4 Hip Pathology That Can Cause Groin Pain in Athletes: Diagnosis and Management

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Introduction

Identifying the etiology of a painful hip in an athlete is challenging. The pain may be difficult for the athlete to characterize clearly, localize accurately, or reproduce reliably. It often develops insidiously without a specific trauma or inciting event and may only limit the athlete in certain provocative positions or activities. The inherent complexity of the anatomy in the region as well as the close proximity to the pelvis, abdomen, and low back complicate the clinical picture and broaden the differential diagnosis. Consequently, a number of potential causes may be proposed including muscle strains, tendinitis, bursitis, athletic pubalgia, hernia, and/or lumbar radiculopathy, and empirical treatment is frequently initiated without an exact diagnosis.

When evaluating an athlete with hip pain, an organized approach should start with the hip joint itself. Intraarticular pathology often is the primary disorder that underlies or leads to secondary conditions and should be suspected in athletes with soft tissue complaints around the hip. Despite an increasing recognition of intraarticular hip disease in athletes, intraarticular causes are frequently overlooked. One recent study of patients with arthroscopically confirmed hip labral tears found that the time from onset of symptoms to accurate diagnosis was 21 months and after a mean of 3.3 healthcare providers had evaluated the patient [1]. Radiographic hip abnormalities are common, and the clinician must correlate key elements from the history and physical examination with the radiographic findings to establish the diagnosis [2, 3].

A wide range of intraarticular hip injury is possible within the athletic population as sports expose the hip to extreme forces and stress. A key factor in the evaluation of a hip injury is the underlying morphology of the joint. The clinician must establish whether an injury has occurred to a morphologically normal joint or whether it has occurred to or because of a morphologically abnormal joint. Abnormal hip morphology has long been implicated in the development of osteoarthritis and is increasingly understood as a risk factor for injury in younger patients [4–6]. Athletes who push their bodies to physiologic limits may accelerate damage. This chapter will outline the approach to the athlete with a suspected intraarticular hip injury.

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Anatomy

The ball-and-socket femoroacetabular joint forms the structural junction between the axial and appendicular skeleton (Fig. 4.1). The acetabulum is a horseshoe-shaped hemispherical socket formed by the confluence of the ilium, ischium, and pubis bones and provides congruent coverage of 170° of the spherical femoral head [7]. Normally anteverted approximately 15–20° in the sagittal plane and inclined 40–50° in the coronal plane, acetabular orientation confers greater coverage posteriorly than anteriorly when the hip is at neutral position [7, 8]. The labrum deepens the acetabulum and along with the anterior capsule augments anterior femoral head coverage [9, 10]. The femoral neck is generally anteverted 10–15° relative to the transepicondylar axis at the knee, and the neck-shaft angle decreases from childhood to an average of 120–130° in adulthood [7, 9].

The hip joint possesses greater intrinsic bony stability than other joints due to the congruent coupling between the femoral head and acetabulum. Additional extrinsic stability is provided by a thick fibrous capsule which envelops the hip joint extending from the periphery of the acetabulum to the intertrochanteric line of the femur anteriorly and the femoral neck posteriorly [11]. The iliofemoral and pubofemoral ligaments reinforce the anterior capsule while the ischiofemoral ligament reinforces the posterior capsule. These ligaments coil around the femoral neck and tighten with hip extension enhancing the screw-home stabilizing effect during stance and ambulation [7, 12]. The extracapsular ligamentum teres arises from within the cotyloid fossa to attach to the femoral head fovea.

The fibrocartilaginous labrum runs circumferentially around the rim of the acetabulum effectively sealing the joint. The labrum deepens the acetabular socket expanding its volume and further enhances hip joint stability through maintenance of negative intraarticular pressure [13]. The elasticity of its fibrocartilaginous structure allows the labrum to conform to the femoral head

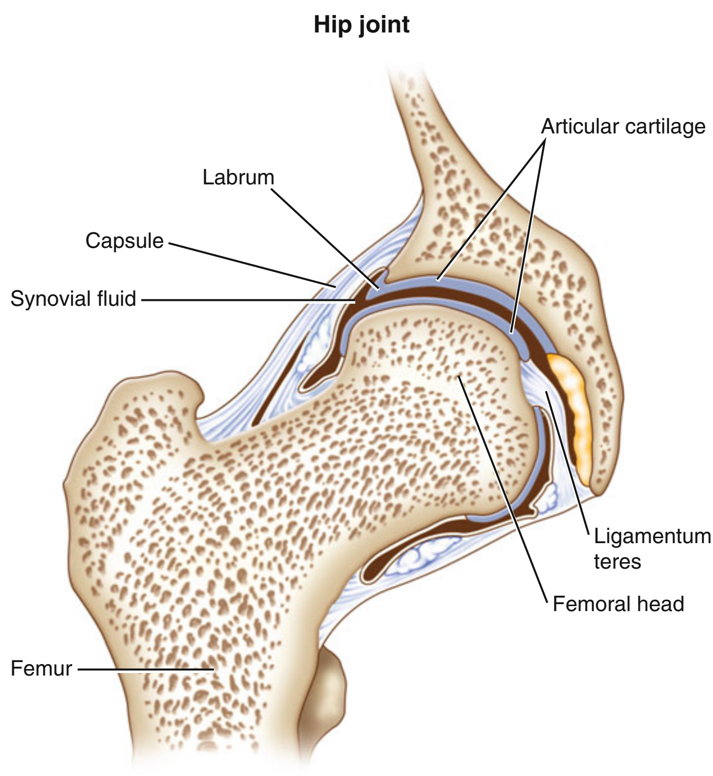

Fig. 4.1 The ball-and-socket hip joint is comprised of the femoral head (ball) and acetabulum (socket). The articular surface is lined with hyaline cartilage. The fibrocartilaginous labrum runs circumferentially around the rim of the acetabulum conforming to the femoral head through effectively sealing the femoroacetabular articulation and regulating the lubrication of the joint surfaces. A thick fibrous capsule reinforced with capsular ligaments encloses the joint

throughout the hip range of motion. This allows it to promote lubrication of the articular surfaces, sustain a vacuum seal that resists joint distraction, and dissipate contact forces across the joint [13]. Similar to the meniscus in the knee, labral fibers are oriented longitudinally parallel to the acetabular rim with a peripheral blood supply that diminishes toward the free margin [10]. Nerve fibers within the labrum provide proprioception and nociception [14]. The labrum is contiguous with the transverse acetabular ligament which crosses the inferior aspect of the acetabulum [10].

History

Some athletes are at increased risk for developing an intraarticular hip injury by virtue of the sports in which they participate [9, 15–17]. Sports such as ice hockey, soccer, and rugby that expose the hip to persistent and intense lateral and rotational movements may generate forces that lead to acute injury or chronic damage [12, 18–23]. Sports that require extremes of range of motion such as dance, gymnastics, and martial arts may exceed the functional limits of the hip [12, 15, 17, 19, 24].

Elements of the injury history may implicate the joint as the source of hip pain (Table 4.1). Intraarticular pain generally localizes to the anterior groin although athletes will often demonstrate the “C-sign” cupping their hand over the lateral hip to describe deep interior hip pain (Fig. 4.2) [25, 26]. The pain may be associated with mechanical symptoms such as clicking, popping, or loss of motion. The athlete with an intraarticular hip injury may tolerate straight-plane activities such as straight-ahead walking or even running while twisting, pivoting, and lateral movement exacerbate the pain [25, 27]. Deep flexion is usually problematic, and the athlete may describe difficulty squatting, putting on shoes and socks, or getting out of a low car seat [27].

Table 4.1 Characteristic features of hip joint abnormality [26]

• Symptoms worse with activity
• Straight-plane activities relatively well tolerated
• Activities on level surfaces better tolerated than on inclines
• Torsional activities less well tolerated (i.e., twisting such as turning and changing directions)
• Seated position may be uncomfortable (especially with hip flexion)
• Rising from seated position often painful (may experience catching sensation)
• Difficulty ascending and descending stairs
• Difficulty with shoes, socks, hose, and so forth

From Byrd JWT. Diagnostic Accuracy of Clinical Assessment, Magnetic Resonance Imaging, Magnetic Resonance Arthrography, and Intra-articular Injection in Hip Arthroscopy Patients. American Journal of Sports Medicine. 2004;32(7):1668–1674

The onset of symptoms in an athlete with an intraarticular hip problem is variable and is dependent upon the etiology. A traumatic injury to a morphologically normal hip may occur with direct impact or after a forceful pivoting, hyperflexion, or traction event. Those athletes generally have no history of hip problems until the trauma. Frequently, hip pain develops insidiously from the repetitive stress of recurrent supraphysiologic demands imposed on the hip. These athletes may loosely associate their hip pain with the increasing training intensity or introduction of new exercises.

