

Femoroacetabular Impingement: The Femoral Side

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KEYWORDS

• FAI • CAM • Femoral osteoplasty • Impingement

Femoroacetabular impingement (FAI) has been recognized as a cause of hip pain, chondrolabral damage, and developing osteoarthritis of the hip.¹⁻³ This impingement results from abnormal femoral head-neck offset (cam) and excessive coverage of the acetabular rim (pincer). However, the combined pathology is the most common pattern found in patients with FAI.^{1,4}

Smith-Petersen was the first to describe FAI in 1936, when he stated “The impingement of the femoral neck on the anterior acetabular margin... would result in traumatic arthritis.”⁵ In this article, a surgical technique was also described, which resembles the technique still used today for FAI treatment. After this description, FAI was mentioned in sparse publications,^{6,7} until the 1990s when investigators started to recognize fragments of the syndrome, such as the impingement sign,⁸ retroversion, as a cause of hip pain⁹ and overcorrection of a acetabular osteotomy leading to impingement.¹⁰ In 2003, Ganz and colleagues² established the modern concept of FAI and proposed the types of impingement. They also described open surgical treatment and demonstrated the association of impingement with acetabular labral tears and early osteoarthritis of the hip. Since then, the literature regarding FAI has grown immensely. Arthroscopic treatment is recognized as an alternative to the open technique with excellent results in a less-invasive approach.^{11,12} Moreover, hip arthroscopy has

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shown good results in the athletic population, with the majority of patients returning to their previous sport.^{13,14} One cannot overemphasize the importance of correction of bony abnormality because it is critical for good surgical outcome.^{15,16} The aim of this article is to describe the diagnosis and treatment of the cam lesion.

ETIOLOGY AND PATHOMECHANICS OF CAM IMPINGEMENT

Cam impingement is characterized by a nonspherical head with abnormal head-neck offset of the proximal femur (**Fig. 1**). The causes of this bony abnormality remain unclear. Siebenrock and colleagues¹⁷ used MRI to measure epiphyseal extension of the proximal femur comparing subjects with FAI and control subjects. Their findings demonstrated that an abnormal epiphyseal extension correlates with a nonspherical femoral head and a decreased femoral head-neck offset. Several developmental disorders can be the cause of cam-type deformity, such as slipped capital femoral epiphysis¹⁸ and Legg-Calvé-Perthes disease.¹⁹ Malunion of the femoral neck fracture in retroversion and varus position also results in cam impingement.²⁰

Abnormal morphologic features in cam and pincer impingement create pathologic contact between the femoral head-neck junction and the acetabular rim at certain positions of hip motion. However, the patterns of articular and labral damages found in the cam impingement are different from the pincer type.¹ A nonspherical femoral head sliding into the anterosuperior labrum during hip flexion produces compression and shear stresses at the chondrolabral junction resulting in a separation between the labrum and the articular cartilage (**Fig. 2**). Avulsion of cartilage from the labrum and the subchondral bone can be seen as a wave sign²¹ when the cartilage is probed during arthroscopy or as a frank cartilage delamination.

Beck and colleagues¹ compared intraoperative findings from surgical dislocation of the hip for the treatment of FAI between subjects with isolated cam lesions and those with isolated pincer lesions. All hips with isolated cam impingement had articular damage in the anterosuperior part of the acetabulum with a mean depth of cartilage damage of 11 mm, which was approximately one-third of the total cartilage depth

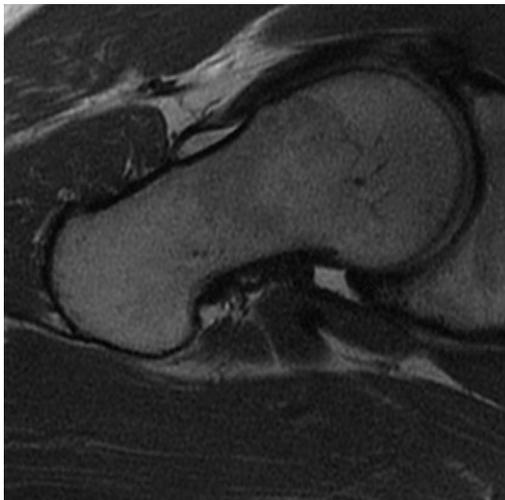


Fig. 1. A nonspherical femoral head as seen on MRI.

