A Clinician's Guide to Femoacetabular Impingement in Athletes

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ABSTRACT

Femoroacetabular impingement (FAI) is the most common cause of hip pain in both professional and recreational athletes. It is caused by abnormal bone development on both the acetabulum and proximal femur as a result of genetic factors and in reaction to high-volume athletics participation. Athletes typically become symptomatic after reaching skeletal maturity and commonly describe deep groin pain that worsens with activities such as squatting, cutting, or pivoting motions. For this reason, sports such as hockey, football, and soccer can be particularly irritating to an athlete with FAI. Moreover, the athlete with FAI often presents with contaminant hip and pelvis pathologies such as athletic pubalgia and iliopsoas tendinopathy that must also be addressed. While this pain often limits performance or participation in sports, perhaps the most significant ramification of FAI is the role it plays in driving early onset osteoarthritis. Fortunately, FAI can be reliably diagnosed through careful history taking, appropriate provocative physical exam maneuvers, and familiarity with hallmark radiographic features. The aims of this review are to provide clinicians with information regarding the pathogenesis of FAI, to thoroughly describe the classic history and physical exam elements, and to introduce various management strategies for athletes suffering from FAI.

KEYWORDS: hip, femoacetabular impingement (FAI), athletes, sports medicine

INTRODUCTION

Femoroaceabular impingment (FAI) is a dynamic pathoanatomic relationship between the acetabulum and the femoral head that results in abnormal contact between the two surfaces. FAI is the most common cause of hip pain in both professional and recreational athletes and is most commonly associated with sports that demand repetitive bursts of acceleration, twisting or cutting motions.[1-3] FAI consists of 3 sub-types of lesions; cam, pincer, and combined (**Figure 1**).[4-8] Cam lesions are the result of the non-spherical shape of the femoral head, often referred to as a "pistol-grip" deformity, which cause abrasions to the acetabular cartilage and subsequent avulsion from the labrum and subchondral bone.

Figure 1. Primary subtypes of FAI. [8]

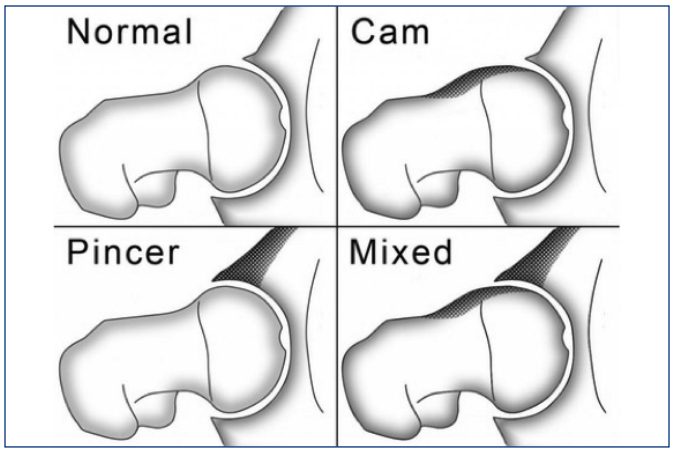
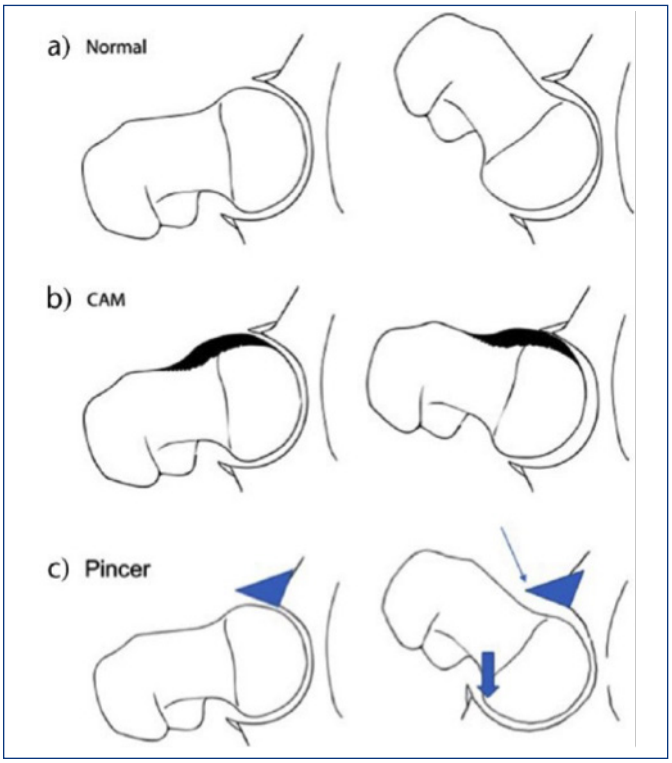