Morphological abnormalities of the femoroacetabular articulation predispose the athlete to hip dysfunction. Most do not appreciate a problem with their hip until they suffer an injury. On further questioning, they may recall recurrent groin strains or other non-specific symptoms suggestive of unrecognized intraarticular pathology. They may also present with secondary symptoms seemingly unrelated to the hip such as low back pain or lower abdominal pain. These athletes often report that they lacked the flexibility demonstrated by their teammates but their restricted motion never posed a functional issue [28]. The secondary findings and inflexibility are suggestive of an underlying femoroacetabular impingement (FAI) that limits the hip from achieving extremes in range of motion. While the hip pain may be uncovered or aggravated by an acute event, the damage to the hip joints in these athletes results from the cumulative effects of repetitive injury from an incongruent joint [29].

Fig. 4.2 *C-sign*. (**a**) This term reflects the shape of the hand when a patient describes deep interior hip pain. (**b**) The hand is cupped above the greater trochanter with the thumb posterior and the fingers gripping deep into the anterior groin (all rights are retained by Dr. Byrd) [25]

Examination

A systematic physical examination is central to the evaluation of a suspected intraarticular hip problem (Table 4.2). The athlete should be examined in the standing position from behind to evaluate spinal alignment, pelvic obliquity, and symmetry. Leg length discrepancy may be assessed by comparing the distances between the anterior superior iliac spine and the medial malleolus. During stance, the athlete with a painful hip tends to shift body weight to the unaffected limb and may hold the hip and ipsilateral knee in a slightly flexed position [25]. An antalgic gait may be present as the athlete shortens the stance phase of gait on the affected side and avoids hip extension. Shifting the upper body over the affected hip during ambulation moves the center of gravity closer to the axis of the hip reducing joint reactive forces.

The examiner should adopt a consistent and reproducible method for recording hip range of motion in order to detect subtle abnormalities or asymmetry and follow an athlete with a hip injury [30]. Stabilization of the pelvis during examination negates compensatory pelvic or lumbar spine motion that may be present in an athlete with hip motion restrictions [31]. The presence of a flexion contracture is assessed with the Thomas test (Fig. 4.3). Positions and motions that produce pain, crepitus, or clicking should be noted. Maximum hip flexion, abduction, and adduction are recorded in the supine position while internal and external rotation may be measured in full extension and with the hip flexed at 90°. Alternatively, evaluation of hip rotation may be performed in the prone position or with the athlete seated as this position ensures the ischium is stabilized against the table [31]. Hip extension is measured in the lateral or prone position.

Table 4.2 Examination findings [26]

• Groin, anterior, and medial thigh pain
• "C-sign" characteristic of interior hip pain: hand gripped above greater trochanter
• Logrolling of leg back and forth: most specific indicator of intraarticular abnormality
• Forced flexion/internal rotation or abduction/external rotation: more sensitive measure of hip joint pain; reproduces symptoms that patient experiences with activities

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Localizing pain to the hip joint during physical examination is challenging due to complex

Fig. 4.3 *Thomas test*. To check extension or presence of a flexion contracture, the unaffected hip is brought into maximal flexion and held by the patient, locking the pelvis. The affected hip is then brought out toward extension and motion recorded (all rights are retained by Dr. Byrd) [25]

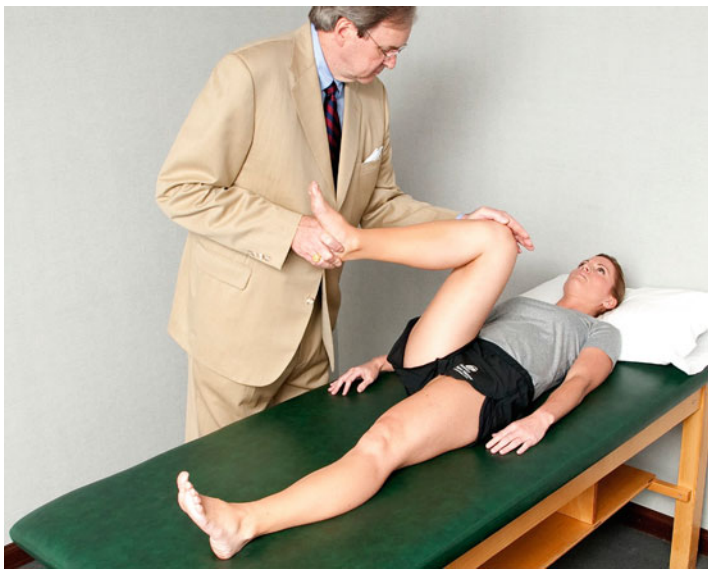

Fig. 4.4 *Impingement or FADDIR test*. Forced flexion combined with adduction and internal rotation is often very uncomfortable and usually elicits symptoms associated with even subtle degrees of hip pathology (all rights are retained by Dr. Byrd) [25]

surrounding anatomy. The depth of the hip joint precludes thorough direct palpation and the examiner must use indirect methods to illicit pain from an irritable joint. Logrolling the relaxed lower extremity isolates the hip as the femoral head rotates within the acetabulum without stressing the surrounding soft tissue structures [25]. Pain with resisted straight-leg raise raises suspicion for an intraarticular process as this maneuver applies force across the articular surface [25].

Groin pain with forceful deep flexion, adduction, and internal rotation of the hip is suggestive of impingement morphology as this position generates pathological contact between the femoral head or neck with the acetabulum (Fig. 4.4). Also known as the "impingement test" or "FADDIR" test, this maneuver is not specific to FAI as it usually provokes discomfort in an irritable hip regardless of the underlying pathology [25]. Posterior rim impingement may be detected with forceful hip extension, abduction, and external rotation. Dynamic internal and external rotatory impingement tests are performed by taking the hip through a wide arc of rotation in the adducted and abducted position, respectively [31]. The position of the hip when pain is reproduced provides information about the location of impingement pathology.

Intraarticular injection of local anesthetic helps to localize the hip joint as the source of pain [26]. Ultrasound-guided injections may be performed in the office setting or local anesthetic may be administered simultaneously with contrast for an arthrogram. Documentation of the patient's symptoms before and after the injection elucidates the contribution of intraarticular pathology to groin discomfort. In many cases, the athlete needs to perform the activity that normally produces pain to obtain an accurate determination of the response to the injection.

Coexistent or associated pathology is common in athletes with intraarticular hip disease and should be evaluated particularly when an intraarticular injection fails to or incompletely alleviates symptoms. Potential secondary conditions include tendinitis or strains of the iliopsoas, hip abductors, adductors, external rotators, or abdominal musculature, greater trochanteric or iliopsoas bursitis, athletic pubalgia, osteitis pubis, sacroiliitis, and lumbar radiculopathy.

Imaging

Plain Radiography

A well-centered anteroposterior (AP) pelvis radiograph provides the foundation for the radiographic evaluation of intraarticular hip disease (Fig. 4.5) [31, 32]. Special attention should be paid to ensuring that the coccyx is centered approximately 1–3 cm above the pubic symphysis and the obturator foramina and radiographic teardrops are symmetrical as even slight malrotation or tilting of the pelvis may cloud interpretation of the hip joint.

On the AP radiograph, a number of architectural factors may be assessed including bone density and trabecular patterns, pelvic obliquity and functional leg lengths, acetabular depth and orientation, and proximal femoral morphology [32]. Radiographic indicators of arthritis including joint space narrowing, sclerosis, and osteophyte formation suggest advanced joint damage and portend unfavorable prognosis. The condition of the pubic symphysis and sacroiliac joints should be noted as well as the visualized lumbar spine.

Additional plain radiographic views are needed to fully characterize the osseous anatomy. The frog-leg lateral radiograph provides an

Fig. 4.5 *Anteroposterior pelvis radiograph*. The coccyx should be centered approximately 1–2 cm above the pubic symphysis. Iliac wings, acetabular teardrops, and obturator foramina should be symmetrical. This view allows assessment of acetabular inclination and depth, anterior and posterior wall orientation, proximal femur morphology and head sphericity, femoral neck-shaft angle, and bone quality. Additionally, the sacroiliac joints and pubic symphysis are visualized

orthogonal view of the femoral neck and can provide a comparison lateral view of the contralateral femoral neck (Fig. 4.6). Alternative views used to assess the femoroacetabular joint include the cross-table lateral, 45° and 90° Dunn views, and false profiles. Some surgeons advocate at least one of the radiographs in the series should be weight-bearing to assess for degree and location of joint space narrowing.

