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Anterior Femoroacetabular Impingement: A Clinical Presentation

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SUMMARY

Femoroacetabular impingement is a cause of groin pain, which frequently afflicts young, active patients. Patients with irregularities in the morphology of the proximal femoral head–neck junction are at risk for developing impingement of the acetabular labrum. Furthermore, the cam effect causes compression and avulsion of acetabular cartilage and can result in irreversible degenerative changes in the joint of these relatively young patients. Understanding the anatomy responsible anterior impingement and disorders of the acetabular rim is essential for joint preservation. Arthroscopic debridement may alleviate acute labral symptoms but does not address the underlying osseous anatomy; treatment should include osteoplasty of the proximal femur to improve the anterior head–neck offset and allow clearance of the anterior acetabular rim. A case is presented to highlight the presentation, exam, diagnosis and treatment recommendations for patients with anterior femoroacetabular impingement.

Key Words: Femoroacetabular impingement, Labrum lesion, Cam effect, Groin pain

INTRODUCTION

Historically, athletic injuries about the hip and groin have been underdiagnosed, representing only 5% to 10% of injuries reported in high school athletes.[1,2] Recent advances in imaging techniques and a higher index of suspicion have brought attention to disorders of the acetabular rim and its associated soft tissue structures as possible sources of hip pain. However, although magnetic resonance imaging (MRI) and magnetic resonance arthrography allow identification of intra-articular and periarticular soft tissue and cartilage lesions, an understanding of the pathomechanics resulting in labral and cartilage injury is imperative before treatment is considered. Minimally invasive arthroscopic labral surgery may palliate the patient's early complaints of hip pain, but the underlying biomechanical abnormality responsible for the labral condition will persist and may predispose patients to early arthrosis or predictable reinjury of the repaired labrum.

The pain associated with labral pathology and progressive chondral damage at the associated articular surface may be the earliest complaints in patients with underlying hip dysplasia. Furthermore, in patients without radiographic evidence of acetabular dysplasia, irregularities in the proximal femoral geometry may render the labrum and anterior acetabular ring susceptible to impingement with extremes of motion. Injury to the labrum and associated soft tissues results from chronic abnormal loading of the acetabular rim, which also increases the contact pressures and joint-loading forces at the articular surface and thus predisposes to arthrosis. Labral disorders may develop in young, active patients with repetitive and forceful range of motion required in the patient's sport, and the patients may present with initial complaints associated with labral tearing well before the joint decompensates and degeneration becomes evident.

The ultimate goals in the patient's treatment are palliation of symptoms and joint preservation. It is essential to understand the pathomechanics resulting in anterior impingement and disorders of the acetabular rim for appropriate diagnosis and treatment because biomechanical correction of the underlying anatomic abnormality may be warranted. The following clinical presentation of a young athlete presenting with groin pain will serve as a template to discuss anterior femoroacetabular impingement and the spectrum of pathomechanical abnormalities that can result in hip pain in the young patient.

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CLINICAL PRESENTATION

History

The patient is an 18-year-old man presenting with a 2-month history of right hip and groin pain. He noted no specific injury to his hip; however, after further questioning, he recalled that 6 years ago he had an acute onset of pain in the same hip and required crutches for ambulation for a short time. At the time he had a diagnosis of early ankylosing spondylitis, but the diagnosis never confirmed with clinical follow-up. The pain in his hip resolved spontaneously and he had been asymptomatic until his recent recurrence.

The patient describes a sharp, knife-like pain in the groin. He did not report locking but rather occasional clicking in the hip. The symptoms were exacerbated by walking and by his sporting activities, especially with hip flexion and internal rotation. There were interludes between painful episodes during which he was completely pain-free, and these times did not correlate with rest or activity modification.