Figure 2. a) Hip demonstrating normal clearance. b) Cam lesion pushes past labrum resulting in damage to the chondrolabral junction. c) Pincer lesion generates crush injury of the labrum by the femoral neck (thin arrow) and contre-coup lesion (thick arrow).[9]



Pincer lesions, on the other hand, are the result of excessive coverage of the femoral head-neck junction by the acetabular rim and can lead to labral tearing (**Figure 2**).[9] The combined subtype incorporates elements of both cam and pincer type morphology.[4]

Determining the true prevalence and specific mechanisms that drive the development of FAI remains a challenge primarily because many patients with FAI morphology are asymptomatic.[10] However, epidemiologic studies have been able to establish that cam lesions demonstrate a predilection for male sex, whereas pincer lesions are more commonly found in females. In patients with symptomatic FAI, combined lesions are the most common subtype and represent up to 85% of cases.[4,10-12] Currently, it is believed that FAI begins with a congenital or acquired bony deformity that is subsequently exacerbated by repetitive microtrauma to the proximal femoral physis and epiphysis. As a result of the increased loading forces over several years there is an accumulation of abnormal bone as the athlete approaches skeletal maturity.[2,11,13]

This hypothesis is supported by the following facts:

1. Individuals with parents or siblings with FAI are more than twice as likely to suffer from FAI.[2,11]
2. There is a higher incidence of FAI in athletes who participate in sports that require repetitive hip motion (i.e. hockey) and enter competitive levels at an early age.[14-16]
3. That radiographic findings of FAI typically begin shortly after physeal closure. [2,11,14,15]

Although the etiology of FAI is not entirely understood, there is a significant amount of literature describing the role of FAI in other sports-related injuries such as ACL tears, athletic pubalgia, and iliopsoas tendinopathy. It is believed that FAI increases the risk for these types of injuries because it restricts internal rotation of the hip which leads to altered biomechanics and increased strain on soft tissue structures.[17–21] Additionally, current data suggests that FAI, more specifically cam and combined type lesions, serve to accelerate the progression to osteoarthritis.[4,10,11] In review of 121 patients under the age of 50 presenting for total hip arthroplasty, only 3 did not have radiographic findings of FAI.[22] Despite the growing recognition of FAI and its implications in long-term joint health, many patients still fail to receive a timely diagnosis with an average time delay of 1–2 years from initial presentation.[10,14]

PRESENTATION AND PHYSICAL EXAM

The evaluation of a patient with suspected FAI must begin with a thorough review of the patient's history, as many of the risk factors or predisposing conditions previously noted are either present in childhood or develop in early adulthood. While FAI can present within a heterogenous population, patients are most often young athletes participating in sports such as hockey, soccer, football, and lacrosse.[13,23] This emphasizes the importance of ascertaining the patient's typical activity level, the ways in which their pain has limited this activity, and any specific return to activity goals they may have. Patients with FAI most commonly describe hip pain or stiffness during or after activity.[13] Their discomfort is typically described as "deep" and located along the hip above the greater trochanter and traversing anteriorly and inferiorly towards the inguinal crease. This is known as the "C-sign". This pain is often exacerbated by deep hip flexion, particularly when coupled with rotation which can occur with physical activity or prolonged sitting.[23,24]