Fig. 4.6 *Frog-leg lateral hip radiograph*. An orthogonal view of the proximal femur morphology and further analysis of the sphericity of the femoral head is afforded by this radiographic view. A cross-table lateral or false profile is needed to further image the acetabulum

Cross-Sectional Imaging

Pathology involving the complex three-dimensional articulation of the femoroacetabular joint is best characterized by cross-sectional imaging such as magnetic resonance imaging (MRI) or computed tomography (CT).

Advantages of MRI include depiction of intraarticular soft tissue structures, in particular the labrum, visualization of the surrounding soft tissue envelope, and demonstration of secondary findings including intraosseous and soft tissue edema, paralabral and subchondral cysts, and effusions [24, 33]. MRI is not optimal for assessing osseous anatomy and may underestimate the severity of articular cartilage injury [26]. Additionally, the modality is only as good as the strength of the magnet and poor resolution images are difficult to interpret [34]. High resolution small field of view images necessitate at least a 1.5-Tesla magnet with surface coils [26].

MR arthrography (MRA) after injection of intraarticular gadolinium improves the sensitivity and specificity of MRI, but the contrast prevents detection of an effusion and obscures edema in the surrounding tissues (Fig. 4.7) [26]. Pre- and

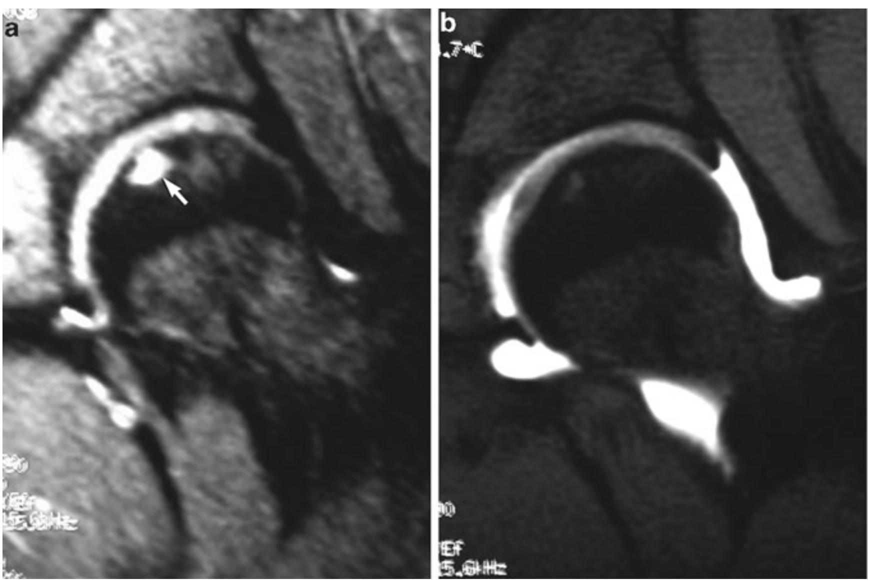

Fig. 4.7 *Magnetic resonance imaging*. (**a**) Conventional MRI is an excellent imaging modality to diagnose intraarticular pathology. In this image, subchondral signal changes are demonstrated in the femoral head (*arrow*). (**b**) Intraarticular contrast enhances visualization of the labrum but obscures the subchondral changes

Fig. 4.8 *Three-dimensional CT*. Excellent demonstration of acetabular and proximal femoral morphology is afforded by CT with 3-D reconstruction

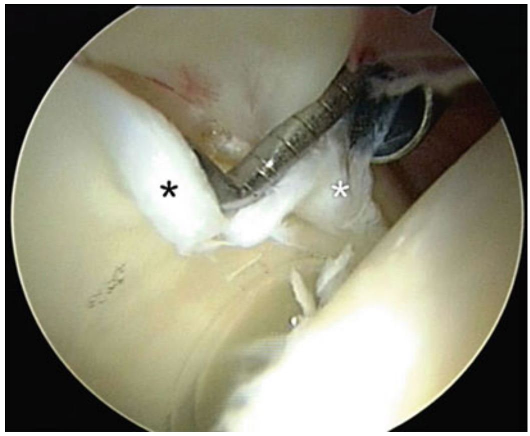

Fig. 4.9 Arthroscopic appearance of a labral tear associated with pincer femoroacetabular impingement.

post-contrast studies increase the diagnostic capabilities of MRI.

Computed tomography has gained widespread application for imaging of the hip, in particular for the characterization of the anatomy underlying FAI. CT is superior to MRI for clearly defining the bony architecture of the acetabulum, and reformatting with three-dimensional reconstructions provides the clearest view of the proximal femoral morphology (Fig. 4.8) [28, 35]. The primary disadvantage of CT is the exposure to ionizing radiation [35].

Arthroscopy

Compared to the rapid implementation of arthroscopy for the shoulder and the knee, the adoption of hip arthroscopy has been more deliberate. Historically, the tight articulation between the femoral head and acetabulum posed an inherent anatomical obstacle to achieving any meaningful surgical correction with arthroscopic technique and required a more methodical evolution of instrumentation and methods [36]. Additionally, unlike the multiple indications for shoulder and knee arthroscopy, intraarticular hip pathology amenable to arthroscopic intervention has only been recently recognized and understood. Advances in techniques, such as the use of traction and the development of specialized instrumentation, have allowed improved access to the hip and generated increasing interest in hip arthroscopy as an alternative to more invasive open procedures, in particular for the young, athletic population [37–39].

Hip arthroscopy has now emerged as the gold standard for surgical management of intraarticular pathology in the athletic hip [27, 37, 40]. The proliferation of hip arthroscopy has been self-perpetuated as the technique has revealed previously unrecognized etiologies of hip pain that can be treated arthroscopically [40]. Conditions amenable to arthroscopic intervention include labral tears, loose bodies, chondral injuries, ligamentum teres ruptures, snapping hip, capsular laxity, and intraarticular proliferative disorders (Fig. 4.9) [10, 15, 41, 42]. Osteoplasty of the acetabulum and/or femoral head in athletes with FAI may also be performed arthroscopically and offers the advantage of improved visualization over mini-open techniques, and less exposure-related morbidity compared to mini-open and surgical dislocation techniques [15, 34, 43, 44].

Despite the advances and proliferation of hip arthroscopy, strict adherence to the diagnostic and treatment algorithm is critical for successful application of the technique. Patient selection is paramount for ensuring a successful hip arthroscopy and reasonable expectations should be set. Prior to hip arthroscopy, an athlete should undergo a conservative treatment protocol aimed at reducing inflammation and optimizing pelvic biomechanics. Acute intraarticular injuries, mechanical symptoms, and correctible structural abnormalities carry the best prognosis for arthroscopic intervention [10, 16, 25, 35]. Patients with chronic pain, advanced arthritis, avascular necrosis, and/or significant dysplasia likely will not benefit from arthroscopy [38, 41, 45]. Potential complications include nerve injury from portal placement, traction-related neurapraxia, compression of perineal structures, iatrogenic chondral or labral injury, and fluid extravasation [38, 40, 46].

Femoroacetabular Impingement

Essentially all hip range of motion is rotational, the absolute limits of which are defined by position of the joint when the femoral neck contacts the acetabular rim [11]. The arc of motion reflects the depth and orientation of the acetabulum within the pelvis and the relative size, shape, and orientation of the femoral head and neck [11]. Impingement occurs when a mismatch between the ball and socket causes abnormal contact between the proximal femur and the acetabulum during a physiologic arc of motion [5]. The significance of the mismatch is influenced by the severity of the deformity and the demands upon the joint. A mild deformity that may be asymptomatic to an average person may be poorly tolerated by an athlete that requires extremes in hip motion.

Ultimately, the pathological biomechanics result in chondral and labral damage and predisposes the hip to osteoarthritis [5]. Additionally, secondary pathology often develops in athletes with FAI in response to the restricted range of motion and intraarticular pain. Abnormal compensatory motion within the ipsilateral hemipelvis and lumbosacral spine may lead to muscle strains, tendinitis, bursitis, arthritis, and/or athletic pubalgia [17, 47, 48]. The athlete may develop a reflexive gait alteration in an attempt to unload the painful hip joint that disrupts the sagittal and coronal plane balance within the pelvis [15].

Two mechanisms of FAI have been described based on the location of the pathology. Pincer impingement is caused by an acetabular deformity in which the rim of the acetabulum abnormally contacts the femoral neck restricting motion [5]. Cam impingement is caused by a deformity of the femoral head–neck junction that results in conflict between the nonspherical ball rotating within the socket [5, 29]. Frequently, deformities on both the acetabular and femoral side contribute to impingement resulting in a mixed type [5, 49]. A recent epidemiological study of 1,130 hips with FAI reported isolated cam impingement in 47.6 %, isolated pincer in 7.9 %, and mixed cam/pincer impingement in 44.5 % of cases [50].