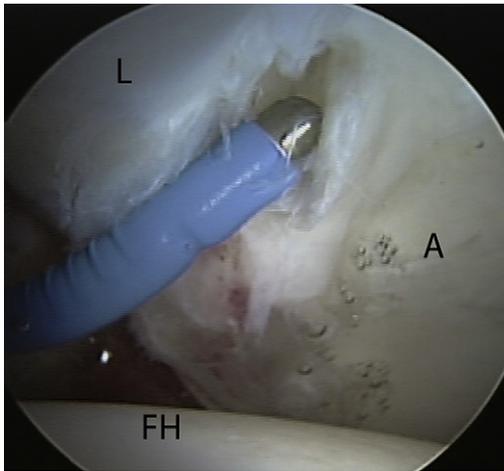


Fig. 2. Injury to the labrum and the adjacent cartilage as commonly seen with cam impingement. A, acetabulum; FH, femoral head; L, labrum.

at this location. A separation of the acetabular cartilage from the labrum was observed in all hips of this group. Cartilage and labral damages in hips with isolated pincer impingement were more circumferential. Chondral lesions found in pincer type were less severe compared with cam type and often limited to a small rim area (mean depth of 4 mm). In pincer and mixed-type impingement, repeated abutment between the femoral neck and the acetabular rim causes degeneration of the labrum. The labrum may be bruised and flattened, and intrasubstance ganglion formation may be found in more severe cases.

CLINICAL PRESENTATION

The majority of patients (50%–65%) with FAI have insidious onset of symptoms.^{4,22} Pain onset following traumatic episode and acute symptoms without a traumatic event are also reported by some patients. Pain is the most common complaint, with moderate or marked severity.⁴ The groin area is the most common location of pain (81%–83%) reported by patients with FAI.^{4,22} Nonetheless, some patients also report pain at their lateral hip, buttock, thigh, and low-back area. Mechanical symptoms and feeling of instability are also reported. These symptoms usually worsen with particular daily activities and sports.

The anterior impingement test is a provocative test that is commonly used and is nearly always positive in patients with FAI.^{2,4} In the supine position, the hip is passively flexed to 90°, followed by forced adduction and internal rotation. The presence of hip pain during this maneuver is considered a positive test. The flexion/abduction/external rotation test is also a useful test for diagnosis of FAI. While the patient is lying supine, the affected leg is brought to the figure-four position of flexion, abduction, and external rotation, so that the ankle is placed proximal to the contralateral knee. Gentle downward force is applied to the knee of the affected extremity while the contralateral side of the pelvis is stabilized. A positive test is demonstrated by an increased distance between the lateral aspect of the knee and the examination table, compared with the contralateral side.

RADIOGRAPHIC EXAMINATION

Abnormal morphology of the proximal femur and the acetabulum can be confirmed with radiographs. The senior author (MJP) uses an anteroposterior (AP)-pelvis, a cross-table lateral, and a false profile as the radiograph work-up²³; however, many other views have been described and can also be used to better evaluate the bony morphology.²⁴ An AP-pelvis radiograph is generally used to demonstrate pincer-type deformity but some features of cam impingement can be shown, such as pistol-grip deformity, head tilt deformity, a lateral bump, and a herniation pit. A herniation pit is a juxta-articular change that can be seen as a radiolucency area at the anterosuperior femoral neck with a surrounding sclerotic margin. Leunig and colleagues²⁵ demonstrated an association between the presence of this lesion and FAI. It is also important to measure the minimum joint space in the AP radiograph, because patients with a joint space of less than 2 mm are more likely to have a lower postoperative modified Harris hip score and are 39 times more likely to progress to a total hip replacement.¹²

Because the nonspherical part of the femoral head is usually located at the anterosuperior part of the head-neck junction, this can be demonstrated in a lateral view of the femur (**Fig. 3**). The femoral head-neck offset can be assessed by measuring the alpha angle as described by Nötzli and colleagues (see **Fig. 3**).²⁶ In the original description, the alpha angle was measured in magnetic resonance (MR) scans, but several recent studies used plain radiographs to determine the alpha-angle.^{23,27–29} Values of more than 50° are suggestive of abnormal femoral head-neck offset. Dunn view and the cross-table lateral seem to be the best radiographic views for alpha angle evaluation.³⁰ Several parameters can be used as alternative measurements, such as the head-neck offset ratio³¹ and the triangular index.³²

MRI provides details of soft-tissue disorders related to FAI. This imaging modality also reveals other causes of hip pain, which can be found concomitant with FAI, such as trochanteric bursitis and hip abductors tears. Moreover, viability of the femoral head is confirmed preoperatively. It is essential to have a study dedicated to the hip because a single-hip MRI has a better resolution than a pelvic MRI. MR arthrography may be used to better demonstrate labral and chondral damages.³³ Three-dimensional reconstructed CT scans can be used to delineate the bony abnormality³⁴ but it is not used routinely at the authors' institution.