As with most other disorders of the hip, the exam findings and provocative maneuvers used to elicit the presence of FAI are sensitive but nonspecific. For this reason, it is imperative to not only confirm the presence of intra-articular pathology,

Figure 3. The anterior impingement, or FADIR test, consists of flexion, adduction, and internal rotation that results in pain or clicking.

Figure 4. FABER test may produce discomfort in various locations, but is only considered positive for FAI if it elicits anterior hip pain.

but also to rule out concomitant extra-articular pain generators such as tendinopathy, bursitis, and lumbopelvic dysfunction when examining these patients.[3,23,24] Observation of gait and seated posture can provide helpful clues as 34.5% of patients experience discomfort even with light walking and 25.5% experience pain when seated for more than 15 minutes. Additionally, almost 45% of patients with FAI report having pain when transitioning from a seated to standing position.[23] Passive range of motion (ROM) should be assessed next while bearing in mind that FAI morphology commonly occurs bilaterally.[25] Patients with FAI routinely demonstrate decreased ROM in flexion, abduction, and internal rotation. Interestingly, when the hip is flexed to 90°, the loss of internal rotation becomes profound. A study by Wyss et al[26] found that at 90° of flexion, patients without FAI morphology had on average 28° of internal rotation whereas those with FAI morphology had only 4°.

While there are several provocative maneuvers that can be used to evaluate for FAI, only two tests have demonstrated clinical efficacy. The first maneuver involves flexion, adduction, and internal rotation (FADIR) and is also referred to as the anterior impingement sign **(Figure 3)**.[9] The second maneuver uses flexion, abduction, and external rotation (FABER) to assume a figure-4 like position (**Figure 4**). The FADIR test assesses for impingement in the anterior portion of the joint and is considered positive if pain or clicking is elicited. The FABER may produce discomfort in various locations, but is only considered positive for FAI if it elicits anterior hip pain or if there is an increased distance from the lateral femoral condyle to the edge of the examination table when compared to the contralateral side. While largely nonspecific, both the FADIR and FABER tests have demonstrated excellent sensitivity at approximately 97%.[3,23,24,27,28] Although the diagnostic accuracy has not been as extensively evaluated, impingement along the posterior aspect of the joint may be tested by extending the hip in an abducted and external rotated position known as the posterior impingement test.[3,24]

RADIOGRAPHIC EVALUATION

Plain Films

If concern for FAI exists after completing a history and physical exam, then weight-bearing plain film imaging should be obtained. This series should include a standard anterior posterior (AP) pelvis, an AP of the symptomatic hip, and a frog lateral. Additionally, clinicians may choose to include a Dunn view or false profile in order to more thoroughly assess the contour of the femoral head and neck. In general, the true AP, Dunn, and modified Dunn are the most useful in assessing pincer morphology while the cross table, and false profile are most useful for cam subtypes.

The AP, Dunn and modified Dunn should first be evaluated for any overt signs of FAI such as egregious over-coverage of the femoral head-neck junction by the acetabulum seen with pincer lesions or the classic pistol grip deformity associated with cam lesions. Additionally, the presence of more subtle findings such as a crossover sign should be explored. The crossover sign is present when the outlines of the anterior and posterior walls intersect and it is indicative of a prominent anterior wall from either overgrowth or excessive retroversion of the pelvis.[4,29,30] Specific measurements that can be made using the AP Pelvis view are the lateral center edge angle (LCEA) and the Tonnis roof angle (TRA) (**Image 1**). The LCEA is formed by a line from the center of the femoral head to the lateral edge of the acetabular sourcil and a vertical line through the center of the femoral head. While there is debate regarding exact cutoff values, an angle of >35-40° is considered to be consisting with pincer morphology. The TRA, also known as the acetabular index, is defined by a line connecting the medial and lateral limits of the sourcil and a horizontal reference line. A TRA of <3° is indicative of pincer morphology.[29,30]

Image 1. AP pelvis demonstrating a LCEA that is within normal limits (31.4°), an abnormal TRA (9°), and evidence of CAM deformity (arrow).