Clinical Exam

The patient walked with a normal gait and demonstrated no abductor weakness. There was no limb length discrepancy. His flexion, internal rotation, and abduction were significantly limited on the right side when compared with the unaffected hip. His flexion on the right side was limited to 120° compared to 130° on the left, and he was able to rotate internally only 15° compared with 45° on the left. Abduction of his affected hip was 30° compared with 40° on the left. Of note, when he maximally flexed his right hip in the supine position, his hip tended to assume an abducted and externally rotated position. There were no crepitation, clicks, or clunks with rotation. The patient had a positive impingement test result (Fig. 1).

FIG. 1. The impingement test. Hip flexion, adduction, and internal rotation reproduces a sharp pain in the groin. Flexion and adduction lead to the abutment of the femoral neck and the acetabular rim, and internal rotation further pinches the anterior labrum, eliciting pain if the labrum is injured.

Imaging

Radiographs, including an anterior–posterior pelvis and frog lateral of the affected hip, showed no evidence of acetabular dysplasia, with an anterior center–edge angle of 45°, an intact Shenton line, and no femoral head migration. The joint was congruent and the joint space well preserved with some subchondral sclerosis on the acetabular side (Fig. 2), consistent with early acetabular degeneration. The lateral contour of the head–neck junction was irregular, with very little offset, a pistol grip deformity, and a conically shaped head with an increasing distal radius.

An MRI (Fig. 3) demonstrated the nonspherical nature of the patient's femoral head and the irregularity at the head–neck junction. There was cartilage damage at the area of impingement and a small exostosis just distal to the presumed area of impingement. There was an acetabular cyst, which additionally is evidence of early arthritis. The diagnosis of anterior femoroacetabular impingement was made based on the history and clinical exam, and reinforced by the imaging studies.

Operative Technique/Findings

Surgical intervention included recontouring the border of the femoral head–neck junction and deepening the offset by resection osteoplasty of the bone involved in the impingement. The femoral head was dislocated surgically through the Kocher Langenbeck approach with a trochanteric osteotomy and an anterior arthrotomy. Impingement was visualized intraoperatively before disarticulation to verify the site of impingement and absolutely identify the offending area of the femoral head–neck junction. The corresponding anterior labrum was found to be intact; however, inspection of the joint after disarticulation demonstrated that the acetabular cartilage in the anterior superior location adjacent to the impingement was soft and avulsed. An area of the anterior femoral head had flattened; the cartilage was frayed and there was early osteophyte formation (Figs. 4A and 4B).

The nonspherical portion of the head–neck junction was excised, improving the femoroacetabular offset (Figs. 4C and 4D). The epiphyseal branches of the medial circumflex femoral artery, which lie subperiosteal at the posterosuperior side of the femoral neck and are the primary blood supply for the femoral head, were preserved carefully. Creation of an improved, deepened femoral head–neck offset by resection osteoplasty of the anterior femoral neck allowed impingement-free motion as verified by direct visualization and image intensification.

Follow-up

Six months postoperatively, the patient was back to his normal activities, including snowboarding and surfing. He