Fig. 3. Alpha angle as measured on cross-table lateral radiograph for the diagnosis of cam impingement.

SURGICAL TECHNIQUE

Arthroscopic treatment of FAI aims to improve the clearance for hip motion and diminish abutment between the proximal femur and acetabular rim. A normal femoral head-neck offset is created by femoral osteoplasty while normal labral seal is maintained. This can be performed either in supine or lateral position depending on surgeon preference. The senior author (MJP) uses the modified supine position (**Fig. 4**) (the affected leg is placed in a position of 10° flexion, 15° internal rotation, 10° lateral tilt, and neutral abduction) with 2 arthroscopic portals (anterolateral and midanterior portals).

After patients are properly positioned and traction is applied, the anterolateral portal is established at 1 cm proximal and 1 cm anterior to the tip of the greater trochanter. Then, the midanterior portal is made 6 to 7 cm from the anterolateral portal at a 45° to 60° angle with respect to the longitudinal line passing through the anterolateral portal. This location is the middle between the longitudinal lines passing through the anterior superior iliac spine and the anterolateral portal. The midanterior portal has a greater distance from the lateral femoral cutaneous nerve compared with the anterior portal.³⁵ Interportal capsulotomy connecting both portals is performed using an arthroscopic blade to allow better mobility of arthroscopic instruments. The central compartment now can be inspected to identify and treat all concomitant pathologies, such as labral tears, chondral lesions, ligamentum teres tears, and a pincer lesion of the acetabular rim.

For femoral osteoplasty, traction is then released and the peripheral compartment is approached. The cam lesion can be usually identified as a bump on the femoral head-neck junction with changes in color (gray, purplish) and texture (fibrillation, fissure, flap) of the cartilage over this area (**Fig. 5**). While the hip is placed in 45° of flexion, femoral osteoplasty can be performed proximally at 1 cm from the peripheral edge of the labrum with the burr introduced through the anterolateral portal. The resection should taper distally along the femoral neck for 1.5 to 2.0 cm. The medial synovial fold and the lateral epiphyseal vessels should be observed and protected during the procedure and these can be used as the inferior and superior boundaries of osteoplasty.

Positioning of the hip is important for accessing different parts of the femoral head-neck junction in the peripheral compartment. The anteroinferior part of the femoral



Fig. 4. Arthroscopic setup for hip arthroscopy in the supine position.

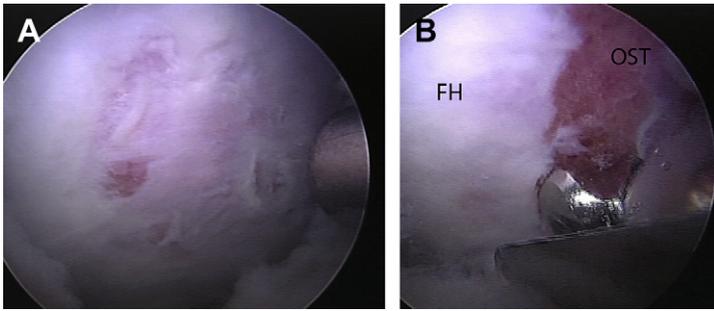


Fig. 5. (A) Femoral head neck bump as seen arthroscopically. (B) Burr shown performing osteoplasty of the area of impingement. FH, femoral head; OST, osteoplasty.

neck can be better visualized by increasing the amount of flexion of the hip. Moving the hip to a lesser degree of flexion and changing the arthroscope to the anterolateral portal facilitates burring at the superolateral part of the femoral neck. The arthroscope can be used as a capsular retractor by a levering maneuver during the procedure.