Pincer Impingement

Pincer impingement is characterized by acetabular overcoverage of the femoral head that impedes terminal hip motion by premature contact between the acetabular rim and the femoral neck (Fig. 4.10) [51]. The pathology underlying pincer impingement is usually localized anteriorly on the acetabulum leading to contact with hip flexion. As the femoral neck collides with the acetabular rim, the labrum is trapped between the bony structures and becomes damaged with repetitive trauma. With further hip flexion, the acetabular rim acts as a fulcrum upon which the femoral neck levers the head from the socket. The resulting impact of the posteromedial femoral head on the posteroinferior

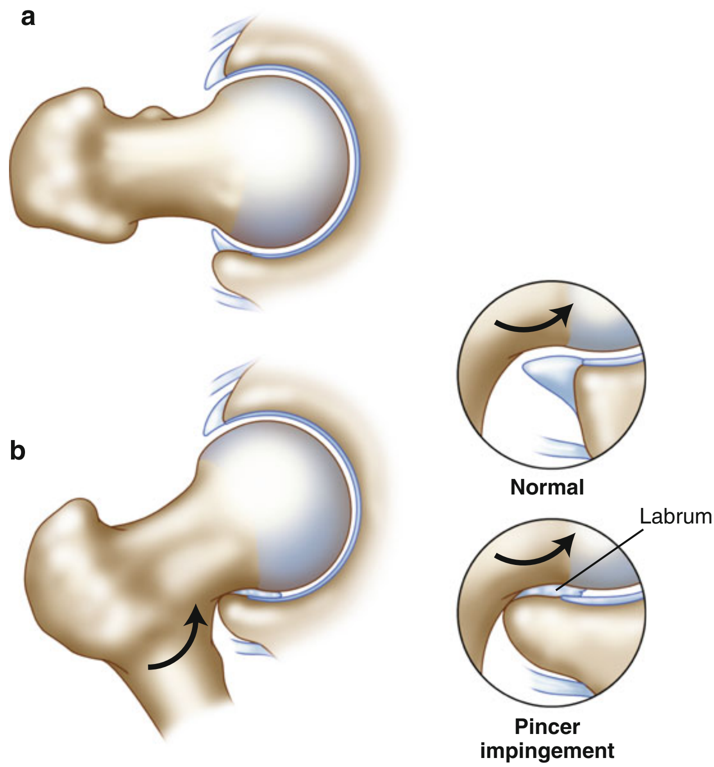

Fig. 4.10 *Pincer impingement*. (**a**) Acetabular overcoverage leads to pathological contact with the femoral neck. (**b**) The labrum is trapped between the two bony surfaces leading to damage with repetitive impingement

acetabulum leads to chondral damage in these locations. Reactive changes and cyst formation may also occur on the femoral neck in response to persistent contact with the acetabular rim.

Morphological features of the acetabulum that result in pincer impingement include abnormal rim shape, acetabular retroversion, or excessive acetabular depth (coxa profunda or protrusio). Prominence of the anterior inferior iliac spine has also been reported as a potential etiology for pincer impingement [52]. More commonly found in females, pincer impingement appears to have a genetic element. Siblings of patients with pincer deformity have a relative risk of 2.0 of having the same deformity [53].

Range of motion deficits may be subtle and reflect the magnitude of the deformity. The athlete may be able to unintentionally avoid the position of impingement by simultaneously externally rotating the hip with deep flexion [51]. While asymptomatic with routine activity, increasing athletic activity overcomes this protective mechanism and produces symptomatic impingement [54]. Mechanical symptoms such as clicking or popping arise with progressive labral pathology. Restricted range of motion may be detected on examination and impingement maneuvers reproducibly provoke groin discomfort [51].

Radiographic markers of pincer impingement on an AP pelvic radiograph include decreased acetabular inclination, a cross-over sign, and coxa profunda (Fig. 4.11) [32, 55]. Prominence of the ischial spine is associated with acetabular retroversion [56]. Sclerosis and cystic changes on the femoral neck may be suggestive of herniation pits from repetitive impingement [51]. Anterior overcoverage is demonstrated by an increased center-edge angle on a false-profile radiograph [32]. Cross-sectional imaging findings characteristic of pincer impingement include increased acetabular depth and acetabular retroversion [33]. Labral tears and herniation pits associated with pincer impingement may be demonstrated on MRI [24, 55].

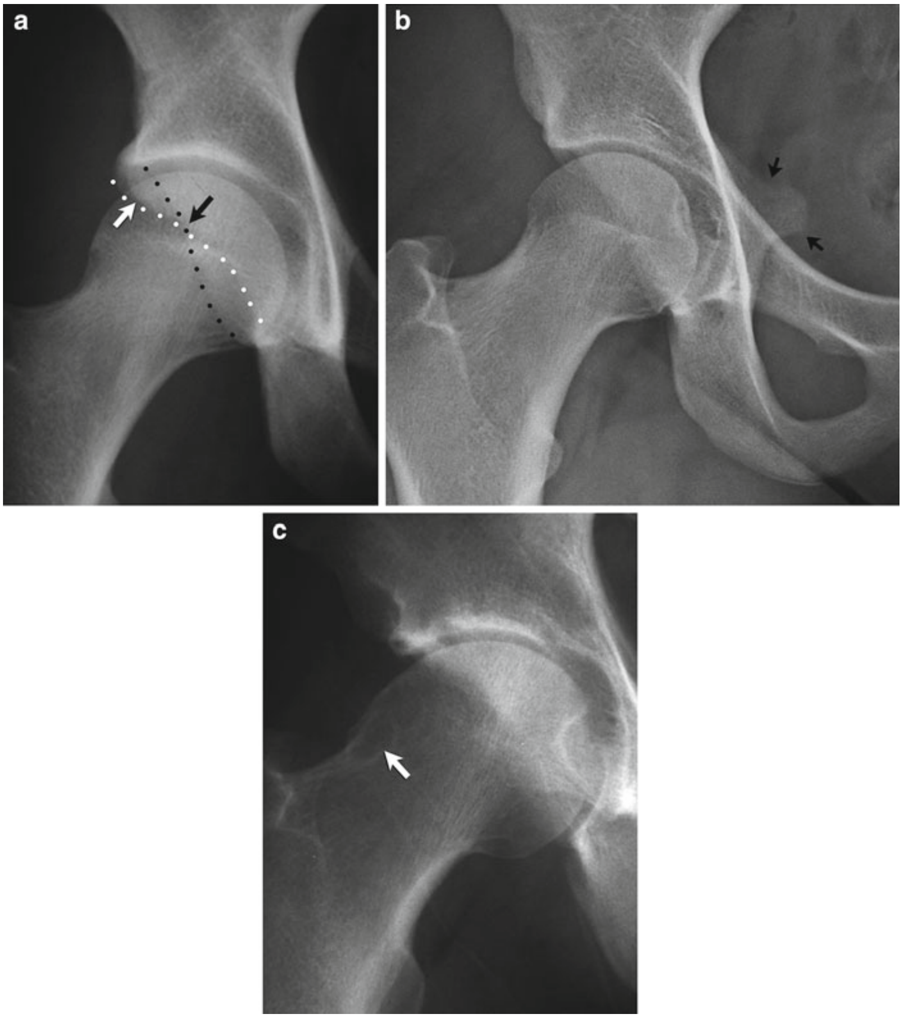

Fig. 4.11 (**a**) *Cross-over sign*. Anterior overcoverage or acetabular retroversion that may predispose to pincer impingement is characterized by a cross-over sign on an AP radiograph in which the anterior acetabular rim (*white arrow*) crosses over the posterior rim (*black arrow*). (**b**) A prominent ischial spine suggests acetabular retroversion. (**c**) Repetitive pathological contact with the acetabular rim may produce cystic changes on the superolateral femoral neck

Cam Impingement

Cam impingement is characterized by an abnormal prominence of the femoral head/neck junction that results in a nonspherical shape and as a result an incongruent joint (Fig. 4.12) [29, 57]. The size and location of the cam lesion is variable but generally it involves the anterior or anterolateral femoral head/neck junction and engagement occurs with hip flexion and internal rotation [29, 57]. Articular incongruity and loss of the femoral head/neck offset restrict motion [16]. The cam effect produced as the prominence engages the acetabulum leads to shear at the articular surface, and chondral delamination and failure of the articular surface occurs with forceful and/or repetitive motion [29, 57]. The pathological contact of cam impingement is within the acetabular vault and as a result the labrum is often preserved initially although secondary damage may occur with disease progression [57].