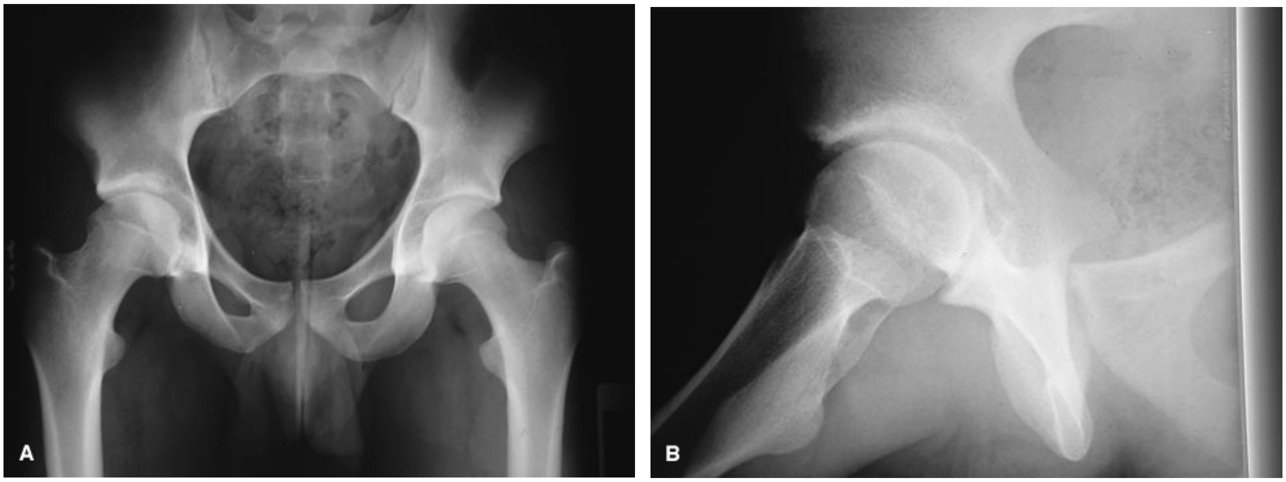

FIG. 2. A, B: Radiographs from the 18-year-old man with right-sided groin pain limiting flexion by 10° and internal rotation by 30°. The anterior–posterior pelvis demonstrating the normal morphology of the acetabulum and the lack of evidence for residual hip dysplasia. There is reactive subchondral sclerosis of the right lateral acetabulum.

had no hip pain the time of his follow-up, and his range of motion was improved; he still lacked 10° of flexion compared with the uninvolved hip (120° vs. 130° on the left), but had symmetric adduction (40°) and internal rotation (45°) bilaterally. His impingement sign was negative. Radiographs demonstrated the proximal femoral recontouring, preservation of joint space, and lack of osteophyte formation at the femoral head (Fig. 5).

