Managing Hip Pain in the Athlete

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KEYWORDS

• Hip • Pain • Athlete • Groin

KEY POINTS

- Hip and groin pain is commonly experienced by athletes.
- The differential diagnosis is extensive and should include both intra-articular and extra-articular sources for pain and dysfunction.
- Evaluation for the underlying disorder can be complicated.
- A comprehensive history and physical examination can guide the evaluation of hip pain and the potential need for further diagnostics such as imaging or diagnostic hip injection.
- Treatment of athletes with hip disorders includes education, addressing activities of daily living, pain-modulating medications or modalities, exercise and sports modification, and therapeutic exercise.

INTRODUCTION

Hip and groin pain is commonly experienced by athletes of all ages and activity levels. Groin pain accounts for 10% of all visits to sports medicine centers and groin injuries account for up to 6% of all athletic injuries.[1,2] Hip and groin injuries occur in 5% to 9% of high school athletes.[3] Sports involving increased amounts of acceleration and deceleration, as well as cutting movements, seem to have increased incidences. A study of high school soccer injuries reported that 13.3% of all injuries sustained by girls involved the hip and thigh.[4] Causes of hip and groin pain can often be complicated by the overlapping signs and symptoms of other disorders, as well as the complex anatomy and biomechanics of the hip. Furthermore, many hip and groin injuries have multiple components or coexisting injuries.[5] This article reviews the causes of hip pain in athletes, provides a clinical approach for accurate diagnosis, and discusses treatment options for common hip disorders.

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DIFFERENTIAL DIAGNOSIS

The differential diagnosis for athletes presenting with hip pain is extensive and can span multiple medical specialties and disciplines. For example, an athlete whose technique of running has altered because of a hip injury may begin to experience pain in other areas, including the pelvic girdle, lumbar spine, and knee. Both musculoskeletal and nonmusculoskeletal sources of hip pain must be considered (**Box 1**). These nonmusculoskeletal sources may include visceral structures of the abdomen and pelvis.

It is important for the sports medicine provider to distinguish between intra-articular versus extra-articular sources of hip pain (see **Box 1**), which is accomplished through a complete evaluation, including a thorough history and physical examination, along with appropriate diagnostic testing.

History

The medical history for a patient presenting with hip pain should include age, onset (and mechanism of injury, if applicable), distribution, quality, severity, progression, exacerbating factors, alleviating factors, and other associated signs/symptoms.

The differential diagnosis for hip pain can vary based on the age of the athlete. In the pediatric and adolescent athlete presenting with hip and groin pain, consideration should be given to apophyseal injuries, Legg-Calve-Perthes disease, and slipped capital femoral epiphysis. In contrast, older athletes are often affected by osteoarthritis (OA) of the hip.

Hip pain with acute onset has a distinct differential diagnosis from hip pain that is chronic or of insidious onset. A detailed mechanism of injury should be elicited with hip pain of acute onset. For example, sudden forceful muscle contractions (particularly eccentric) often result in muscle strains or tears in adults and apophyseal avulsions in adolescents. The adductor muscles are often involved, particularly in soccer, football, and hockey athletes. Adductor strain is the most common cause of groin pain in athletes.[6] Further, fracture should be considered in athletes with sudden onset of pain associated with a specific event. The event may not have seemed to be significant enough to cause a bony fracture, but athletes with an underlying bone mineralization deficit may become symptomatic with a seemingly benign event.

The distribution of hip pain is wide and variable but should be assessed by the health care provider to assist in making a diagnosis and to reassess following treatment. Anterior groin pain is often associated with intra-articular hip disorders. These disorders include femoral or acetabular fracture, avascular necrosis, OA, synovitis, ligamentum teres tear, and prearthritic hip disorders (isolated acetabular labral tears, developmental hip dysplasia [DDH], and femoroacetabular impingement [FAI] with and without acetabular labral tears). Extra-articular sources associated with anterior groin pain include the pubic rami, iliopsoas, adductor group, and abdominal muscles. Sports hernia typically involves injury to the abdominal muscles, particularly the external oblique muscle and aponeurosis, with possible injury to the adductors. In addition to the muscles and surrounding soft tissues, higher lumbar radiculopathy should also be considered as a source of an athlete's groin pain.

Lateral hip pain can be associated with intra-articular hip disorders, including all of those listed for anterior distribution of pain. In isolation, lateral hip pain is often associated with extra-articular disorders, including greater trochanteric bursitis or greater trochanteric pain syndrome, which may include gluteus medius or minimus tendinopathy, or pain related to tensor fascia lata/iliotibial band dysfunction. Lumbar spine disorders, particularly those involving the L4 to L5 distribution, can present with lateral hip pain.