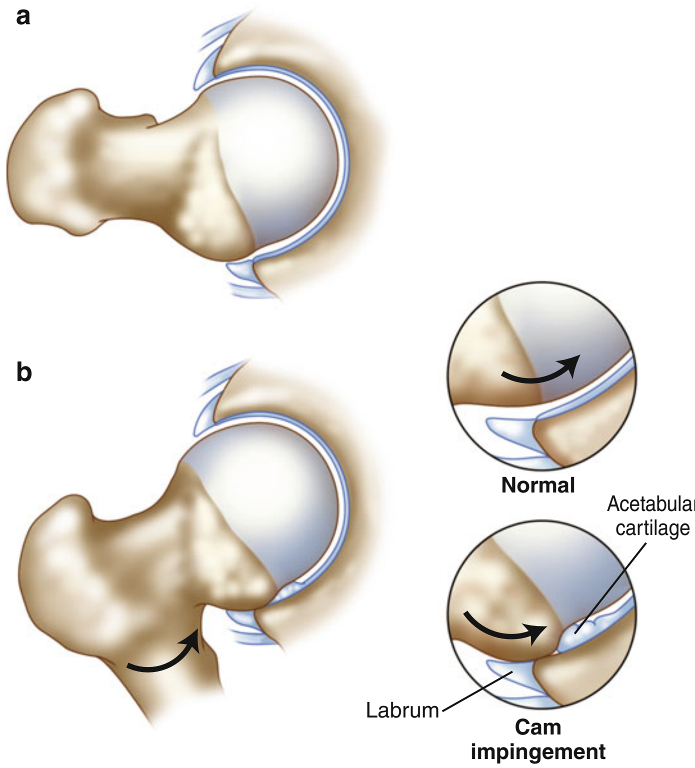

Fig. 4.12 *Cam impingement*. The nonspherical femoral head creates a cam effect with hip rotation. The prominence of the head/neck junction engages the acetabulum resulting in shear forces across the articular surface and cartilage damage and delamination

Cam impingement affects male athletes approximately three times more frequently than their female counterparts [29]. Siblings of patients with cam deformity have been shown to have a relative risk of 2.8 of having the same deformity [53]. Vigorous athletic activity during adolescence has been proposed as a risk factor due to the stresses on the developing hip joint [58]. Asymmetrical closure of the capital femoral epiphysis may produce the pistol grip deformity that underlies cam impingement [58]. Slipped capital femoral epiphysis or physeal fracture may also be responsible for the deformity.

Like pincer impingement, cam impingement is frequently asymptomatic in athletes until increasing demands of the sport uncover the abnormal hip anatomy. Consequently, age of onset is influenced by participation in athletics [29]. In individuals with cam-type morphology who do not participate in athletics, symptoms may not present until middle-age when elements of osteoarthritis have developed [29].

The pistol grip deformity suggestive of cam impingement may be evident on the AP pelvis radiograph although frequently the anatomy responsible for cam impingement is more subtle [59]. The location of the cam lesion is variable and multiple views of the proximal femur may be necessary to adequately visualize it [57]. The deformity is usually most clearly demonstrated on a lateral view and is characterized by an increased alpha-angle representative of loss of femoral head sphericity (Fig. 4.13) [32]. Femoral head–neck offset can also be quantified on a lateral radiograph [32].

Cross-sectional imaging is necessary to fully characterize the cam lesion and should be used to supplement plain radiographs. Computed tomography or MRI allow improved localization of the deformity and afford more precision in measurement of alpha angle and femoral head/neck offset. Computed tomography with three-dimensional reconstructions provides the most accurate representation of the size, shape, and

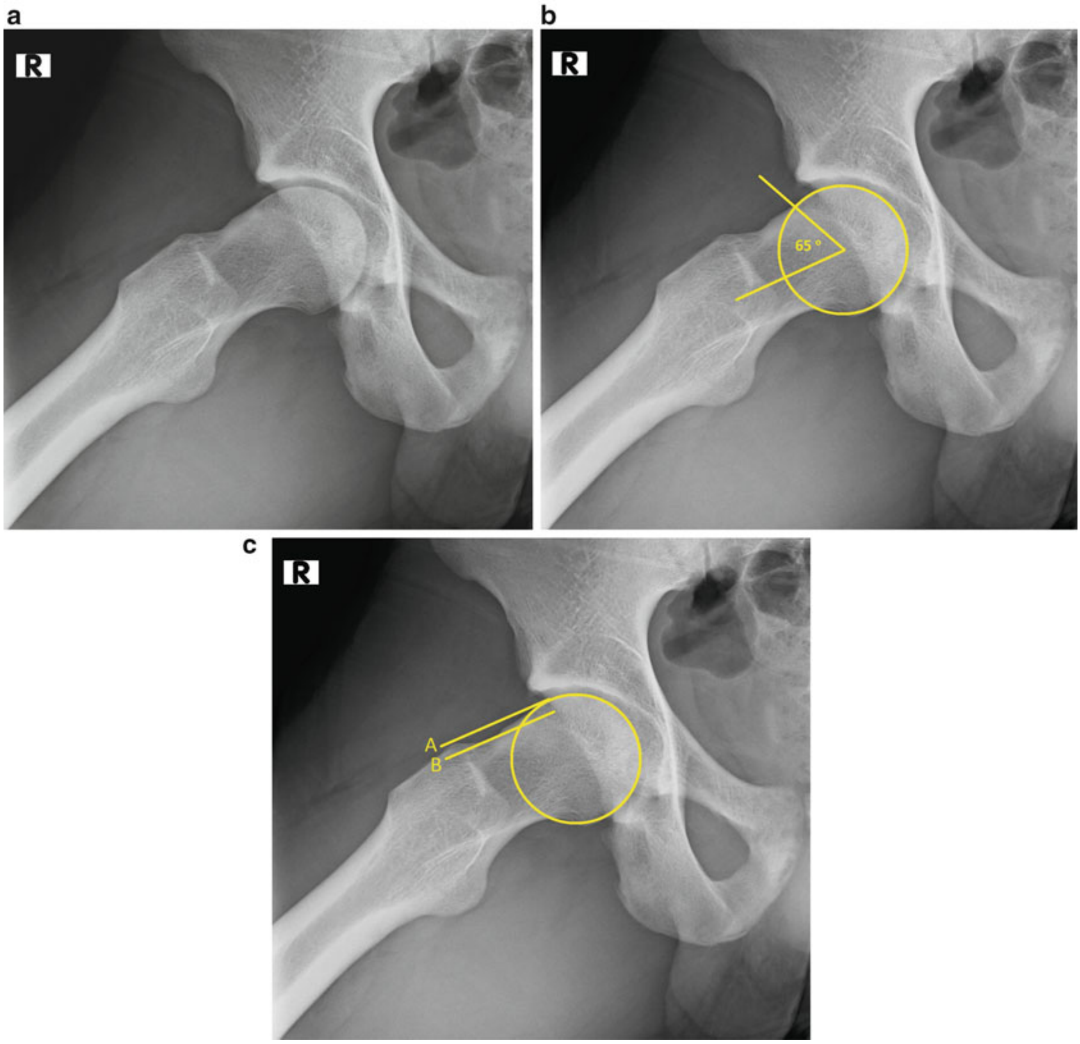

Fig. 4.13 (**a**) Prominence of the femoral head/neck junction is demonstrated on this frog-leg lateral radiograph. (**b**) Alpha angle. A *circle* is placed over the femoral head on a lateral radiograph. The alpha angle is formed by a line along the long axis of the femoral neck and a line from the center of the femoral head to the point at which the bony contour exits the circle. An alpha angle greater than 55° is associated with cam impingement. (**c**) Head–neck offset. Two lines parallel to the long axis of the femoral neck are drawn, *line A* through the most anterior aspect of the femoral head and *line B* through the most anterior aspect of the femoral neck. The femoral head–neck offset ratio is calculated by measuring the distance between the two lines and dividing by the diameter of the femoral head. A ratio of <0.17 is associated with cam deformity

location of the cam lesion and is a powerful preoperative tool for osteoplasty planning (Fig. 4.14) [57].

Treatment of FAI

The initial management of an athlete with FAI should emphasize optimizing the biomechanics of the hip joint through a systematic non-operative algorithm. In most cases, the athlete has become symptomatic because of the increased demands on the hip from training or participation in his or her sport. Activity modification is central to conservative management, and successful treatment may be as simple as correctly identifying and avoiding the offending activity [57]. An individualized physical therapy program is formulated through an analysis of athletic demands, hip range of motion, compensatory changes in the pelvis and lumbar spine, posture, and muscular strength and flexibility [16]. Functional improvement in hip biomechanics may be obtained by core and hip muscle strengthening, postural adjustments, and stabilization of the pelvis [60]. Non-steroidal anti-inflammatories may be used to control symptoms, and the judicious use of intraarticular steroid injections has utility as a diagnostic and therapeutic tool [61].

