DEFINITION

Femoroacetabular impingement (FAI) is the result of abnormal contact between the proximal femur and the acetabular rim.

Abnormalities can be identified on either the femoral or acetabular side, but are more commonly seen on both sides.

This abnormal contact can lead to acetabular chondral lesions and/or labral lesions, leading to hip pain and the development of diffuse osteoarthritis of the affected hip if left untreated. 1,2,3

ANATOMY

The proximal femur and acetabulum normally articulate without abutment through a physiologic range of motion (ROM).

The acetabulum normally is anteverted 12 to 16.5 degrees.

The acetabulum covers the femoral head to a depth that avoids impingement (ie, overcoverage) and instability (ie, dysplasia or undercoverage) with a horizontal, thin, sourcil (ie, the weight-bearing zone).

The proximal femur has a spherical head-neck contour that allows for impingement-free ROM.

The normal femoral neck shaft angle is 120 to 135 degrees; the femoral neck typically is anteverted and is 12 to 15 degrees.

It is important to recognize and respect the location of the retinacular vessels that have been shown to enter the antero- and posterolateral portions of the femoral neck and supply the majority of the femoral head’s blood supply.

PATHOGENESIS

- There are two primary mechanisms of FAI: pincer and cam impingement. 1-3

Pincer impingement is the result of contact between an abnormal acetabular rim and normal femoral head-neck junction (FIG 1A).

- Pincer impingement typically is the result of a deep acetabulum (coxa profunda), local anterior overcoverage (acetabular retroversion), or, less commonly, posterior overcoverage.

- It leads to labral bruising and tearing, and eventually may result in ossification of the labrum and contrecoup posterior acetabular chondral injury.

Cam impingement is the result of contact between an abnormal femoral head-neck junction and the acetabulum (FIG 1B).

- Cam impingement results in a shearing stress to the anterosuperior acetabulum, with predictable chondral delamination and labral detachment or tearing in some cases.

FIG 1 • A. Pincer impingement is the result of contact between an abnormal acetabular rim and a normal femoral head–neck junction. B. Cam impingement is the result of contact between an abnormal femoral head–neck junction and the acetabulum.
Although cam impingement is reported to predominate in young athletic males and pincer impingement in middle-aged women, most patients with FAI have a combination of both cam and pincer impingement.

**NATURAL HISTORY**
- The likelihood of an individual with untreated FAI developing hip osteoarthritis is unknown, because there have been no longitudinal studies prospectively following these patients before the development of symptoms.
- Clinical experience with over 600 surgical dislocations of the hip in patients with FAI has revealed a strong association of this disorder with progressive acetabular chondral degeneration, labral tears, and progressive osteoarthritis.\(^1\)\(^2\)\(^3\)
- It is now well accepted that many patients with FAI will develop progressive chondral and labral injury that can ultimately lead to end-stage hip osteoarthritis.

**PATIENT HISTORY AND PHYSICAL FINDINGS**
- Patients typically are young to middle aged (2nd through 4th decade) with complaints of groin pain exacerbated by physical activity.
- Prolonged sitting, arising from a chair, putting on shoes and socks, getting in and out of a car, and sitting with their legs crossed often exacerbate the symptoms.
- We have found that patients may have a history of siblings, parents, and grandparents with hip pain or osteoarthritis of the hip, and patients may have milder or similar symptoms in the contralateral hip.
- Patients often have had pain for months to years with the diagnosis of chronic low back pathology, hip flexor strains, and sports hernias, and not infrequently have had other surgeries without relief of their pain.
- Physical examinations should include:
  - Evaluation of hip ROM: global ROM restriction indicates advanced osteoarthritis.
  - Anterior impingement test: groin pain indicates anterolateral rim pathology.
  - Posterior impingement test: groin pain or posterolateral pain indicates posterolateral rim pathology.
  - FABER test: FABER means flexion, abduction, and external rotation of the hip. Increased distance from the lateral knee to the examination table can indicate femoroacetabular impingement.