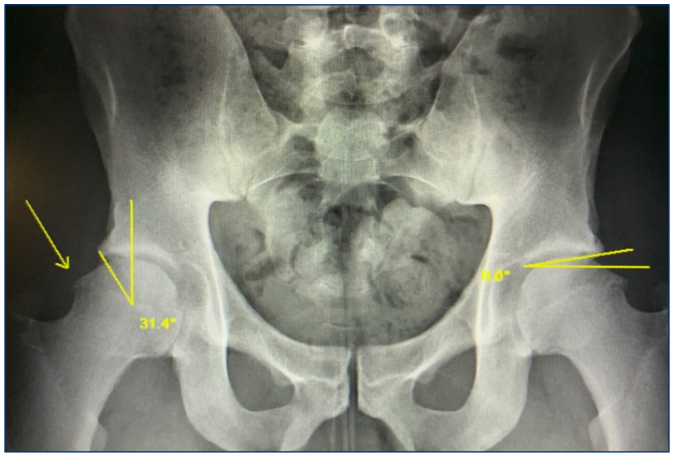
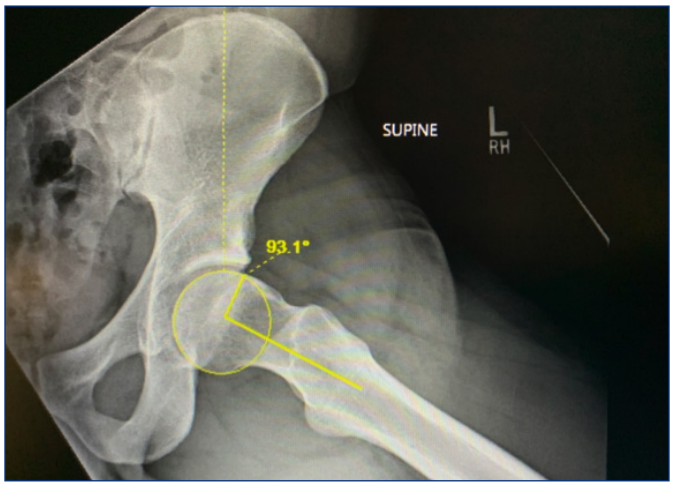


Image 2. Frog leg lateral demonstrating an alpha angle of 93.1° consistent with CAM deformity (>55°).



As previously stated, the most useful information for assessing cam lesions can be found using laterally oriented projections.[4,29,30] The senior author's preference is the frog leg lateral. Here, the sphericity of the femoral head-neck junction, or lack thereof, can be appreciated by calculating the alpha angle. The alpha angle consists of a line connecting the center of the femoral head to the point where the femoral head begins to flatten and a reference line through the axis of the femoral neck (**Image 2**). Angles >55° are considered to be consistent with cam lesions.[4,29,30]

MRI

Although one's history, physical exam, and plain films can establish a diagnosis of FAI, they are unable to adequately assess the articular cartilage and soft-tissue structures surrounding the hip. Magnetic resonance imaging/arthrogram (MRI/A) should be obtained to investigate the condition of these tissues.[4,29,31,32] Traditional teaching had been that 1.5T MRA was the imaging modality of choice, but more recent data has shown equivalent or superior performance of 3T MRI images.[31] 3T MRI not only provides optimal spatial resolution, but also eliminates the need for intra-articular hip injections.[29,31]