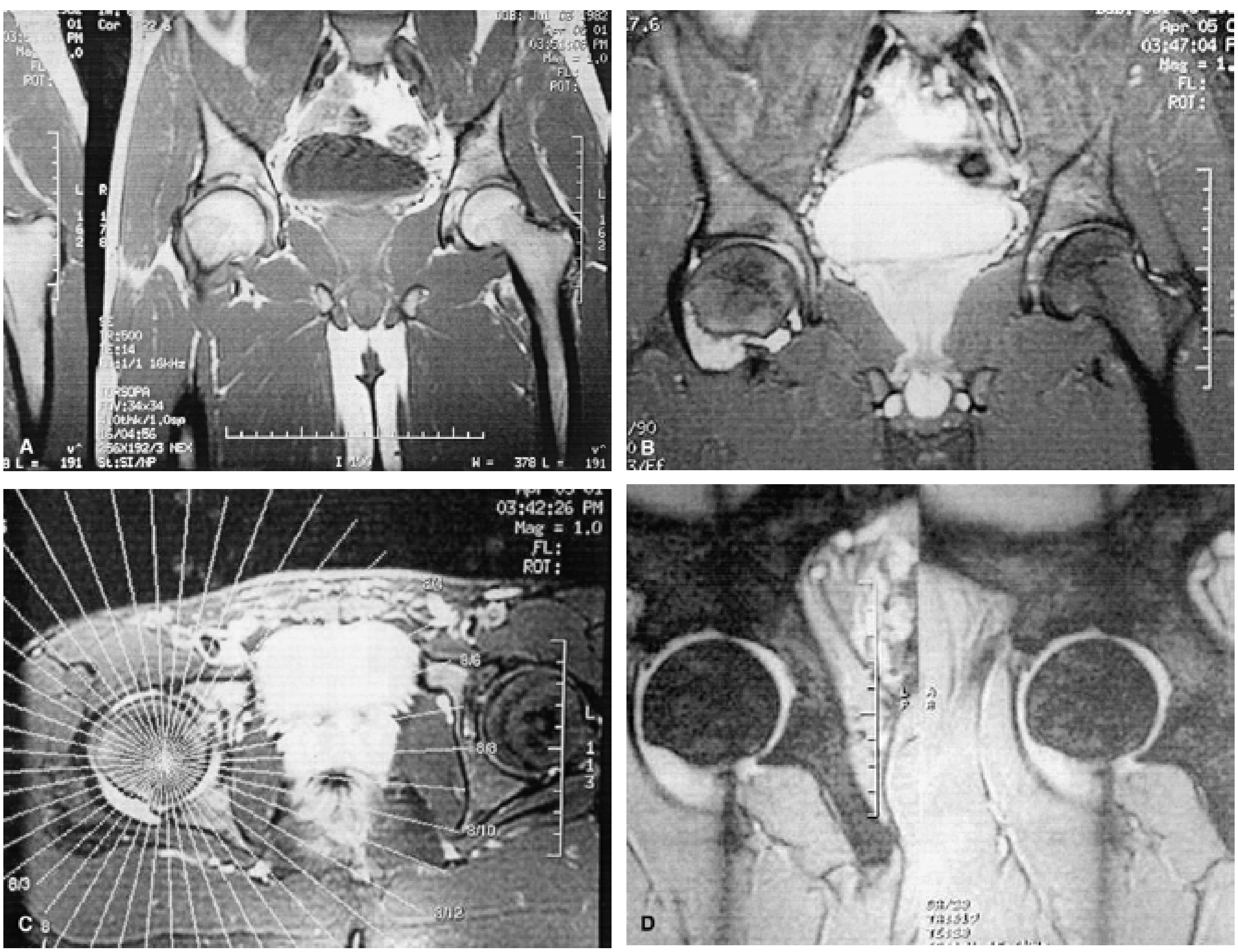

FIG. 3. A through D: Special protocol MR arthrogram with radial section of the femoral head and neck to better assess proximal femoral geometry. The nonspherical head can be appreciated. A lesion of the anterior superior acetabular cartilage can be appreciated, as can an associated acetabular cyst.