**IMAGING AND OTHER DIAGNOSTIC STUDIES**
- Plain radiographs including an anteroposterior (AP) pelvis, frog lateral, and ideally a cross-table lateral and false profile view are obtained.
- The AP radiograph should have a coccyx to symphyseal distance of 0 to 2 cm with the coccyx centered over the symphysis to properly evaluate acetabular version.
- The following are measured on the AP radiograph (FIG 2A):
  - A lateral center edge angle of 25 to 40 degrees distinguishes deep acetabulum from dysplasia.
  - The presence of a crossover sign indicates local anterior overcoverage (retroversion).
  - The posterior wall sign indicates posterior undercoverage (retroversion).
  - Cam impingement indicates decreased head-neck offset.
- The frog-leg lateral and cross-table lateral views with 15 degrees internal rotation ideally evaluate:
  - A femoral head neck cystic changes and sclerosis
  - A femoral neck version: retroversion may contribute to impingement.
  - The false profile is used to evaluate:
    - Anterior center edge angle: anterior over- and under-coverage
  - An MRI arthrogram is useful to evaluate for labral and chondral pathology, acetabular retroversion, or a prominence of the femoral head neck junction which is best seen on the axial cuts (FIG 2B).
  - Synovial herniation pits at the femoral head neck junction are also indicative of FAI.
  - An anesthetic agent should be included with the gadolinium to verify the hip joint as the source of pain, which is indicated by temporary pain relief with provocative maneuvers in the first couple of hours after the injection.
  - Occasionally it is helpful to obtain a three-dimensional CT study to appropriately map the area of impingement.

**FIG 2**
- A. Lateral center edge angle, posterior wall sign, and crossover sign are depicted. B. Alpha (α) angle is elevated in cam impingement. C. Prominence of the anterolateral femoral head–neck junction is seen on axial MRI images.
This may be done routinely or in cases of subtle FAI or suspected unusual locations of FAI (e.g., posterior femoral head/neck prominences).

**DIFFERENTIAL DIAGNOSIS**
- Sports hernia or athletic pubalgia
- Lumbar spine pathology
- Gynecologic or urologic pathology
- Intra-abdominal pathology
- Hip flexor pathology or iliopsoas snapping
- Iliobial band pathology or snapping
- Pelvic stress fracture
- Intra-articular pathology not related to FAI

**NONOPERATIVE MANAGEMENT**
- Nonoperative management of FAI consists of avoiding painful activities such as deep hip flexion, aggressive hip flexion-based weight training, and athletic activities that aggravate symptoms.
- Intra-articular pathology often progresses without symptoms early in the disease, and there is concern that without surgical treatment arthritis eventually will develop.
- Nonoperative management may be best employed in the already degenerative hip with joint space narrowing prior to total hip arthroplasty, and consists of activity modification, core muscle strengthening exercises, and occasional intra-articular corticosteroid or hyaluronic acid injections.

**SURGICAL MANAGEMENT**
- Physical examination and imaging studies consistent with FAI
- Pain despite activity modification
- Pain in patient who is unable or unwilling to modify activity
- Minimal to no degenerative changes
- Arthroscopic versus open procedure for FAI (Table 1)

*There are no strict indications for open versus arthroscopic management of FAI.*