Fig. 4.14 Three-dimensional CT helps to demonstrate the size, shape, and location of the cam lesion

While conservative treatment may improve symptoms, the fundamental anatomical deformity that underlies FAI frequently requires surgery to address the articular mismatch [34]. Delay in surgical correction may accelerate disease progression, particularly in those athletes with more significant deformities [5, 16, 34]. Surgical intervention involves osteoplasty of the acetabulum and/or proximal femur to correct the anatomical factors that contribute to the mechanical conflict between the two surfaces (Fig. 4.15) [5]. Additionally, secondary pathology including labral tears and chondral damage may be addressed. Although the primary objective of surgery is to eradicate pain and return the athlete to play, a secondary but perhaps more important objective is to prevent future degenerative changes associated with impingement [16, 35].

Open surgical dislocation provides outstanding exposure for reshaping of the proximal femur and/or acetabulum and good outcomes with reliable return to play have been reported [62]. While effective surgical correction can be obtained, the potential complications and exposure-related morbidity limit widespread utilization in athletes [44, 63]. Less invasive open approaches have been introduced with less exposure-related morbidity,

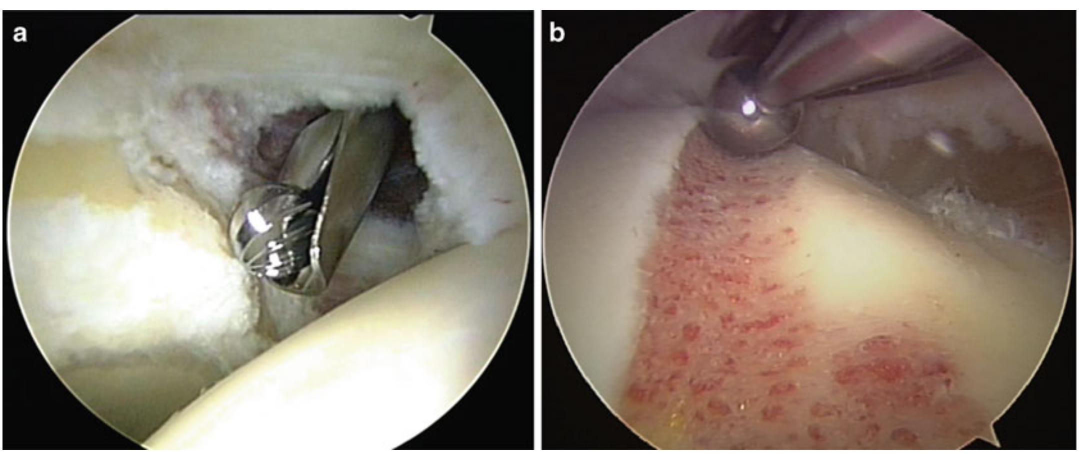

Fig. 4.15 (**a**) Arthroscopic correction of pincer lesion of the acetabular rim. (**b**) Arthroscopic femoroplasty to address a pathological cam lesion

but poor access to the joint may result in inadequate correction and need for revision [44, 64].

The evolution of arthroscopic instrumentation and techniques has established hip arthroscopy as a mainstay of treatment for FAI [39]. Correction of the impingement deformity has been demonstrated to be equivalent to open surgical dislocation [65, 66]. Arthroscopy also has been shown to have equal to or better outcomes than open methods with minimal exposure-related morbidity and fewer complications [44]. In a study of 47 athletes with FAI, Nho et al. demonstrated a significant improvement in hip functional outcome and a 79 % rate of return to play at a mean of 9.4 months post-operatively. Philippon et al. [43] report high patient satisfaction and 100 % return to play at an average of 3.8 months in 28 professional hockey players who underwent arthroscopic treatment of FAI. Byrd and Jones [67] report return to previous level of competition in 95 % of professional athletes and 85 % of collegiate athletes among 116 athletes studied.

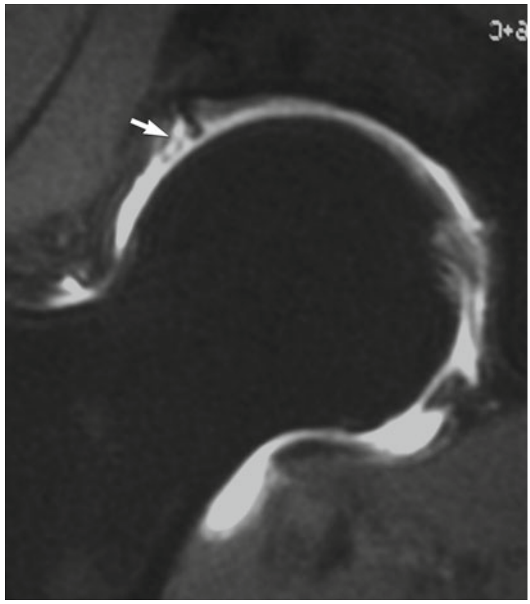

Fig. 4.16 Coronal MR arthrogram demonstrates increased signal within the superolateral labrum and detachment from the acetabular rim indicative of a tear

Labral Tears

Labral tears are common in athletes with hip pain and are a leading indication for hip arthroscopy [22, 41]. Athletes who participate in sports that require repetitive pivoting or deep hip flexion such as ice hockey, soccer, dance, and football are at increased risk [1, 10, 38, 68, 69]. Isolated acute traumatic labral tears in a structurally normal hip are uncommon but may result from a subluxation event or severe pivoting force [70]. More commonly, an underlying structural abnormality such as FAI, hip dysplasia, capsular laxity, or hip hypermobility predisposes the labrum to injury [69, 70]. In a recent study of 1,076 patients with FAI, more than 90 % were found to have labral tears during arthroscopy [50].

Groin pain with associated mechanical symptoms is a hallmark of labral injury [10]. The athlete may correlate onset of pain to a specific traumatic injury but frequently symptoms develop insidiously with episodic activity-related exacerbations [1]. The presentation is variable and often concomitant symptoms from secondary conditions such as adductor or iliopsoas tendinitis obscure the diagnosis [1]. Physical examination will demonstrate an irritable hip with positive impingement signs. Motion abnormalities suggest underlying FAI or acetabular dysplasia. Reproducible clicking with hip rotation may indicate an unstable labral tear, but this finding may also be present with an incidental extra-articular cause such as a snapping iliopsoas tendon.

MRI is the imaging modality of choice to evaluate a labral tear and may show intralabral signal, effacement of the perilabral sulcus, or detachment from the acetabulum (Fig. 4.16) [33, 71]. MRA improves the diagnostic capability and is 92–96 % sensitive for detecting clinically significant labral pathology [72, 73]. Most tears occur in the anterior superior labrum and are best demonstrated in the oblique axial and sagittal plane [33]. Indirect findings such as a joint effusion or paralabral cyst should raise suspicion for labral pathology (Fig. 4.17) [28, 33, 74]. Labral variants and false positives are common and the diagnosis should be supported by the clinical history and examination [3, 26, 75]. In equivocal or complicated cases, intraarticular administration

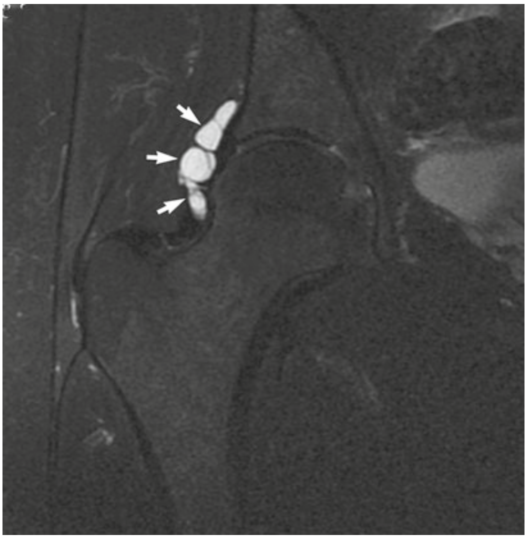

Fig. 4.17 Paralabral cyst formation should raise suspicion for a labral tear

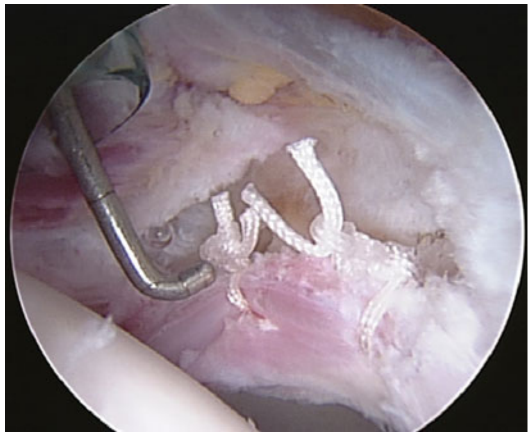

Fig. 4.18 Suture anchors are used to repair the labrum to the underlying acetabular rim to restore its multiple anatomical functions

of a local anesthetic isolates the joint as the source of pain and helps predict response to arthroscopic surgery [26, 43].