Box 1
Differential diagnosis of hip pain

Musculoskeletal hip pain disorders:

- Intra-articular
  - Ligamentum teres tear
  - Hip dislocation/subluxation/capsular injury
  - Fracture/stress fracture
  - Synovitis
  - Infection
  - Osteonecrosis of femoral head
  - Osteochondritis dissecans
  - Legg-Calve-Perthes disease
  - Slipped capital femoral epiphysis
  - Femoroacetabular impingement
  - Developmental hip dysplasia
  - Acetabular labral tear
  - Osteoarthritis
- Extra-articular
  - Hip
  - Bursitis
  - Muscle strain/tendinopathy/tear: gluteus medius/minimus, piriformis, adductors, rectus femoris, iliopsoas, rectus abdominis, proximal hamstrings, tensor fascia lata
  - Greater trochanteric pain syndrome
  - Snapping hip syndrome
- Regional musculoskeletal
  - Pubic ramus stress fracture/osteitis pubis
  - Sports hernia/pubalgia
  - Lumbar spine: facet joint pain, lumbosacral radiculopathy
  - Sacroiliac joint dysfunction
  - Peripheral nerve entrapment: genitofemoral, iliohypogastric, ilioinguinal, lateral femoral cutaneous, obturator, pudendal, superior and inferior gluteal

Nonmusculoskeletal hip pain disorders:

- Gastrointestinal: appendicitis, diverticulitis, lymphadenitis, inflammatory bowel disease, inguinal/femoral hernia
- Genitourinary: endometriosis, prostatitis, urinary tract infection, pelvic inflammatory disease, ovarian cysts, nephrolithiasis, ectopic pregnancy
- Pelvic tumor

Posterior pelvic pain is the area of great overlap between the hip, pelvic girdle, and lumbar spine and is not fully understood. Multiple structures contribute to posterior pelvic pain,[7] including the sacroiliac joints, ischial bursa, and the insertion of the proximal hamstring.[7] The European guidelines for evaluation and treatment of pelvic girdle pain continue to provide a comprehensive resource for understanding the relationships of the pelvic girdle and lumbar spine and include diagnostic and therapeutic evidence-based reviews.[8] Increased tone, fatigue, or dysfunction of the hip abductors, extensors, lateral rotators, and the lumbopelvic fascia are confounding factors. Lumbar spine disorders also commonly present with pain in the posterior pelvis and can range from structural and physiologic changes of the intervertebral disc, facet joint, and central or foraminal canal, ranging from L1 to S1 myotome and dermatome levels. Less understood is the role of the hip in posterior pelvic pain. In a previous descriptive study, 20% of patients successfully treated with hip arthroscopy for acetabular labral tears in isolation with pain unresponsive to conservative treatment reported posterior pelvic pain as part of the distribution of pain before surgery.[9] In a series of descriptive studies, posterior pelvic pain was reported by patients before surgery in 17.3% of patients with DDH, 29% of patients with FAI, and 38% of patients with isolated acetabular labral tears.[10–12] Patients with FAI also reported a 23% incidence of low back pain and 12% incidence of posterior thigh pain.[11] Lumbar spine, pelvic girdle, and hip disorders can present with a variety of distributions of pain that overlap across regions. Recognizing this overlap in the distribution of symptoms enables the sports medicine provider to consider an underlying hip disorder in athletes with isolated groin pain as well as in the lumbopelvic region.

Pain quality, severity, progression, exacerbating factors, and alleviating factors provide additional information to narrow the differential diagnosis. Burning pain is often associated with a neuropathic cause. Pain with active contraction or passive stretch of a particular muscle suggests a tendinopathy or muscle strain/tear. Symptoms that are worse with coughing or sneezing and causing an increase in intra-abdominal and intraspinal pain may suggest an intervertebral disc or abdominal or inguinal hernia as a source of pain.

Specific motions or weight bearing associated with snapping, catching, or locking can be associated with extra-articular and intra-articular hip disorders. Snapping hip is commonly associated with hip pain and has been estimated to occur in 5% to 10% of the general population, but is especially seen in athletes such as soccer players, runners, weight lifters, and dancers who perform significant hip flexion and extension movements.[13–15] It is most commonly associated with snapping of the iliotibial band or the gluteus maximus over the greater trochanter[16] that occurs during return to full extension of the hip. Another common cause of anterior snapping hip is aberrant movement of the iliopsoas tendon snapping over the iliopectineal eminence.[16] This snapping often occurs while climbing stairs, getting out of a car, or rising from a chair.[17] Catching or locking symptoms are also associated with hip pain and can suggest acetabular labral tear or loose body.[18] In patients undergoing surgical treatment of acetabular labral tears, 53% report mechanical symptoms of popping or snapping, whereas 41% report true locking or catching.[10]

Neurologic deficits in strength and sensation imply nerve root damage (radiculopathy) or peripheral nerve entrapment. Affected nerves can include the obturator, pudendal, superior gluteal, inferior gluteal, genitofemoral, iliohypogastric, ilioinguinal, and lateral femoral cutaneous nerves. Past surgical history may often be associated with peripheral nerve entrapments.

Providers should be aware of signs and symptoms that may indicate nonmusculoskeletal sources of hip pain, including various gastrointestinal and genitourinary disorders. Further questioning regarding bowel and bladder function, sexual activity, and menstrual history should be considered.

Physical Examination

The physical examination for hip pain should be guided by each athlete's history. In general, it should include inspection, range of motion, palpation, a neurologic examination, and provocative hip testing.