**Guidelines for Arthroscopic Versus Open Repair of Femoroacetabular Impingement**

<table>
<thead>
<tr>
<th>Pincer impingement</th>
<th>Cam impingement</th>
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<tbody>
<tr>
<td>Lateral center edge angle</td>
<td>If resection of &gt;30% of the width of the neck is required to restore the alpha angle to normal, consider concomitant osteotomy (severe pistol grip deformity)</td>
</tr>
<tr>
<td>&gt;25 degrees: arthroscopic acetabular rim trimming</td>
<td>Significant femoral neck retroversion or coxa vara is present, a concomitant or staged osteotomy is considered when impingement is still present after arthroscopic proximal femoral osteoplasty. Pastoral areas of femoral head–neck impingement can be more challenging, and, depending on the surgeon’s experience, may be better addressed through an open approach.</td>
</tr>
<tr>
<td>20–25 degrees: avoid excessive rim trimming laterally</td>
<td>Posterior areas of femoral head–neck impingement can be more challenging, and, depending on the surgeon’s experience, may be better addressed through an open approach.</td>
</tr>
<tr>
<td>&gt;16 to 20 degrees: consider osteotomy</td>
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- The goal of arthroscopy is to reproduce the open approach for managing FAI.
- Although controversial, some higher-level athletes may prefer a less invasive arthroscopic approach with a more predictable return to sports.\(^1\)

**Preoperative Planning**
- Initially, a fluoroscopic evaluation is done, including anteroposterior, frog lateral, and cross-table lateral evaluation of the acetabulum and proximal femur.
- Dynamic fluoroscopic evaluation by abduction of the hip in flexion, external rotation, and extension with internal and external rotation occasionally reveals impingement of the acetabulum on the proximal femur and results in a vacuum effect in the joint as the proximal femur is levered out of the acetabulum.

**Positioning**
- Arthroscopic management of FAI begins with standard hip positioning in either the supine or lateral position.
- We prefer the supine position with the hip in slight flexion, neutral abduction, and internal rotation (FIG 3).

**Approach**
- Most cases can be performed using the standard anterior paratrochanteric and anterior portals, with occasional use of the posterior paratrochanteric or accessory distal portal (FIG 4).
DIAGNOSTIC ARTHROSCOPY

- Initially the intra-articular portions of the hip are evaluated, including the acetabular labrum, acetabulum, and femoral head articular cartilage; fovea; ligamentum teres; transverse acetabular ligament; and capsular structures (TECH FIG 1A,B).
- The peripheral compartment is evaluated, including the femoral head, labrum, zona orbicularis, medial synovial fold, femoral neck, and peripheral capsular attachments (TECH FIG 1C).

![Image A](imageA.png)
![Image B](imageB.png)
![Image C](imageC.png)

**TECH FIG 1 • A.** View from the anterior paratrochanteric portal reveals the anterolateral labrum, acetabulum (left), and femoral head (right). **B.** View of the fovea (top), ligamentum teres (center), and medial femoral head (bottom). **C.** View of the peripheral compartment through the anterior portal reveals the zona orbicularis (top), femoral neck and medial synovial fold (center), and femoral head-neck junction (bottom). **D.** Chondral delamination of the anterior superior acetabulum consistent with cam impingement. **E.** Diffuse labral ecchymosis (left) consistent with pincer impingement.

PINCER IMPINGEMENT

- When pincer impingement is present, the labrum is evaluated, and any tearing is carefully debrided, taking care to preserve the peripheral labrum when possible.
- If complex tearing of the labrum is present, the labrum is generously debrided; however, the periphery of the labrum often remains intact and is amenable to repair or refixation (TECH FIG 2A).
- If the labrum is amenable to repair or refixation, it is carefully detached from the acetabulum using a Beaver blade and shaver, beginning at the periphery and extending to the articular side of the labrum (TECH FIG 2B).

- Care must be taken to detach as much of the labrum as possible without cutting too deep on the articular side, which could result in inadvertent delamination of the acetabular articular cartilage.
- The labral detachment usually extends from the anterior portal to the 12:00 position. More or less may be detached further, superiorly and posteriorly, depending on the extent of acetabular overcoverage anterolaterally or posteriorly, and should include detachment of all of the torn or ecchymotic labrum.
**Techniques**

**Tech Fig 2**

- A. Acetabular chondral delamination and articular-sided labral tear (left) with preserved peripheral labral tissue.
- B. A Beaver blade is used to detach the labrum from the acetabulum (left), creating a bucket handle labral tear.
- C. A burr is used to begin the acetabular rim trimming, starting at the level of the anterior portal site.
- D. Completion of the rim trimming to the anterolateral acetabulum. The labrum is retracted into the joint (right).
- E. A suture anchor is placed just below the subchondral bone of the acetabulum, taking care not to enter the acetabular chondral surface.
- F. One limb of the suture is passed under the labrum and then pulled over or through the labrum.
- G. Completion of the acetabular rim trimming and labral refixation with two suture anchors. Left: labral repair; right: femoral head.