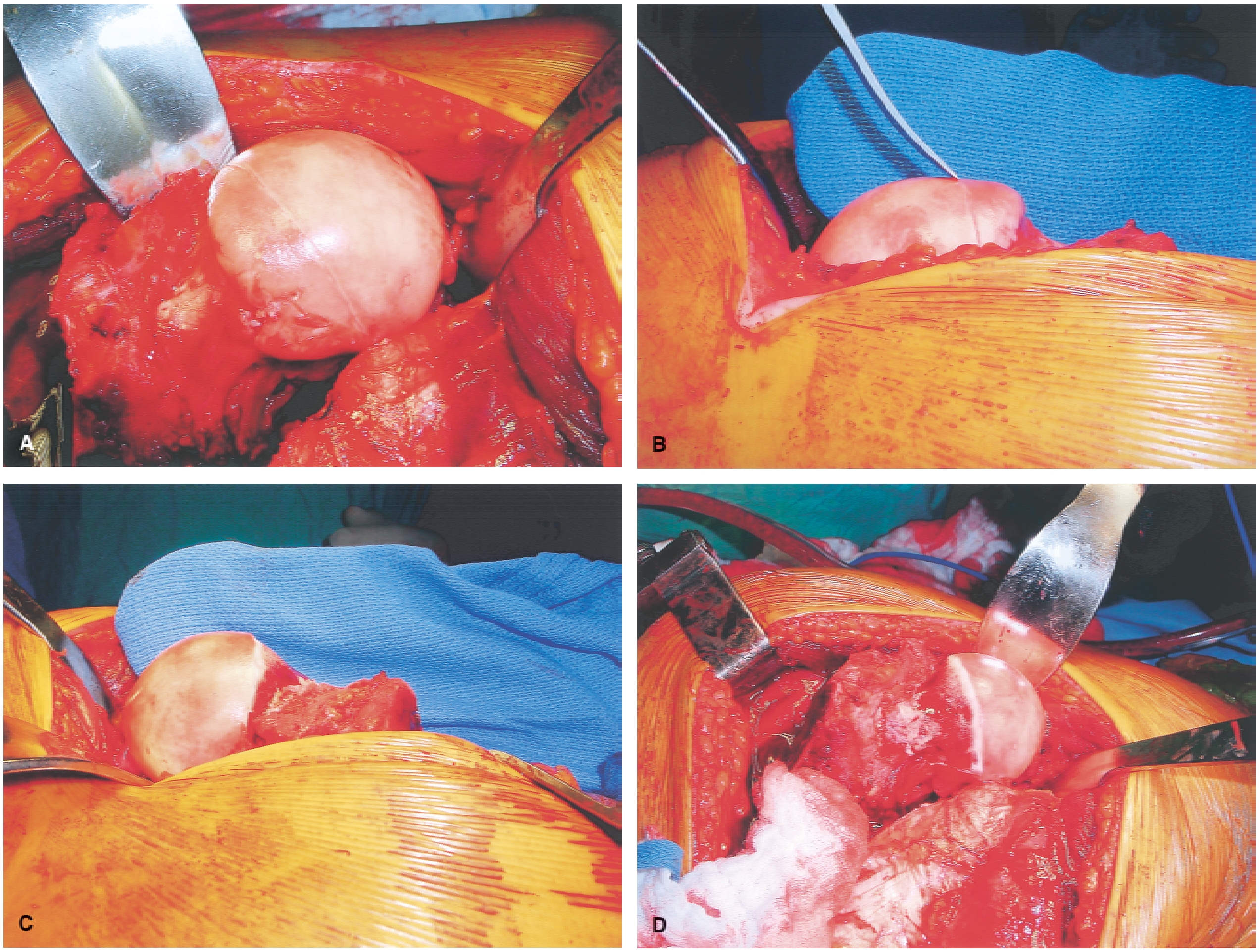

FIG. 4. Intraoperative findings. **A:** The disarticulated femoral head is nonspherical. A groove can be seen running circumferentially around the femoral, representing the rim of the acetabulum being wedged into it. **B:** The impinging area of bone is removed with a curved osteotome. **C,D:** The recontoured femoral head after the osteoplasty.

DISCUSSION

Hip dysplasia refers to an abnormality of shape, size, or orientation of the acetabulum, femoral head or neck, or of their proportions or spatial relationships to each other. Labral lesions of the anterolateral acetabular rim are common in patients with acetabular dysplasia and are often responsible for the patient's initial presentation. Dysplasia characterized by a shallow and vertically oriented acetabulum allows instability and anterolateral migration of the femoral head. The femoral head exerts a chronic shear stress on the labrum and capsule at the acetabular rim, ultimately causing the labrum