Using these images, clinicians are able to thoroughly assess any lesions or alterations to both the labrum (**Images 3 and 4**) and underlying cartilage as well as identify common conditions associated with FAI such as athletic pubalgia (**Image 5**) and hip flexor tendinopathy.[31] However, it important to remember that not all radiographic findings have clinical implications, particularly when it comes to labral tearing as it has been found in up to 69% of asymptomatic hips.[33] This underscores the importance of one's history and physical exam as the primary driver of diagnostic probability. Although debate exists around the role of the capsule in hip stability and FAI, most authors agree that MRI provides a reasonable qualitative assessment of capsular defects.[31] As an added benefit, 3T MRI can also provide further insight into osseous configurations pertaining to acetabular depth and width, femoral and acetabular version, and femoral head that may not be apparent on plain films.[29,31]

Computed Tomography (CT)

While the previously mentioned imaging modalities are incorporated in the standard workup of FAI patients, the role of CT is far more limited. CT is generally reserved for cases in which complex deformities are present or plain films and MRI do not provide sufficient information for proper surgical planning. In these cases, CT scans can be used to not only map the hip and pelvis, but also to produce a 3-dimensional reconstruction that predicts specific positions of discomfort that will help guide operative resection.[4,29]

Image 3. Coronal T2 MRI demonstrating a tear in the superior portion of the labrum associated with FAI.

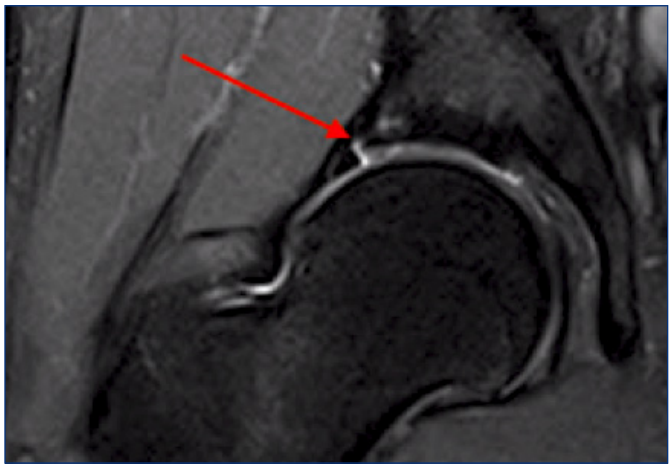


Image 4. Proton denisty weighted, fat suppressed sagittal oblique MRI demonstrating a tear in the anterior portion of the hip labrum in assocition with FAI.

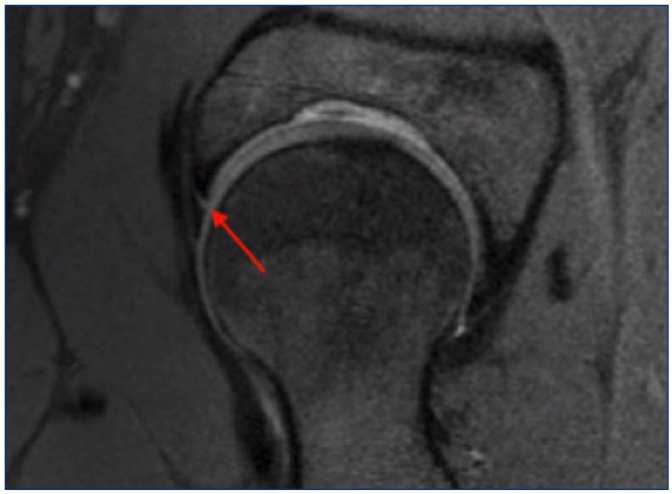
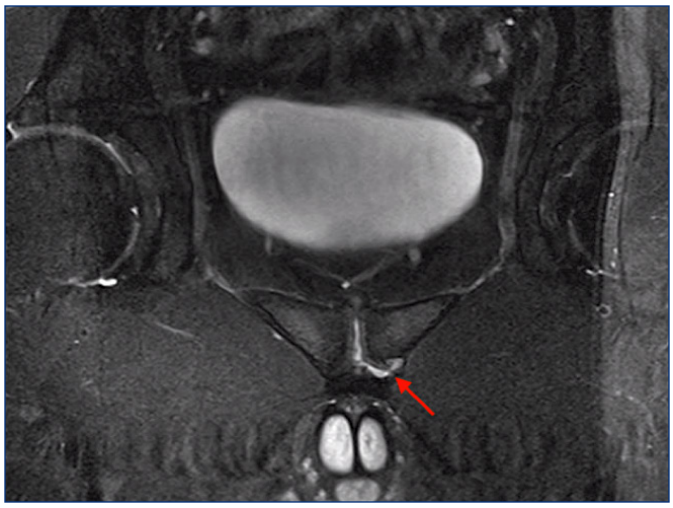