- The labrum then falls into the joint, creating a bucket handle tear, and a 5.5-mm burr is used to trim the acetabular rim to a depth of 5 to 10 mm (Tech Fig 2C-D).
- An attempt is made to trim all of the acetabulum with abnormal articular cartilage to a residual lateral center edge angle of 25 to 30 degrees, taking more or less according to the preoperative center edge angles.
- If areas of grade 4 chondromalacia remain after acetabular rim trimming, microfracture is performed on the exposed bone.

- Suture anchors (usually two to four anchors) are then placed just under the acetabular subchondral bone, and the sutures are first passed under the labrum and then pulled over or through the labrum, securing the labrum to the rim with standard knot-tying techniques (Tech Fig 2E-G).
- Care is taken to place the knot on the capsular or medial side of the labrum to avoid damaging the femoral articular cartilage with prominent suture during weight bearing and ROM.

**Os Acetabuli/Pincer Impingement**

- Occasionally an os acetabuli is responsible for local anterior overcoverage and typically is attached to the acetabulum just peripheral to the labrum.

- The os is exposed and excised using a burr beyond the fibrocartilage attachment of the native acetabulum with or without labral débridement or detachment and refixation (Tech Fig 3).
CAM IMPINGEMENT

- Exposure of the femoral head–neck junction can be performed using a generous capsulotomy, capsulectomy, or small capsular window.
- We prefer a generous capsulotomy beginning anterior to the anterior portal and extending to the posterolateral portal site (TECH FIG 4A).
- Traction is then released, and the hip is flexed to varying degrees, allowing for visualization of the peripheral head–neck junction and the cam lesion.
- The normal head–neck junction is spherical (TECH FIG 4B), whereas in cam impingement it appears egg-shaped, flat, or with a prominence at the head–neck junction (TECH FIG 4C).
- The cam lesion is covered with healthy-appearing articular cartilage with varying mild degrees of eburnation, progressing very early in the process to a more degenerative peripheral head–neck junction with clefts and intraosseous cysts in more advanced cases (TECH FIG 4D).
- A 5.5-mm burr is used to reshape the anterolateral prominence, typically removing 5 to 10 mm and occasionally more, depending on the size of the lesion and thickness of the neck (TECH FIG 4E,F).
- A recent cadaveric study recommended resecting no more than 30% of the thickness of the femoral neck to avoid pathologic fractures postoperatively.6
- A frog lateral and cross-table lateral view with internal rotation are used to verify restoration of a normal alpha angle (TECH FIG 4G,H).
- For more superior and posterior lesions, the hip is slowly extended and internally rotated, and the working and
Final confirmation of adequate resection is then verified arthroscopically by flexing the hip more than 90 degrees with maximal internal rotation, external rotation, and abduction.

Capsular closure is then performed with one or two absorbable sutures passed through one side of the capsule with a looped suture passer and grasped through the other side of the capsule (TECH FIG 41).

A knot is then tied blindly at the periphery of the capsule using standard arthroscopic knot-tying techniques.

The hip is then infiltrated with an anesthetic, and the portals are closed in the usual fashion.

arthroscopic portals can be exchanged from the anterior and anterior paratrochanteric portals to the anterior and posterior paratrochanteric portals for better visualization.

Care is taken to avoid aggressive resection down the anterolateral and posterolateral regions of the femoral neck to avoid damage to the retinacular vessels which should be visualized and protected throughout the case.