Inspection should assess seated and standing postures, transfers, ability to bear weight, and gait. Areas of asymmetry, including muscle atrophy or masses, should be noted. Antalgic and asymmetric movements with transfers and gait should also be noted to help further characterize the underlying disorder. Foot position preference in standing and with ambulation should be noted because it is an initial indicator of pain, bony abnormality, and/or soft tissue adaptation or restriction. Observing a Trendelenburg gait gives the sports medicine provider an initial impression of gluteal weakness that has implications for dysfunctions across regions including the lumbar spine, pelvic girdle, and hip.

Active and passive range of motion of the hip should be performed, assessing for asymmetries from side to side and available end range. Hip range-of-motion parameters are variable in the literature. Age, gender, bony deformity, and soft tissue laxity and restrictions can all influence hip range of motion but are not consistently controlled for in studies assessing active and passive hip range of motion, which likely contributes to the variability of reported normal.[19–26] Asymptomatic elite female soccer athletes showed variability in hip passive range of motion by age and experience.[27] Specific hip disorders have been found to be associated with patterns of reduced hip range of motion. Patients with FAI have reduced hip flexion and internal rotation,[11] whereas those with hip OA may first experience reduced hip internal rotation and progress to a loss of motion in all planes. Active range of motion of the lumbar spine should be performed to assess whether pain is provoked in a specific direction, which may help determine whether a spine disorder is contributing to the constellation of symptoms associated with a hip disorder.

Palpation of relevant anatomic structures (as described earlier) of the lumbar spine, posterior pelvis, lateral hip, and anterior groin can help identify underlying disorders when pain is provoked or asymmetries are palpated in the bony and soft tissue structures. Dynamic palpation tests can also be used, such as palpation of the inguinal canal during coughing in the setting of a possible inguinal hernia. Abdominal hernia can be assessed by palpation of the abdominal muscle insertion in the midline on the superior pubis insertion during lower abdominal contraction. If an asymmetrical fullness is noted with pain at the time of contraction versus at rest, abdominal hernia becomes a consideration. Palpation of the iliopsoas tendon with concentric and eccentric contraction may elicit the pain and the snap. Likewise, palpation of the iliotibial band during hip flexion and abduction may provoke a painful snap.

Evaluation of strength and length in the muscles about the hip can identify areas of movement system breakdown that may be contributing to the patient's hip pain. For example, extra-articular muscle imbalances between posterior hip abductors and external rotators in combination with shortened hip flexors and iliotibial band can lead to groin and lateral hip pain.[28]

A neurologic examination consisting of sensory, motor, reflex, and neural tension provocative tests can further assess neurologic involvement in the patient's hip pain. If any of the neurologic examination tests are positive, regional sources for pain in the pelvis and lumbar spine should be considered.

Several provocative hip tests can help assess intra-articular versus extra-articular hip disorders (**Table 1**). None are specific enough to be used in isolation but collective

Table 1
Provocative tests of the hip

Name of Test	Purpose	Sensitivity/Specificity	Description of Test
Anterior hip impingement test	To assess hip disorder, impingement, or anterior superior labral tear	0.59–1.00/0.05–0.75[29]	Patient lies supine. Examiner passively flexes hip and knee, internally rotates and adducts hip. A positive test reproduces anterior or lateral hip pain
Patrick test or FABER test	To discern between hip, sacroiliac joint, and low back disorders	0.42–0.81/0.18–0.75[29]	Patient lies supine. Examiner places the ankle of the test leg just above the opposite knee in the position shown in Fig. 4. The opposite ASIS is stabilized with one hand and the other hand applies pressure to the test leg's knee toward the table. A positive test for sacroiliac joint or low back disorder reproduces posterior pelvic pain
Resisted straight leg raise test or Stinchfield test	To assess hip disorder	0.59/0.32[29]	Patient lies supine and actively flexes hip with knee extended to 30° against resistance. A positive test reproduces anterior or lateral hip pain
Log roll test	To assess hip disorder	Unavailable	Patient lies supine with hips and knees extended. Examiner passively internally and externally rotates test leg while stabilizing knee and ankle so that motion occurs at the hip. A positive test reproduces anterior or lateral hip pain
Posterior hip impingement test	To assess hip disorder, posterior labral test	0.97/0.11[29]	Patient lies prone with hip and knee extended. Examiner passively extends, adducts, and externally rotates hip. A positive test reproduces anterior hip or posterior pelvic pain

Ober test	To assess iliotibial band posterior fiber length	0.41/0.95[30]	Patient lies on side. Lower leg is flexed at the hip and knee. Examiner passively extends the patient's upper leg with the knee flexed at 90°. While supporting the knee, the examiner slowly lowers the leg. If the iliotibial band is shortened, the leg remains abducted and does not fall to the table
	To assess iliotibial band anterior fiber length	0.41/0.95[30]	Patient lies on side. Lower leg is flexed at the hip and knee. Examiner passively flexes the patient's upper limb hip with the knee flexed at 90°. While supporting the knee, the examiner slowly lowers the leg. If the iliotibial band is shortened, the leg remains abducted and does not fall to the table
Thomas test	To assess hip flexor contracture	0.89/0.92[29]	Patient sits at the edge of table. Patient flexes 1 knee to chest and rolls onto back while allowing test leg to remain extended at the hip off the edge of the table. If the hip does not fully extend, this indicates hip flexion contracture. If the leg abducts, this indicates iliotibial band tightness
Trendelenburg sign	To assess hip abductor strength	0.23–0.97/0.77–0.96[29]	Patient is standing. Examiner places hands on top of the iliac crests and monitors. Patient stands on the affected leg in a single-leg stance. Test/sign is positive if pelvis droops on the unaffected side, which indicates hip abductor weakness on the side of the stance leg