Image 5. T2 axial oblique MRI demonstrating tearing of the rectus aponeruosis from the pubic tubericle.



TREATMENT AND OUTCOMES

Conservative

The first line treatments for femoroacetabular impingement are conservative measures. This includes physical therapy, anti-inflammatory medications, and activity/lifestyle modifications. Studies have shown that good outcomes can be achieved with nonoperative management. One publication showed that 93 hips in 76 patients were successfully managed with physical therapy, rest and activity modifications.[7] It is recommended that athletes initially discontinue participation in their offending sport.[7,34] Physical therapy regimens should focus on core strengthening and stabilization as well as postural retraining with normalization of the dynamic relationship between the hip and pelvic muscles.[7,34,35] Activities such as deep flexion, positions that provoke symptoms, squats and heavyweight strength training should be avoided.[7,34,36,37] Physical therapists and athletic trainers can help athletes work on correcting their movements within the limits of pain and ensure they have appropriate pelvic tilt.[36] For high-level athletes, if the patient can continue to function at a high level despite their pain, then they can be managed with exercises and non-opioid analgesics in season.[35] Physicians can additionally consider local injections to manage symptoms during the season.[34]

Steroid injections can be used to obtain a faster effect in pain relief while hyaluronic acid injections can obtain a more delayed effect in functional improvement.[38] Pain relief from intra-articular injections support the diagnosis of FAI, but a negative response to the injection may predict poor short-term outcomes from surgical interventions.[39] When focusing on non-operative management, another study showed that there is no difference when groups were randomized to receive manual therapy and supervised exercise in addition to a regimen of standard advice and home exercise.[40] Medical and conservative management should be the focus when there are already degenerative changes to the hip joint, as joint-preserving operations such as arthroscopy are no longer indicated.

Many patients have successful outcomes with conservative management. One study of random allocation to arthroscopy versus physical therapy showed no significant difference between the groups at two years of treatment.[41] Another study treated their entire cohort of FAI patients with physical therapy initially. They demonstrated that 70% were successfully managed with conservative measures, while 12% required a steroid injection and 17% progressed to surgery.[7] The authors identified that hips with cam or combined cam-pincer impingement were 4.4 times more likely to progress to surgery than those with isolated pincer deformities.[7] Although conservative measures are often effective as described above, it is important to consider surgical management for FAI patients, especially those with cam lesions. Cross-sectional and longitudinal natural history studies have shown that cam lesions are associated with developing osteoarthritis.[22]

Surgical

Hip arthroscopy is the mainstay of surgical treatment for femoroacetabular impingement. It is most frequently performed with the patient in the supine or lateral position with peritrochanteric, midanterior, and anterior portals. Traction is used to access the central compartment within the acetabulum, where pathology to the articular and labral components can be addressed. The peripheral compartment is also accessed to address any pathology or deformity of the proximal femur. During arthroscopy, the labrum, acetabulum, femur, and capsule can all be addressed. Labral repair is recommended as this leads to greater improvements in postoperative functional scores when compared to labral debridement.[42] If a labral repair is not possible, a labral reconstruction is then employed. Acetabuloplasty can be performed to address the pincer lesion, while femoral osteotoplasties can be performed to address the cam lesion.[43] It is crucial for surgeons to perform an adequate bony resection intra-operatively. Unaddressed or undertreated bony impingement lesions have been found in 79% of revision cases, according to one study.[44]