Conservative treatment for labral injury should involve a period of rest and anti-inflammatory medication to allow acute symptoms to subside followed by range of motion exercises, core and pelvic muscle strengthening, and activity modification to avoid provocative stresses. While symptoms may stabilize, most labral tears do not heal with conservative treatment and arthroscopic surgery is indicated for persistent symptoms.

The surgical approach for labral injury is based upon the nature of the tear but is also contingent upon the underlying pathology. Analogous to the meniscus in the knee, much of the labrum is avascular and which limits the healing potential of some tears. The peripheral third of the labrum is perfused from capsular-sided blood vessels which diminish toward the central articular-sided region [76]. On the articular side, the labrum blends seamlessly with the articular cartilage forming the chondrolabral junction and maintaining a vacuum seal of the joint. The objective of labral repair is to restore its multiple critical functions by reestablishing the anatomy (Fig. 4.18) [69]. Inversion or malreduction of the labrum with the repair technique should be avoided as well as repair of a labral cleft [27]. Visualization of the repaired labrum from the peripheral compartment after release of traction allows verification of the quality of the repair and conformity to the femoral head. Unstable labral tissue with minimal healing potential should be debrided to eradicate mechanical symptoms while leaving adequate labrum to maintain the articular seal [77].

If an underlying structural cause for labral damage is present but not addressed, no amount of labral surgery can correct the problem as the same mechanical factors that created the tear will persist. Impingement lesions should be identified and decompressed to prevent repetitive compression and shear on the labrum. Pincer morphology frequently requires labral takedown and refixation to remove the pathological acetabular rim. During suture anchor reattachment of the detached labrum to the cancellous bed, the surgeon should strive to restore the anatomy and sealing function of the labrum [42, 51].

Multiple studies support the efficacy of labral debridement for symptomatic improvement [38, 75, 77, 78]. Significant chondral damage and degenerative joint disease are associated with a worse prognosis [37, 38, 77]. Labral repair should be performed to preserve hip function, and improved outcomes have been demonstrated with labral repair versus debridement [13, 69, 79–81]. In a review of 96 patients with FAI at a mean follow-up of 2.4 years, Schilders et al. [79] demonstrated a 7.3 point higher Harris hip score in those who underwent repair compared to those who underwent debridement. In a prospective, randomized study of 36 female patients with FAI, Krych et al. [81] showed significantly better daily activity, sports, and subjective outcomes in those who underwent labral repair compared to debridement at a mean follow-up of 32 months.

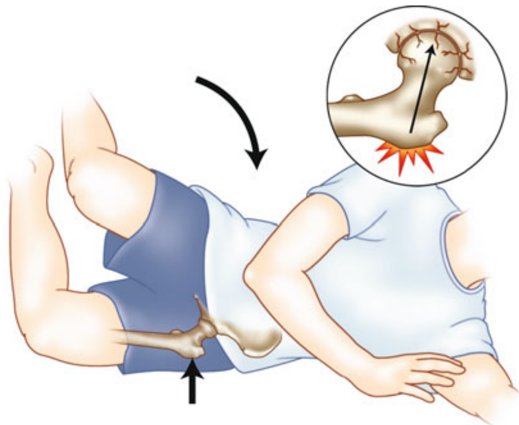

Fig. 4.19 A forceful fall onto the lateral hip drives the femoral head into the acetabulum and may result in chondral damage

Chondral Injury

A traumatic event to the athlete's hip may damage the articular cartilage depending on the mechanism as well as the position of the hip at impact. The chondral injury occurs at the point of traumatic contact between the two articular surfaces and is related to the magnitude and direction of force. In a direct impact injury, such as a fall onto the lateral hip, the femoral head is driven into the acetabulum and the resultant cartilage injury is seen on the medial femoral head and medial acetabulum (Fig. 4.19) [82]. Traumatic subluxations or dislocations frequently cause chondral or osteochondral injury to the posterior acetabular rim and femoral head [21]. Delayed femoral head cartilage loss may also develop after a subluxation or dislocation event if a compromised blood supply leads to avascular necrosis [42].

Chronic cartilage damage develops from mechanical wear, frequently as a result of abnormal hip morphology [49]. The repetitive shear created by cam impingement leads to failure of the calcified layer of cartilage and sometimes severe delamination of the anterosuperior acetabular articular surface [29]. Contrecoup damage from longstanding pincer impingement affects the cartilage of posteromedial femoral head and posteroinferior acetabulum [49]. Chondral wear in dysplasia involves the anterosuperior acetabulum and femoral head [83]. Osteoarthritis leads to diffuse cartilage wear particularly in weight-bearing areas.

Athletes with significant chondral damage generally present with symptoms of hip irritability with variable mechanical complaints. In traumatic cases, hip pain has persisted since the trauma despite rest and adequate time to improve. Insidious onset of intraarticular symptoms with episodic exacerbations suggests a chronic process of cartilage damage. Detached chondral or osteochondral fragments form loose bodies which may cause episodic catching or locking [22]. While examination usually distinguishes the hip joint as a source of pain, findings are nonspecific and blend with those of coexistent intraarticular pathology.

Plain radiographs are usually negative in cases of isolated chondral defects. Joint space narrowing is representative of global degenerative cartilage wear which is a contraindication to arthroscopy [10, 55]. MRI has limitations for characterizing clinically significant cartilage injury [26]. In a recent study comparing MRA to arthroscopic findings, MRA was found to have sensitivity of 47 %, specificity of 89 %, positive predictive value of 84 %, negative predictive value of 59 %, and accuracy of 67 % for detecting cartilage injuries [84].

Arthroscopy is the gold standard for the assessment and treatment of chondral injury [26]. Arthroscopic findings range from mild softening of the cartilage to exposed bone [85]. Probing may reveal a wave sign or a peel back phenomenon suggestive of carpet delamination in which the interface between the cartilage and underlying

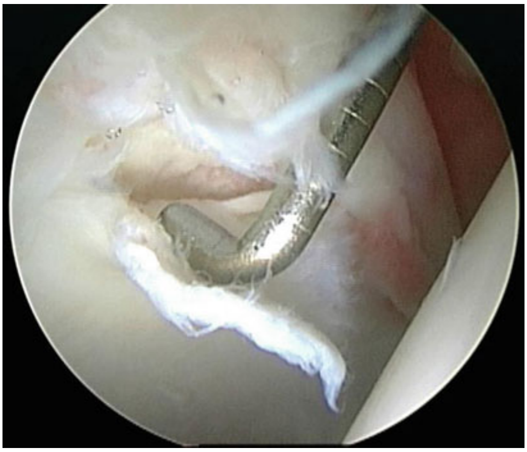

Fig. 4.20 Peel-back lesion signifying acetabular chondral delamination from prolonged cam impingement

bone is completely disrupted (Fig. 4.20) [29]. A clock-face method or geographic zones may be used to document of the size and location of the cartilage injury [86].

Like surgical treatment of labral injury, correcting the underlying pathologic morphology is central to properly addressing chondral injury and preventing further wear [5]. The congruent articulation and deep acetabular socket restrict access to the articular surface and requiring use of curved equipment and specialized instruments [39]. Debridement of unstable chondral flaps to a stable rim may ameliorate friction or catching during joint motion. Microfracture may be used for focal contained grade IV chondral defects with healthy surrounding cartilage and intact subchondral bone [27]. Other cartilage repair techniques such as autologous chondrocyte implantation, mosaicplasty, and osteochondral allografting are utilized with less frequency [87].

Hip Instability

Traumatic Instability

The normal hip possesses considerable intrinsic stability conferred by the constrained osseous articulation between the acetabular socket and the femoral head. As a result, substantial force is required to dislocate or subluxate a normal hip. Most cases of traumatic instability are posteriorly directed and result from an axial load applied to the femur with the hip joint in flexion and neutral rotation.

Hip dislocations are uncommon but may occur in high velocity or impact sports. An athlete with a posteriorly dislocated hip presents with a flexed, adducted, and internally rotated leg. Emergent reduction is mandatory to restore blood flow to the femoral head and requires sedation and adequate muscle relaxation [88]. Careful review of pre-reduction plain radiographs is important to ensure the absence of a non-displaced femoral neck fracture that could potentially displace with a reduction attempt [88]. Post-reduction CT should be obtained to ensure a congruent reduction and diagnose intraarticular fragments [12].