During femoral osteoplasty, the cam lesion should be adequately removed while a smooth and concave head-neck transition is created. Over-resection can increase the risk of femoral neck fracture and also has a negative effect on the labral seal. A herniation pit, which can be found in some patients, should be evacuated and usually becomes a shallow defect after finishing the femoral osteoplasty. For a large herniation pit, the senior author (MJP) prefers to fill the bony void with a bone-graft substitute plug. Periodic examination by moving the hip in all impinging motions is crucial to ensure that adequate bony resection is achieved while good labral seal is well maintained (**Fig. 6**). Capsular closure is performed using an absorbable suture. Platelet-rich plasma is injected for homeostasis purpose.

POSTOPERATIVE REHABILITATION

Postoperative protocol after hip arthroscopic treatment of FAI involves restriction of weight bearing, rotation, and motion.³⁶ Patients are kept at 20 lb of flat-foot weight

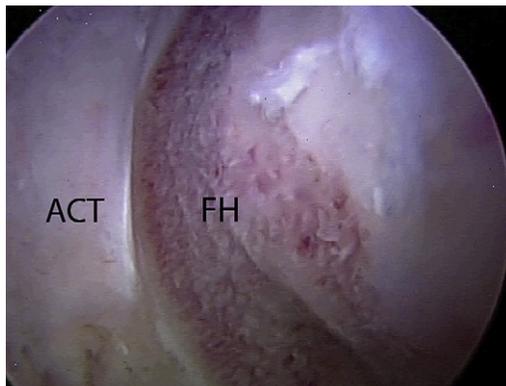


Fig. 6. Femoral head (FH) articulating in acetabulum (ACT) verifying adequate decompression and labral seal.

bearing for 2 to 3 weeks to protect the femoral neck after osteoplasty. Four hours of continuous passive motion machine is used for 2 weeks combined with use of a stationary bike at 0 resistance for 20 minutes. A modified hip brace and an antirotational bolster are used for 2 to 3 weeks to limit hip external rotation and extension, which will protect the early phase of capsular healing.

Physiotherapy should start with restoration of passive motion, followed by active motion and then strength. Passive circumduction movements are recommended to prevent adhesion. Active flexion of the hip should be gradually progressed to avoid flexor tendonitis.

COMPLICATIONS

Complications related to femoral osteoplasty have been reported and should be prevented, such as residual cam lesion, over-resection of the femoral neck, femoral neck fracture, avascular necrosis of the femoral head, and capsular adhesion.

A residual cam lesion is one of common causes of revision surgery after arthroscopic FAI treatment.¹⁵ This lesion can be prevented by carefully identifying the cam deformity and performing periodic dynamic examination during femoral osteoplasty. On the other hand, over-resection of the femoral neck can increase the risk of femoral neck fracture and has an adverse effect on the labral seal. Aggressive osteoplasty should be avoided. A smooth contour of the bony resection can be achieved by switching the arthroscopic portals to appreciate the 3-dimensional geometry of the femoral neck.

Femoral neck fractures have been reported as complications of arthroscopic femoral osteoplasty³⁷ and of combined arthroscopical and limited anterior approach.³⁸ Mardones and colleagues³⁹ performed a cadaveric study showing that resections up to 30% of the anterolateral head-neck junction of a morphologically normal femur did not significantly alter the load-bearing capacity of the proximal femur bone, and advised that 30% should be the greatest resection performed. Nonetheless, this amount of resection is seldom necessary. Weight-bearing restriction after femoral osteoplasty is emphasized to prevent this complication and the duration should be prolonged for patients with lower bone quality.

Avascular necrosis of the femoral head is a rare complication.⁴⁰ Both the medial synovial fold and the lateral epiphyseal vessels should be well visualized and protected during osteoplasty. Capsular adhesion is another common cause for revision surgery.¹⁵ Progressive range-of-motion exercise, both passive and active motions, is used to prevent this problem.

SUMMARY

Femoroacetabular impingement is an abnormal conflict of the acetabular rim and the femoral head-neck junction. This condition causes labral and cartilage damage and leads to early osteoarthritis of the hip. After clinical evaluation and radiographic examination, hip arthroscopy is one of the treatment options for FAI. During hip arthroscopy, the bony abnormalities can be corrected. Femoral osteoplasty is performed to restore normal femoral head-neck offset while the amount of bony resection is monitored by periodic examination. Postoperatively, patients are kept at partial weight bearing and rehabilitation focuses on range of motion. Complications related to this procedure are not common.

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