Abbreviation: FABER, flexion, abduction, external rotation.

assessment can help direct further diagnostic evaluation and treatment. The log roll test, anterior hip impingement, and flexion, abduction, external rotation (FABER)/Patrick test have been shown to have high inter-rater agreement in asymptomatic young adults (**Figs. 1** and **2**).[31]

Fig. 1. Log roll test.

Fig. 2. Anterior hip impingement test.

DIAGNOSTIC IMAGING

Many hip disorders are diagnosed by history and physical examination. However, imaging can confirm a diagnosis and reveal or rule out other possible structural entities. Plain radiographs are typically the first-line imaging method to assess hip pain. They are useful for detecting osseous abnormalities, including fractures, OA, and intra-articular bodies. Radiographic views that best evaluate the hip include anteroposterior (AP) pelvis, false-profile, Dunn, frog-lateral, and cross-table lateral views.[32,33] In general, the AP pelvis (**Fig. 3**) and false-profile views provide the most information regarding acetabular morphology, and the lateral and Dunn (**Fig. 4**) views provide the most information regarding the proximal femur.[32]

Fig. 3. FABER/Patrick test.

Fig. 4. Resisted straight leg test.

Radiographs remain the best way to assess bony hip structure. There are several measurements used to describe bony structure and hip deformity (**Box 2**). Examiners should be aware that these measurements can be adequately assessed only with standardized, high-quality radiographs with proper positioning of the patient.[32] Examples of measurements including the alpha angle, femoral head and neck offset

Box 2
Radiographic measurements in FAI

Name of Measurement or Sign	Purpose	Abnormal Values	Description of Measurement
Alpha angle	To detect cam-type deformity	$\geq$63°	First, determine best-fit circle to the femoral head. First arm of the angle is drawn from the center of the femoral neck to the center of the femoral head. Second arm is drawn from the center of the femoral head to the point where the femoral head-neck junction extends beyond the margin of the circle
HNO	To detect cam-type deformity	$\leq$8 mm	First, determine axis of the femoral neck. Then, 2 parallel lines are drawn to the femoral neck axis at the anterolateral edge of the femoral head and at the anterolateral aspect of the femoral neck. The distance between these 2 lines define the femoral HNO
Crossover sign	To detect acetabular retroversion	Presence of sign	Sign is present when the anterior wall projects lateral to the posterior wall before converging at the lateral acetabular sourcil
Posterior wall sign	To detect acetabular retroversion	Presence of sign	Sign is present when the center of the femoral head is located lateral to the posterior wall
Ischial spine sign	To detect acetabular retroversion	Presence of sign	Sign is present when any portion of the ischial spine projects within the pelvic brim

Abbreviation: HNO, head-neck offset.

ratio, and cross-over sign are shown in **Figs. 5–8**. Hip expert examiners from different practices have not shown high inter-rater reliability for these common measurements, but inexperienced examiners trained by one expert showed good inter-rater reliability.[34] The cutoff points for normal range of measurements and deformity have varied in the past but a recent consensus review by an international group of hip experts[33] suggested the current range of cutoffs for FAI and hip OA (see **Box 2**). Using this range of cutoffs for specific measurements, an estimated 8% to 13% of asymptomatic male patients and 2% to 7% of asymptomatic female patients[33,35] have measurements on hip radiographs consistent with FAI. As a result, the determination of hip deformity does not uniformly determine the athlete's source of pain and dysfunction. OA found on plain radiographs of the hip has important implications on counseling and management of the athlete with intra-articular hip pain. The Tonnis grade or Kellgren-Lawrence scale are commonly used to describe the extent of OA based on the presence and degree of joint space narrowing, osteophytes, sclerosis, and subchondral cysts. It is important to delineate the extent of degenerative change in an athlete's hip. Athletes with a Tonnis grade 2 or higher are poor candidates for hip preservation surgery.[35,36]