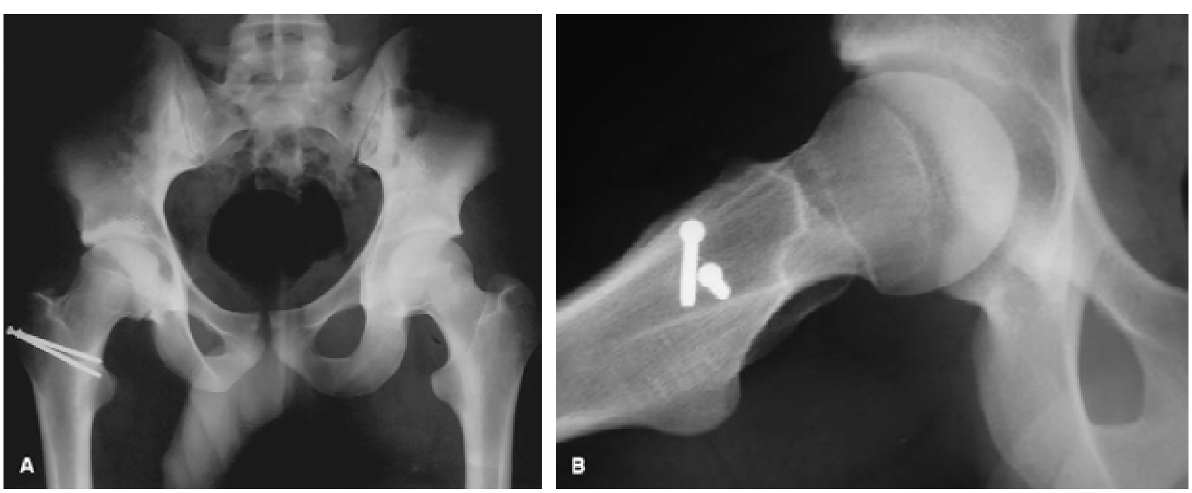

FIG. 5. **A,B:** Follow-up radiographs. The femoral offset has been improved by the osteoplasty.

to degenerate and tear from its acetabular attachment. Dysplasia in which the hip is congruent but has inadequate femoral head coverage (short roof) results in elevated contact pressure at the acetabular rim due to the reduced surface area available for load sharing. The overloaded roof rim may develop fatigue fracture and separation of the rim fragments, with or without labral tearing or detachment. In either case, the mechanically compromised articulation exposes the intrinsically normal capsulolabral complex and articular cartilage to excessive loading forces.

Recently, the phenomenon of anterior impingement of the femoral neck on the anterior acetabular rim has been identified as a source of hip pain and labral injury in a group of patients without radiographic signs of acetabular dysplasia. Impingement occurs when the anterior femoral neck comes into contact with the rim of the anterior acetabulum and its associated structures. This can occur only if 1) a geometric mismatch in the proximal femur and the acetabular rim permit abutment and the cam effect to occur and 2) the hip is positioned in a specific point in the range of motion that permits contact of the anterior femoral neck and the acetabulum.

An elaborate evaluation by Ito et al.[3] demonstrated that patients with reduced anteversion or decreased head–neck offset in the anterior aspect of the femoral neck were at risk for developing symptoms of anterior impingement. In these patients, the relatively larger anterior radii and shallower taper of the neck causes a decrease in the space available for clearance of the acetabular rim during flexion, especially in combination with internal rotation and adduction. With these movements, the head–neck junction of the irregularly shaped proximal femur will abut against the anterior acetabular cavity, causing this region to impinge against the labrum and anterior rim. The nonspherical femoral head then forcefully enters the constrained joint and grinds against the superior acetabular cavity with further flexion and rotation. The anterior superior acetabulum is pressurized as the conical portion of the femoral head engages it, creating what Ganz has labeled the cam effect.[3,4] This results in compression and avulsion of the anterior acetabular cartilage as well as microtrauma and tearing of the impinged labrum.[3,4]

Femoroacetabular impingement is pathomechanically similar to anterior impingement in total hip arthroplasty, in which contact between the prosthetic femoral neck and the acetabular component edge results in excessive wear of the anterior liner as well as leverage of the head out of the cup and a posterior dislocation (Fig. 6). The prosthetic neck geometry, version, and the head–neck ratio (head diameter to neck diameter ratio, or offset) are well recognized as important factors in prosthetic impingement.[5,6] An increase in the anterior neck radius, such as in a prosthesis with a circular neck cross section, a large taper, or a skirted head, will cause early impingement and decreases in the functional flexion, internal rotation, and abduction in flexion.[7] A circulotrapezoidal neck, in which the neck's cross-sectional anteroposterior diameter is decreased and the relative anterior space occupation decreased, provides less frequent neck and socket contact because there is more space available for clearance during flexion, adduction, and internal rotation. Similarly, in patients with intrinsically less anteversion or offset in their proximal femur, the head–neck junction lies in closer proximity to the acetabular rim so that normal range of motion will bring the head–neck junction against the anterior acetabular cavity, resulting in impingement.