The typical pattern of cam impingement extends down the neck on the anterolateral femoral head-neck junction and closer to the articular cartilage margin of the femoral head, more superiorly in the region of the retinacular vessels.

PEARLS AND PITFALLS

- **Indications**
  - History, physical examination, and imaging studies should be consistent with femoroacetabular impingement.
  - Intra-articular anesthetic injection should confirm the hip as the source of pain.

- **Exposure**
  - Care should be taken to excise the labrum peripherally and detach on the articular surface without undermining the acetabular chondral surface to allow for adequate tissue for refixation.
  - Adequate capsulotomy or capsulectomy should be performed to allow for exposure of the femoral head-neck junction.
  - Flexion, extension, and rotation allow for complete visualization of the femoral head-neck prominence in cam impingement.

- **Pincer**
  - Generally 5 mm of acetabulum is trimmed with more removed based on the extent of chondral damage taking care not to create a dysplastic acetabulum based on preoperative center edge angles.
Cam

- Adequate (usually 5 to 10 mm) but not overly aggressive femoral osteoplasty is confirmed by repeated arthroscopic ROM evaluation and fluoroscopic frog lateral, cross-table lateral, and anteroposterior images.

Complications

- More complex cases of FAI managed arthroscopically can be lengthy procedures, and alternating between traction and flexion or release of traction can help prevent traction-based neuropathies.
- Meticulous irrigation of all bony debris and postoperative use of nonsteroidal anti-inflammatories can help to minimize the incidence of heterotopic bone formation.

**POSTOPERATIVE CARE**

- Pre- and postoperative radiographs confirm adequate osteoplasty and rim trimming (**FIG 5**).
- Postoperative restrictions are not consistent from one surgeon to the next and are based on the procedures done.

Acetabular labral repair and refixation is treated with toe-touch weight bearing for 2 weeks and avoidance of the extremes of external rotation for 2 weeks.

Microfracture procedures are treated with 6 to 8 weeks of toe-touch weight bearing.

The first 2 months focus on restoration of ROM, gait and pelvic alignment, and gentle core strengthening.

At 2 months, more aggressive core strengthening is instituted, with resumption of full sporting activities at 3 to 6 months based on functional improvement.

Further research is required to develop the optimal rehabilitation programs after the various procedures that have been discussed.

**OUTCOMES**

Early and midterm results of open procedures for FAI indicate that reduction in pain and functional improvement directly correlate with the degree of osteoarthritic changes found at the time of surgery.1,2,7,9

Some evidence indicates that repair or refixation of the labrum results in improved outcomes when compared to labral debridement or excision in a consecutive series.2,4

It is unclear, however, whether the improvement is the result of labral preservation or of improved technical skills, because the study was performed in a consecutive series of patients.2,4

Little has been published in the literature with respect to outcomes after arthroscopic management of FAI.

In a review of 45 professional and Olympic level athletes with FAI treated arthroscopically, all had symptomatic improvement and returned to play.10

In another series of 320 patients with FAI treated arthroscopically, 90% had elimination of the impingement sign and were reportedly satisfied with their results.12

Larson and Giveans5 prospectively followed 100 patients with FAI treated arthroscopically for up to 3 years, with a statistically significant improvement in Harris hip, SF-12, and visual analogue pain scoring consistent with that seen after open management of FAI.

No well-designed, long-term, or randomized studies have been done to evaluate outcomes of management of FAI to determine whether osteoarthritis has been delayed or prevented in this patient population. Longer-term follow-up and studies of open versus arthroscopic treatment should better define the optimal indications and procedure for patients with FAI.

**COMPLICATIONS**

- Anterolateral femoral cutaneous nerve neuropraxia
- Heterotopic bone or myositis ossificans formation
- Iatrogenic acetabular and femoral chondral damage
- Rarely postoperative femoral neck fracture
- Potential for sciatic or pudendal nerve neuropraxia
- Potential for avascular necrosis

**REFERENCES**