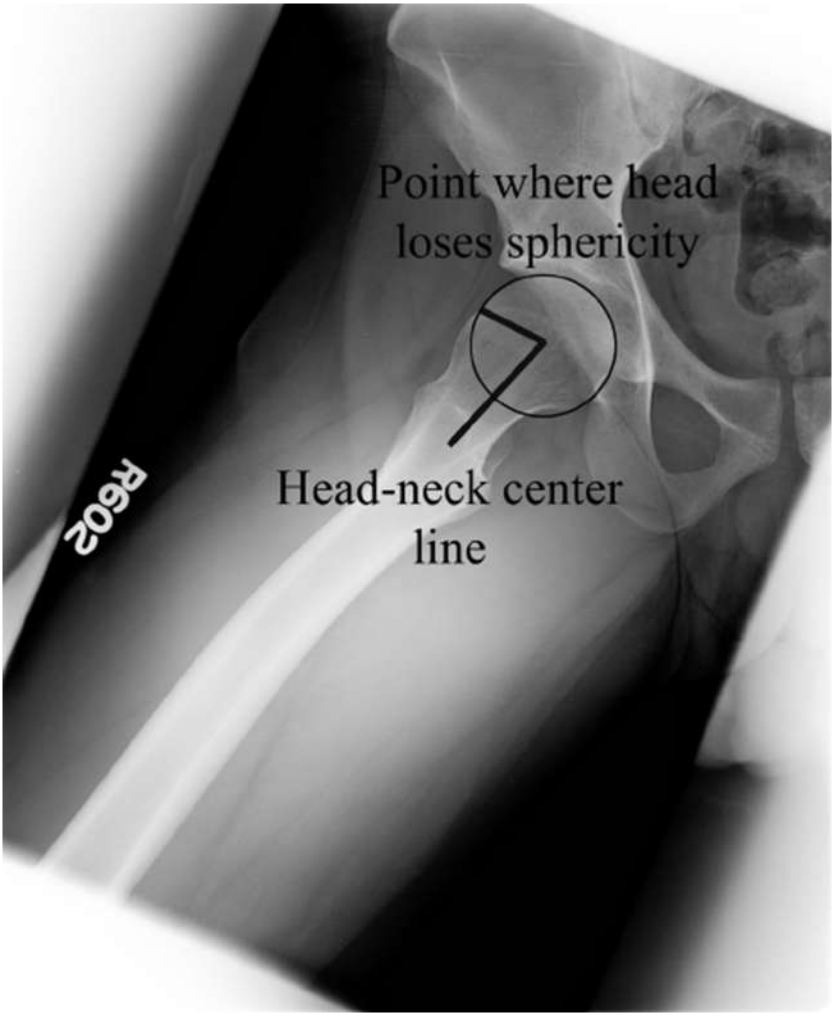

Fig. 5. Lateral frog leg of the hip.

For FAI, the maximal bony deformity is commonly located at the anterosuperior head-neck junction.[37,38] The 45° Dunn view best profiles this location.[39] The standing AP pelvis, false-profile, and Dunn views are the preferred series in the young athletic population. This combination allows the practitioner to make the appropriate measurements to assess for FAI and DDH with the least amount of radiation.[32,33] The quantitative radiographic measurements used most commonly for detecting a cam-type deformity in FAI are the alpha angle (see **Fig. 3**) and the head-neck offset ratio (see **Fig. 4**).[33] The radiographic evaluation of pincer-type deformity in FAI focuses on the detection of acetabular retroversion with the presence or absence of a cross-over sign (see **Fig. 5**), posterior wall sign, and prominent ischial spine sign.[32,33] Global acetabular coverage, a form of pincer-type FAI, is evaluated with measurement of the lateral center edge angle as well as the presence or absence of acetabular protrusion or coxa profunda.[33]

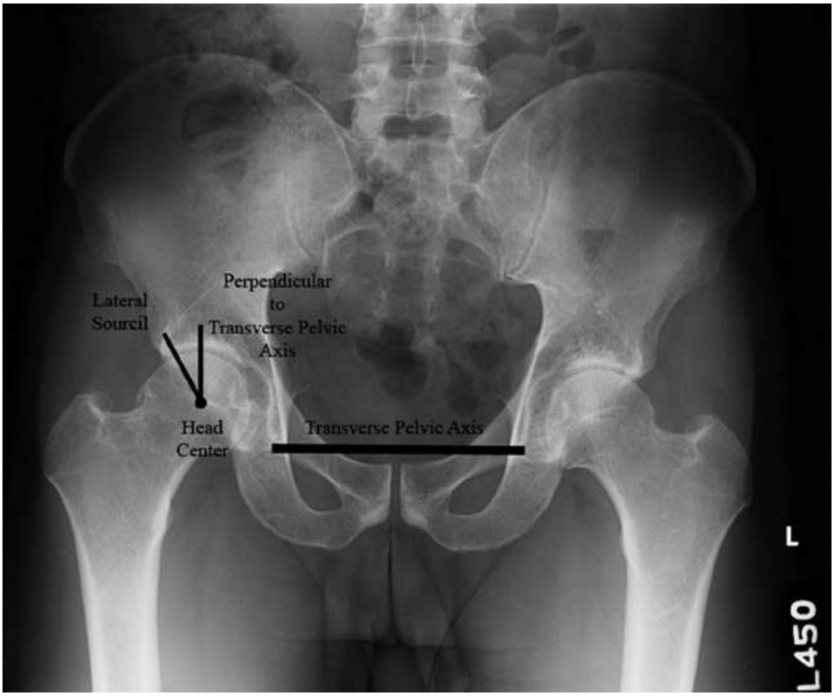

Fig. 6. AP view of the pelvis showing the center of edge angle of Wiberg.