Hip subluxation with spontaneous reduction is likely under-recognized in athletes and may result from a seemingly minor impact [23, 61]. A high index of suspicion should be maintained in an athlete with groin pain after a fall forward onto a flexed knee or impact from behind with the ipsilateral knee on the ground [23]. Plain radiographs after a suspected hip subluxation will usually demonstrate a concentrically reduced joint unless there is an associated fracture. MRI may reveal hemarthrosis, labral injury, posterior acetabular lip fracture, disruption of the hip capsule, and/or loose bodies [9, 89].

Protected weight-bearing with gradual return to activity is recommended after a traumatic instability event. Intraarticular pathology is ubiquitous after hip dislocation or subluxation and may be an indication for arthroscopy in athletes who have persistent symptoms. In one study, loose bodies were found in 92 % (33 of 36) of patients who underwent hip arthroscopy after closed reduction of a traumatic dislocation [90]. Philippon et al. [21] performed arthroscopy on 14 professional athletes after traumatic hip dislocation and found labral and cartilage damage in all cases, loose osteochondral fragments in 11, and ligamentum teres tears in 11. Caution is emphasized when performing early arthroscopy after dislocation as the disrupted capsule may accelerate fluid extravasation [42].

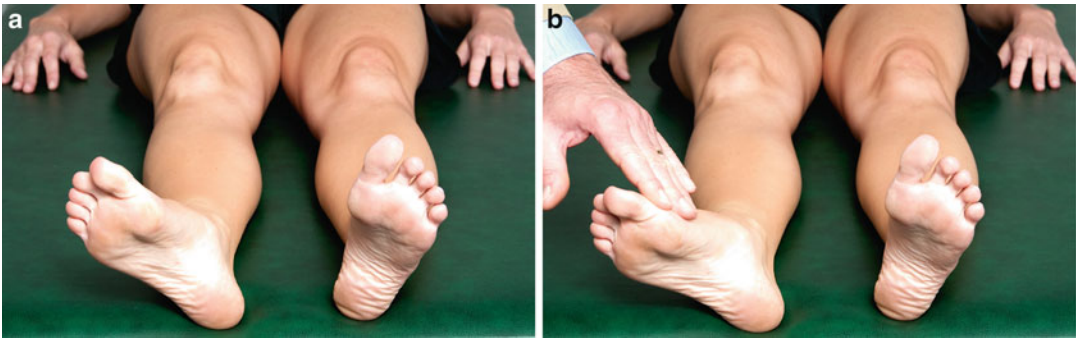

Fig. 4.21 *Dial test*. (**a**) Increased resting external rotation of the affected extremity is suggestive of anterior capsular laxity. (**b**) A positive dial test is verified with a soft endpoint on further passive rotation of the extremity

Atraumatic Instability

Atraumatic hip instability may develop in an athlete as a consequence of chronic overuse from recurrent rotation with axial loading [12, 22]. Sports such as golf, gymnastics, ballet, figure skating, hockey, and soccer require repetitive hip rotation and are commonly implicated in hip instability [9]. Athletes with generalized ligamentous laxity, capsular redundancy, labral dysfunction, FAI, and/or acetabular dysplasia are at increased risk [9, 12]. Loss of the intraarticular vacuum seal with a significant labral tear may also compromise hip stability [11, 91].

Repetitive rotational forces across the femoroacetabular joint cause attenuation of the capsular ligaments with subsequent microinstability and abnormal forces within the hip [12]. Aberrant translational motion at the articular surface leads to early cartilage wear, labral tearing, and degenerative changes [11]. Additionally, as the static stabilizers become compromised, increased reliance on dynamic stabilizers such as the iliopsoas and iliotibial band results in problematic secondary soft tissue conditions [12].

Making the diagnosis of hip instability is challenging as symptoms are vague and difficult to characterize. Athletes may present with hip pain, apprehension, abnormal gait, coxa saltans, or recurrent subluxations [9]. Examination may demonstrate an underlying condition that predisposes the athlete to hip instability. Generalized hyperlaxity is indicated by Beighton's criteria which include the ability to hyperextend the elbow, knee, and small finger metacarpal-phalangeal joint, the ability to touch the thumb to the forearm, and the ability to bend at the waist to place both palms on the ground [92]. A Trendelenburg gait from weak hip abductors is characteristic of developmental dysplasia [24].

Examination of the problematic hip may reveal irritability, an increased arc of motion, apprehension or discomfort with abduction and external rotation, and apprehension with traction [42]. Anterior capsular laxity is demonstrated by a positive Dial test in which the affected hip tends to lie in excessive external rotation and a soft end point is encountered with further passive external rotation of the limb (Fig. 4.21) [25]. Iliopsoas and iliotibial band tightness can develop in athletes with capsular laxity as the musculature surrounding the hip works harder to stabilize the hip [93].

Plain radiographs should be scrutinized for features of hip dysplasia including a shallow acetabulum, increased Tonnis angle, and decreased anterior and/or lateral center-edge angles (Fig. 4.22) [9, 32, 42]. Traction views or fluoroscopy allows dynamic visualization of the degree and direction of instability [9]. CT better characterizes bony abnormalities that may predispose to atraumatic instability and should be obtained if corrective surgery is planned. Capsular redundancy, attenuation of capsular ligaments, and increased capsular volume are MR indicators of atraumatic instability [9]. A hypertrophied anterior

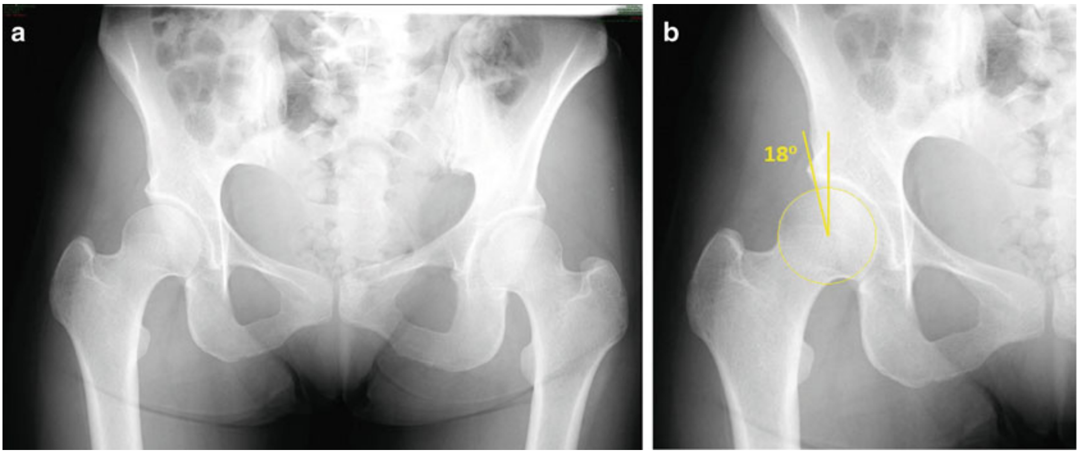

Fig. 4.22 (**a**) Anteroposterior radiographic features of developmental dysplasia of the right hip include a shallow acetabulum, increased acetabular inclination, and undercoverage of the femoral head. (**b**) Lateral center-edge angle. A vertical line perpendicular to the transverse axis of the pelvis is drawn through the center of the femoral head. A second line is drawn from the center of the femoral head to the most lateral aspect of the sourcil. Values of <25° may indicate inadequate femoral head coverage associated with dysplasia

labrum may accompany the shallow acetabular socket of hip dysplasia [94].

Initial management includes rest and activity modification followed by physical therapy to strengthen the dynamic stabilizers of the hip and enhance proprioception. Arthroscopic capsulorrhaphy may be performed in athletes with capsular redundancy and persistent instability symptoms despite conservative treatment [93, 95]. While arthroscopy can address labral pathology, chondral damage, and loose bodies in athletes with atraumatic instability from acetabular dysplasia, caution should be used in severe cases due to poor results and potential for iatrogenic instability [83, 94, 96, 97]. Corrective osteotomy should be discussed in symptomatic athletes with significant developmental dysplasia [12, 69, 91, 96].

Conclusion

Sports expose the athlete's hip to significant forces and movements, and intraarticular hip pathology is common. The supraphysiologic forces and motions required for participation in certain sports may uncover subtle anatomical abnormalities. Hip dysfunction influences the muscles and joints that surround the hip leading to secondary conditions that may confound the diagnosis. Thorough examination of the hip joint is essential to the assessment of an athlete with groin pain. Advanced imaging and intraarticular injections are indicated in athletes with persistent symptoms to isolate the hip as the source of pain. Appropriate management requires careful analysis of the underlying morphology and correction of osseous abnormalities is essential to restore normal biomechanics and prevent joint degeneration. Arthroscopy has emerged as a powerful tool to diagnose and treat intraarticular hip problems in athletes. As arthroscopic techniques continue to evolve, increased recognition and understanding of hip pathology will dramatically improve management of athletic hip injuries.

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