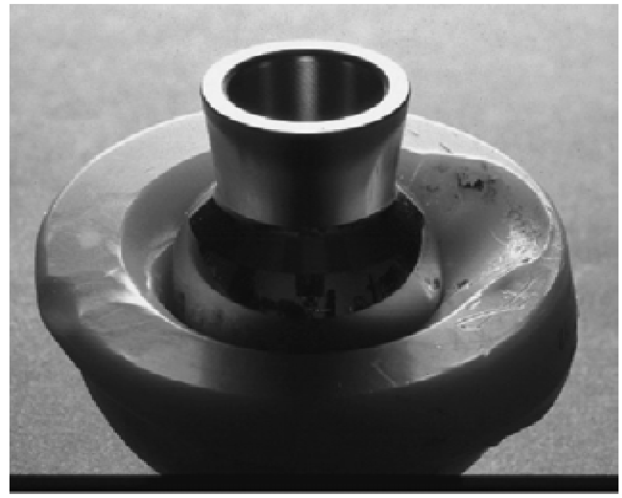

FIG. 6. Acetabular polyethylene liner with a skirted femoral head demonstrates excessive wear of the anterior liner corresponding to prosthetic impingement in flexion.

Any mismatch in the shape of the proximal femur and the acetabular opening that reduces the clearance available for movement of the neck can produce impingement. Impingement has been reported in patients who have suffered femoral neck fractures and healed in retrotorsion and varus.[4] This malunion of the proximal femur effectively decreases the anteversion and preferentially increases the anterior and anterolateral neck radii. Patients with acetabular retroversion, in which the mouth of the acetabulum is oriented posterolaterally rather than in the normal anterolateral direction, may develop impingement despite a femoral neck of anatomically normal version and offset[8] because the position of the acetabular rim is effectively closer to the anterior surface of the neck. Interestingly, patients who have undergone correctional periacetabular reorientation osteotomy for dysplasia may develop anterior impingement.[9] The reorientation procedure is often indicated in patients with inadequate anterior acetabular coverage of the femoral head; however, it is interesting to recognize that there coexists a lack of offset in the femoral head neck junction. When the corrective procedure reorients the acetabulum into a more "normal" and anterior spatial position, impingement may occur due to the pre-existing irregularities in the femoral neck.

Regardless of the predisposing anatomic irregularity resulting in impingement, the ultimate injury to the anterior acetabular rim soft tissues is similar. Unlike dysplastic hips, in which the acetabular rim is subjected to a chronic shear and excessive loading, injury to the labrum in patients prone to anterior impingement results from repetitive microtrauma during flexion, internal rotation, and adduction. This combination of movement brings the anterior femoral neck in contact with the anterior acetabular rim. When the head–neck junction comes into contact with the anterior acetabular rim, the labrum is impinged and, after time, may degenerate and ultimately tear. The pressure on the acetabular cartilage created from the cam effect causes softening and ultimately avulsion of the anterior superior cartilage, thus predisposing these patients to arthrosis. Inspection of the articular pathology at the time of surgical intervention for impingement in patients who are status post femoral neck fracture malunion demonstrated labral and adjacent acetabular cartilage damage anteriorly at the exact site of the impingement in all patients.[4]

Most patients present as young adults without a specific history of trauma; however, with further questioning, a previous episode of similar pain that subsided spontaneously may be elicited.[10] Because impingement cannot occur without the proximal femur positioned in a specific point in relation to the acetabular cavity, the patient's activity may be an important element in the development of anterofemoral impingement. Young, active individuals and athletes with an underlying anatomic irregularity of the femoral neck who partake in activities involving repetitive forced adduction combined with rotation or flexion (breast-stroke swimmers, catchers and pitchers, soccer players) may be at higher risk of developing symptoms related to impingement than a low-demand patient with similar femoral neck morphology.

The typical pain pattern is one of a sharp, knife-like pain in the anterior groin. The sensation of pain in these patients is likely a result of the shear or compression of the labrum, which is innervated with nociceptive fibers similar to the knee meniscus.[11] Pain is thus felt when the patient assumes the impinging position, usually a combination of flexion, adduction, and internal rotation, which brings the femoral neck to the anterior acetabular rim. These patients may describe reproducible clicking in the hip, and some develop symptoms of locking or giving way at the hip. There is often a report of a pain-free interval in which the hip is completely asymptomatic, and the patient may not be able to identify factors associated with resolution. There may be trochanteric bursitis exacerbated by abductor weakness if there is an underlying element of acetabular dysplasia.