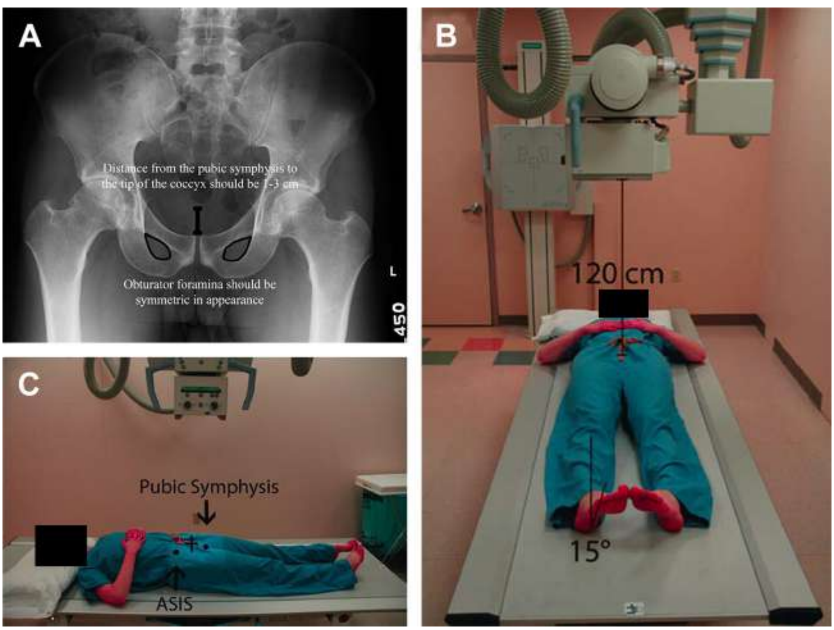

Fig. 7. (*A*) AP view of the pelvis, which allows appropriate hip measurements. (*B*) Appropriate positioning for AP view of the pelvis with attention to positioning of the lower extremities. (*C*) Appropriate positioning for anterior posterior view of the pelvis with attention to positioning of the anterior superior iliac spine (ASIS).

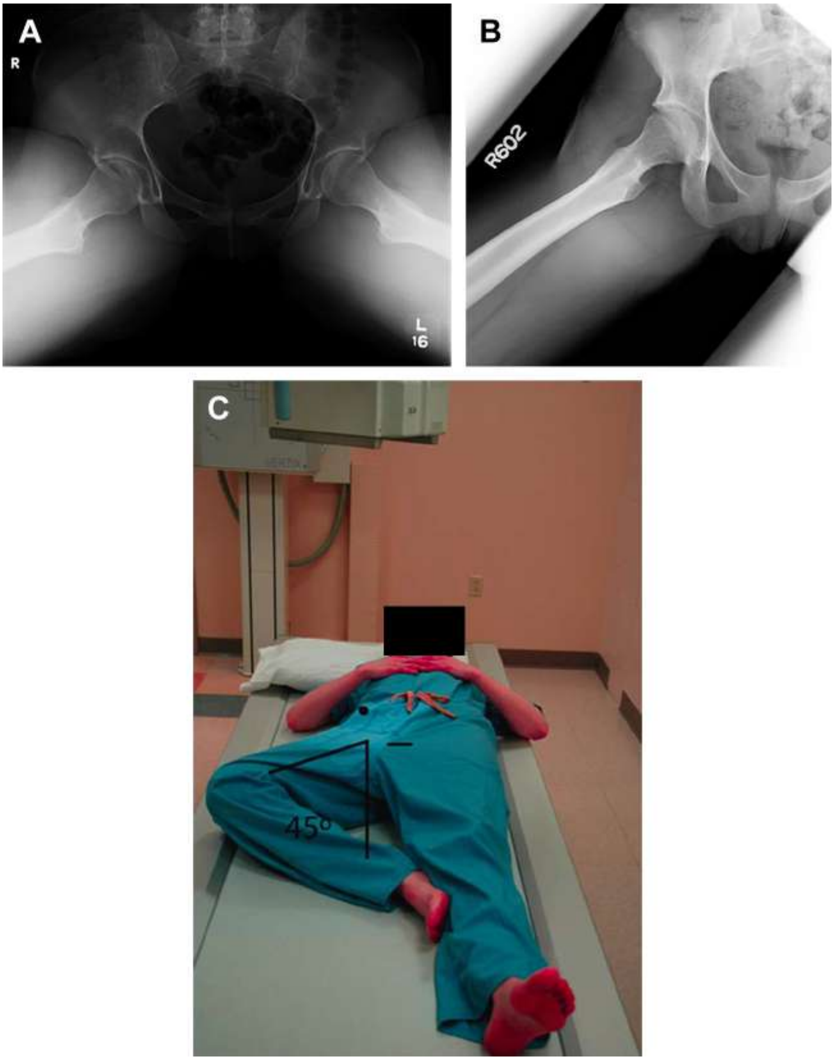

Fig. 8. (*A*) Bilateral Dunn view. (*B*) Lateral frog hip view. (*C*) Patient position for the frog view.