Athletes with FAI managed surgically can have very high rates of returning to play. One study of 66 athletes showed that 94% of recreational athletes returned to play while 88% of higher level amateur athletes returned, with a significant improvement in all patient reported outcome measures in both groups.[45] Another study analyzing higher level athletes showed that 74% returned to play at preinjury level after surgery for FAI, with professional athletes demonstrating a higher return to sport rate than collegiate athletes.[46] A publication on a Danish registry had less promising results, with only 57% of athletes returning to preinjury level after arthroscopy.[47]

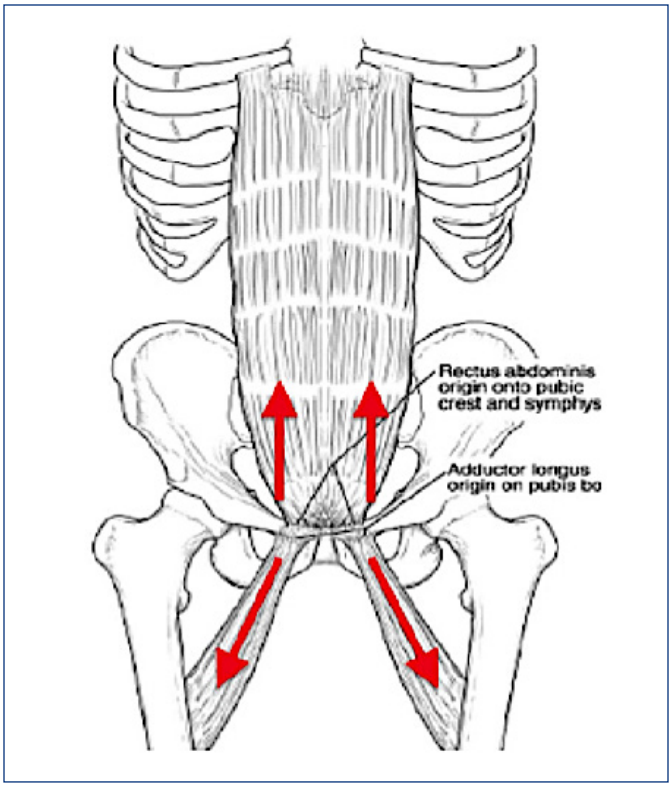
Postoperatively, patients treated with arthroscopy for FAI showed a significant improvement in hip flexion and extension strength; however, this measure still remained lower compared to control groups.[48] Regarding long-term outcomes from arthroscopic management of FAI, a study analyzing patients 7–10 years postoperatively demonstrated a significant decrease in VAS pain scale with significant increases in patient-reported outcome measures.[49] Soccer players have a high rate of return to sport, with the current literature suggesting 96–100% at 9–10 months postoperatively.[50,51] One study showed that 100% of basketball players returned at an average of 7.1 months.[52] Football players had a slightly lower rate of return, with a reported range of 87–92.5% at a mean 6.0 months postoperatively.[53,54] Hockey players had a much broader reported range of return with 67–100% returning to skating/hockey drills at an average of 3.8 months.[55,56]