Physical exam should include an assessment of gait, abductor strength, and leg length discrepancy. Check the patient's range of motion and compare it against the unaffected hip. The pain can usually be elicited with the impingement test, in which the thigh is passively flexed, adducted, and internally rotated. This brings the anterior femoral head–neck junction into contact with the anterior acetabular rim and exerts a shear force on the labrum at the point of impingement, reproducing the pain if the labrum has been damaged at that site.

Assess the anatomic morphology and joint biomechanics with standing anterior–posterior pelvis, frog lateral, and false-profile views of the involved hip. Scrutinize the films for any subtle signs of residual acetabular dysplasia, including the center–edge angles, the acetabular depth, and the coverage of the femoral head. Inspect the lateral radiograph for irregularities at the proximal femoral head–neck junction and reduced anterolateral femoral head–neck offset. Note the presence of early changes associated with osteoarthritis. Techniques for MRI and magnetic resonance arthrography continue to evolve and allow excellent visualization of articular lesions of the cartilage, labral lesions, loose bodies, and the bony architecture. Controversy exists over the use of MRI arthrogram with intraarticular gadolinium, which has a reported sensitivity of 90% and accuracy of 91% for detecting labral pathology.[12] In some reports,[13,14] the accuracy and sensitivity of MRI alone has not proven as accurate; however, new technology and high-resolution MRI have been suggested to detect labral and chondral abnormalities with a high degree of accuracy.[15]

Treatment remains controversial. Labral alterations are known early precursors of osteoarthritis of the hip; however, it is yet unclear if the labral lesion itself is sufficient to predispose arthritic changes. Femoral head instability secondary to a compromised labrum can result in elevated joint contact pressures at the acetabular rim, and the joint-sealing function of the intact capsulolabral complex may be required for cartilage lubrication and symmetric joint pressure distribution.[16] However, the labral tear is often secondary to an underlying osseous abnormality rendering the articulation mechanically compromised and predisposed to cartilage degeneration. The ultimate goal is symptom resolution as well as joint preservation. While repairing the labrum arthroscopically may effectively address the patient's current complaints, it may not be sufficient to ultimately preserve the joint.

The patient with anterior femoroacetabular impingement has a mechanical irregularity that causes symptomatic labral pathology but also predisposes arthritic changes due to cartilage damage. Ganz[4,17] described the proximal femoral osteoplasty to recontour the femoral head–neck junction and improve the anterior head–neck offset to allow clearance of the anterior acetabular rim. This surgical technique is an adaptation of resection osteoplasty procedures described for corrections of malunited femoral neck fractures and later for severe cases of slipped femoral epiphysis.[18,19] Intraoperatively, the postresection range of motion can be seen to be impingement-free via the anterior arthrotomy, and if the labrum is detached or torn, it can be effectively repaired. Although there may be opportunity for cartilage recovery in the young patient, the established damage to the acetabular cartilage caused by the cam effect cannot be repaired; these lesions are debrided with resection of floating parts of cartilage and drilling of the subchondral bone when possible. Early diagnosis and treatment is thus potentially essential to prevent ongoing damage to the cartilage and decrease the rate of arthritis.

In conclusion, femoroacetabular impingement is a cause of groin pain, which frequently afflicts young, active patients. Athletes may be predisposed to early presentation because of the nature of their activities. A high index of suspicion, critical exam of the patient, and imaging studies can aid in diagnosis. Like patients with residual dysplasia of the acetabulum, these patients may have signs and symptoms from labral pathology; however, the underlying osseous morphology may be responsible for the soft tissue damage and may also put the patient at risk for joint degeneration. Early treatment is essential to prevent further chondral damage, and should consist of recontouring of the femoral head–neck junction to prevent further impingement and avulsion of the acetabular cartilage.

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