Magnetic resonance imaging (MRI) can detect abnormal soft tissue disorders of a tendon, muscle, or bursa and can assess the degree of degenerative changes or early avascular necrosis to a greater extent than radiographic imaging. It is also becoming the imaging study of choice for the evaluation of bony stress injuries.[40] With intra-articular contrast administration (magnetic resonance arthrography [MRA]), cartilage lesions and labral tears can adequately be assessed.[41] A meta-analysis comparing conventional MRI with MRA in the detection of acetabular labral tears found MRA superior to MRI, with a sensitivity of 87% and specificity of 64% for MRA compared with a sensitivity of 66% and specificity of 79% for MRI.[42] The health care provider must keep in mind that MRI is especially limited. One study showed 22% sensitivity[43] in its ability to detect acetabular cartilage flaps or delamination lesions, which often accompany labrochondral junction injuries. MRI provides a description of the anatomy of the acetabulum, including acetabular version, acetabular depth, labral size,[44] labral integrity, and labral ossification/acetabular rim bony apposition.[45] Biochemical MRI and delayed gadolinium-enhanced MRI of cartilage are being investigated to detect early changes in cartilage, and these are likely to lead to more detailed diagnostic information.[46,47]

Ultrasonography, or sonography, evaluates superficial tendons, muscles, and bursa about the hip.[48] The dynamic real-time potential of ultrasonography, including sonopalpation, is an advantage compared with static plain radiographs and MRI. This advantage may be particularly helpful in the case of a snapping hip. However, ultrasonography has difficulty with evaluating deep structures in which visibility can be reduced based on patient size. Ultrasonography has lesser diagnostic ability than MRA in the detection of anterosuperior acetabular labral tears. One study found the sensitivity and specificity of ultrasonography to be 82% and 60%, respectively, whereas the sensitivity and specificity of MRA were 91% and 80%, respectively.[49] Despite this reduced specificity and sensitivity, using ultrasonography in the athletic population can be useful in the acute setting of symptoms because of its low cost and potential ease of access. However, if symptoms persist and a cause remains undetermined or requires confirmation, more sensitive and specific imaging modalities should be used.

DIAGNOSTIC INTRA-ARTICULAR HIP INJECTION

A diagnostic hip injection should be considered to confirm an intra-articular process. A positive response to an intra-articular diagnostic injection is 90% predictive of intra-articular disorder found at arthroscopy.[41] A diagnostic (anesthetic only) injection that provides relief in symptoms and resolution of provocative hip tests paired with MRI/MRA that shows deformity with or without a labral tear can help confirm the intra-articular source of pain.

MANAGEMENT

Management of select hip disorders encountered in athletes (divided by intra-articular and extra-articular processes) is presented later. In general, the treatment of hip pain involves reduction of pain, activity modification, movement retraining, and progression to return to sport with implementation of a maintenance program.[28,50]

INTRA-ARTICULAR PROCESSES

Prearthritic Hip Disorders

There are limited data on the outcomes of comprehensive conservative care of athletes with prearthritic hip disorders that include symptomatic DDH and FAI with and without acetabular labral tears. A recent systematic review of nonoperative treatment of symptomatic FAI by Wall and colleagues[51] found only 5 studies that reviewed treatment, and 2 of the 5 specifically described treatment. The investigators concluded that, with limited experimental data, there is a suggestion that physical therapy and activity modification are of benefit to patients. One of the studies that specifically described treatment described patients with history, physical examination, and imaging findings consistent with intra-articular hip disorders with and without mild deformity.[52] The 52 patients in the study underwent comprehensive conservative treatment including patient education, activity modification, a standardized physical therapy protocol[53] that allowed for individualization, and intra-articular hip injection as indicated for pain control. Patients were followed for 1 year. Pain, function, and progression to surgery were measured. Patients treated with conservative treatment alone compared with those who chose to have surgical intervention following conservative treatment showed similar improvements in pain and function at 1 year. Baseline pain, function, and degree of deformity did not affect outcome at 1 year. The only statistically significant differences between the two groups were that the group of patients who chose surgery was more active at baseline.[52] Specific therapeutic exercises have not been determined or fully studied for these disorders. Some therapeutic approaches for treatment are designed to reduce anteriorly directed forces on the hip by addressing the patterns of recruitment of muscles that control hip motion, by correcting the movement patterns during exercises such as hip extension and gait, and by instruction in the avoidance of pivotingmotions in which the acetabulum rotates on the femur, particularly under load. In particular, the control of the hip abductor, deep lateral rotator, gluteus maximus, and iliopsoas muscles should be optimized and dominant involvement of the quadriceps femoris and hamstring muscles should be corrected.[53] The specifics of appropriate conservative treatment have not been definitively determined. However, athletes with prearthritic hip disorders need education regarding the mechanisms involved in the disorder. Activity modification plays a major role and includes activities other than exercise and sports. Evaluation of the athlete's technique is imperative in modifying symptoms during sports. Although image-guided intra-articular corticosteroid injections can help modify pain in athletes with early OA, steroid injections should be avoided in this prearthritic population to minimize potential damage to chondrocytes.[54]