ASSOCIATED CONDITIONS

Athletic Pubalgia

In addition to femoroacetabular impingement, athletic pubalgia, or sports hernia, is a well-known cause of groin pain in young athletes. The syndrome is described as having exertional inguinal and adductor pain (**Figure 5).** This pain is potentially caused by the disruption of the insertion of the rectus abdominis muscle or the internal oblique muscle from the pubic tubercle, or potentially an abnormality in the external oblique aponeurosis.[18] There is likely a connection between the pathology of athletic pubalgia and FAI. Impingement in the hip joint will lead to altered or restricted movements of the pelvis, which can result in higher stress on compensatory regions such as the pubic symphysis.[18,21] The increased stress can lead to injury to the posterior inguinal wall, resulting in athletic pubalgia. This connection would explain the high prevalence of FAI in patients with athletic pubalgia. One study showed radiographic evidence of impingement in at least one hip in 86% of patients having surgery for athletic pubalgia.[57] Another series of athletes undergoing surgery for femoroacetabular impingement showed that 32% previously had surgery for athletic pubalgia and another 39% complained of athletic pubalgia symptoms at the time of arthroscopy.[58] Combing these subgroups suggest that athletic pubalgia can be present in up to 71% of patients with impingement.[58] As patients often present with both pathologies, intra-articular and extra-articular injections can be used to determine the degree of pain coming from each pathology.[35] Persistent pain on physical exam/exercise challenge after image guided intra-articular injection is consistent with athletic pubalgia.[35]

Figure 5. Restricted range of motion about the hip increases work requirements, and therefore strain, at the insertion of the rectus abdominus and origin of the adductor longus.[21]



In those athletes whose abilities are limited by their symptoms, earlier surgical intervention can be considered. Generally, both conditions are addressed simultaneously as this has historically produced optimal results. Athletes who undergo athletic pubalgia surgery alone generally have a return to play rate of 25% whereas those who undergo FAI surgery alone have a return to play rate of 50–60%.[58,59] However, those who had both conditions corrected at the time of surgery have a return to play rate of 89%.[59] For this reason, when evaluating high level athletes with FAI and athletic pubalgia, physicians should consider simultaneous surgical treatment in order to obtain a more predictable return to sport and minimize time lost from training.[35,59]

Iliopsoas Impingement/Tendinopathy

Another condition associated with femoroacetabular impingement is iliopsoas impingement and tendinopathy. This condition is also referred to as internal snapping hip syndrome. It can imitate joint pain, so it is important to distinguish this diagnosis with careful history and physical exam. The condition stems from a decrease in range of motion, specifically external rotation and abduction. Patients develop a contracture of the iliopsoas and feel a pop over the pectineal eminence. Current literature indicates that iliopsoas fractional lengthening for painful internal snapping is the second most common concomitant procedure performed with FAI surgery, with 73% of the patients in the cohort having both procedures.[60] Fortunately, patients with this associated condition benefit from surgical intervention. Patients with combined FAI and painful snapping hip who had iliopsoas lengthening at the time of treatment had similar improvements and complication rates compared to patients who only had arthroscopy for isolated FAI.[61]

Iliopsoas tendinitis can be a postoperative issue for patients who underwent arthroscopy for FAI. It was diagnosed in 24% of a cohort of 252 postoperative patients.[20] Within this subgroup, 47% improved with activity modification/NSAIDs/PT, 53% required a corticosteroid injection, and 12% required revision arthroscopy and iliopsoas release.[20] A different study looking at revision hip arthroscopy found that 29% of patients had a tight psoas tendon and corresponding labral impingement, for which a partial psoas tendon release was performed.[44] This data stresses the importance of assessing the iliopsoas during the index procedure as these patients do well if it is appropriately addressed, but can have issues postoperatively if it is not.

CONCLUSION

FAI results from a deformity of the proximal femur and/or acetabulum. It is a common cause of hip pain in athletes. Patients should be evaluated with history, physical and the appropriate imaging. Patients can often be managed with conservative measures such as physical therapy. However, patients have high returns to sport with hip arthroscopy. Patients with FAI should also be evaluated for athletic pubalgia and iliopsoas impingement, as they are frequent concomitant conditions.

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