supply and a potential stress riser along the femoral neck. Conversely, the goal of the arthroscopic pincer procedure is to reduce the prominence of the acetabular rim, debride the portion of the labrum that is degenerative, and to re-attach the uninvolved labrum. The difficulty of this technique is the potential inability to restore the normal labral anatomy.

Limitations of arthroscopy include difficulty in removing bony prominences on the femur that extend to the posterior neck. In addition, over resection or under resection may occur, because it is difficult to assess the true depth of resection. Additionally, arthroscopic resection of an impinging acetabular rim that is retroverted is technically demanding. Finally, it is difficult to treat chondral lesions, especially ones that lie beneath a normal labrum.<sup>17</sup>

An outcome study by Sampson<sup>18</sup> of 156 patients demonstrated that 50% of patients had complete pain relief by 3 months, 75% by 5 months, and 95% by 1 year postopera-

tively. During this study, three patients required total hip arthroplasty, with the failures correlating directly with the amount of articular cartilage damage noted at arthroscopy. The investigators again stress the importance of early diagnosis and treatment prior to significant chondral damage with subsequent degenerative changes. Studies by Farjo and colleagues,<sup>19</sup> Beck and coworkers,<sup>20</sup> Guanche and Bare,<sup>21</sup> and Phillipon and Schenker<sup>22</sup> report similar successful short-term results of arthroscopic treatment of FAI, with failures occurring in patients who have advanced degenerative changes.

### Arthroscopy with Limited Open Techniques

Hybrid techniques combine arthroscopy with a limited open approach to treat FAI.<sup>6</sup> This procedure approach can be utilized to treat focal cam impingement, and labral and chondral lesions, with the advantage of improved exposure without having to perform a surgical dislocation. Proponents of this technique feel that there are fewer complications than open dislocation, along with a faster recovery. The procedure utilizes a Smith-Peterson or trans-tensor fascia lata approach without dislocating the femoral head. The disadvantage (and documented contraindication) of this technique arises from the inability to treat posterior or circumferential lesions. There are no substantial articles regarding the outcome utilizing this approach for the treatment of FAI.

### Open Techniques

As with the other treatment modalities, open treatment for FAI should be reserved for patients who exhibit no worse than grade I OA, as the aforementioned studies have documented poor outcomes associated with advanced arthritis.<sup>19-22</sup> Ganz and associates<sup>4</sup> routinely utilize intraoperative findings for decisions on whether to treat FAI with joint-sparing techniques or a total hip arthroplasty. Risks of joint sparing techniques (surgical dislocation) include, but are not limited to, osteonecrosis secondary to damage to the branches of the medial femoral circumflex arteries supplying the head. Additionally, resection of too much of the femoral neck can place the patient at risk for subsequent femoral neck fracture.

### Acetabular Management

In regard to the acetabulum, there are typically two treatment options, depending on the depth of the posterior wall and the appearance of the articular cartilage. Rim osteoplasties with labral repair have been advocated by Espinosa and colleagues<sup>23</sup> in their experience with 32 patients treated with labral refixation. Their cohort recovered earlier and had superior clinical and radiographic results at 1 and 2 years when compared to 22 patients who underwent labral resection.

Another option is to perform a periacetabular osteotomy (PAO). The potential risk associated with this procedure includes the possibility of iatrogenic posterior impingement due to over correction. However, Siebenrock and coworkers<sup>24</sup> demonstrated 90% good to excellent results in their series of patients with acetabular retroversion treated with

a PAO. Long-term studies regarding open procedures are not currently available. However, short-term results show good to excellent results in the appropriately indicated patients.<sup>4,16,20,25</sup> These studies stressed the importance of intraoperative evaluation of the chondral surfaces to avoid unnecessary procedures on a patient with more advanced degenerative changes who would benefit from some form of arthroplasty.

### Conclusion

FAI can be a significant cause of pain in young to middle-aged active patients. The morphological abnormalities associated with FAI may be responsible for the initial insult leading to OA in older patients.<sup>9</sup> With an appropriate history, physical examination, and critical analysis of radiographs, physicians can treat these patients prior to the development of degenerative changes from repeated chondral damage.

Arthroscopy can be helpful to evaluate the severity of the disease and can simultaneously address simple labral and chondral lesions. A limited open resection osteoplasty can be performed for better exposure without a formal surgical dislocation. Extensive or global disease or posterior hip impingement requires surgical dislocation of the hip to provide adequate exposure, as well as access to the entire acetabulum and proximal part of the femur.

Long-term outcome studies for the treatment of FAI have not been reported in the literature. Future studies will provide insight into defining the optimal treatment algorithms. Furthermore, they are needed to better delineate the natural course of the deformity and assist in determining whether young patients would benefit from newer resurfacing procedures, total hip arthroplasties, or isolated treatment of the FAI. Despite these controversial issues, it has been well established that successful treatment of FAI must encompass both the morphologic abnormalities, in addition to the associated labral and chondral injuries.

### Disclosure Statement

None of the authors have a financial or proprietary interest in the subject matter or materials discussed, including, but not limited to, employment, consultancies, stock ownership, honoraria, and paid expert testimony.

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