When comprehensive conservative management of the athlete has been attempted without satisfactory improvement, surgical intervention should be considered. With recent advances in hip arthroscopy techniques, more is known about the surgical options for these patients.[33] When mixed deformity is present, arthroscopy may not be an option and more extensive hip preservation surgery such as surgical dislocation or periacetabular osteotomy may be indicated.[55,56] The inherent goals of these surgical procedures are to reduce pain, improve function, and correct bony deformity with the hope of reducing the progression of hip OA. However, as expected with new interventions, patient selection is imperative[33] and the inadequacies of surgical intervention will be realized with time and experience.[57]

OA

Research has shown a higher prevalence of hip arthritis in former track athletes compared with age matched control groups.[58] This association has also been found in former long distance runners.[59] The cause of this association remains to be determined, but theories include repetitive trauma and underlying hip deformity[60] contributing to the development of secondary hip OA. However, the literature remains inconclusive about a causal relationship between running and OA.[61] Athletes with intra-articular hip pain, hip deformity, and secondary arthritis of Tonnis grade 2 or more have poor outcomes with hip preservation surgery. Therefore optimizing conservative measures is the first choice of treatment. Activity modification to avoid painful range of motion during sport, activities of daily living, and therapeutic exercise is essential. These patients may also benefit from a trial of glucosamine and chondroitin, medication regimens for pain control including acetaminophen and nonsteroidal antiinflammatory drugs, and intra-articular image-guided corticosteroid injections to modify pain and therefore improve function. Surgical intervention with hip resurfacing or total hip arthroplasty is a viable option in athletes with end stage arthritis not controlled with conservative measures.

Femoral Neck Stress Fracture

The major focus of treatment of femoral stress fractures is to avoid preventable complications. In one report of a series of athletes treated for femoral stress fractures, 30% had a complication, including nonunion, malunion, osteonecrosis, and development of OA.[62] Treatment of the stress fracture is determined by the location. Stress fractures on the tension side of the femoral neck, involving the superior portion, often require internal fixation because of potential instability and high rate of complications.[63] Compression side stress fractures involving the inferomedial femoral neck are typically treated conservatively with reduction in weight bearing for 6 to 8 weeks and graded return to activity. Frequent radiographic monitoring is recommended for possible progression, given the high rate of complications, and to confirm healing.[63] Widening of cortical cracks, displacement of fractures, or fractures that do not respond to conservative treatment generally require surgical stabilization.[64,65]

During the period of rest following diagnosis of stress fracture, use of crutches may be indicated initially if ambulation is antalgic. Oral analgesics may be required. Once the patient has achieved pain-free activities of daily living, then a gradual return to sport may be initiated. Treatment of the stress fracture should also include addressing any predisposing or contributing factors, such as low bone mineral density, menstrual dysfunction, and low energy availability (including inadequate calcium and vitamin D intake), especially in the female athlete.[66] In addition, any related training errors and biomechanical factors should be addressed.

Hip Dislocation/Subluxation

Although rare, dislocation of the hip may be caused by a collision in contact sports or in snow skiing.[64] Most cases are posterior dislocations, accounting for 87% to 93% of all dislocations.[67] The dislocated hip requires emergent treatment in order to minimize the risk of complications. The most common complication is osteonecrosis, but nerve injury, acetabular labral tears, and chondral injuries may also occur.[64,68] The incidence of osteonecrosis increases by as much as 20-fold if the time from injury to reduction is more than 6 hours.[68] After neurovascular assessment, closed reduction under conscious sedation is the initial treatment. In some cases, general anesthesia may be required. Open reduction is indicated if closed reduction is unsuccessful after 2 or 3 attempts, or if loose intra-articular osteochondral fragments or interposed soft tissue are present.[64,68,69] Following reduction, treatment involves protected weight bearing with crutches, followed by gradual range of motion, strengthening, and return to activity for a total of 6 to 8 weeks.[64,68,69]

EXTRA-ARTICULAR HIP DISORDERS

Greater Trochanteric Pain Syndrome

Greater trochanteric pain typically responds to conservative measures, including activity modification, physical therapy, antiinflammatory medications, ice/heat, and corticosteroid injection. Success rates for these conservative measures, either alone or in combination, can exceed 90%.[70] However, recurrence is common. In these cases, further evaluation to investigate the mechanism of the breakdown in the musculoskeletal system is imperative to find a point of resolution or, at a minimum, a reliable maintenance program; this is especially the case for greater trochanteric pain, because it is commonly caused by more than an isolated trochanteric bursitis. Microtrauma leading to tears of the hip abductor tendons may be the leading cause of this syndrome.[71] Physical therapy should focus on addressing the altered lower extremity biomechanics that are associated with greater trochanteric pain as a result of tensor fascia lata/iliotibial band tightness or pain; hip external rotator strain; and OA of the spine, hip, or knee.[72] Corticosteroid injections at the greater trochanter and low-energy shock wave therapy have been found to be effective in multiple studies.[73,74] Tendon damage or rupture is a potential complication of corticosteroid injections, and possible short-term benefits from repeated injections should be weighed against potential long-term risks. Platelet-rich plasma (PRP) has gained attention in recent years for soft tissue injuries, especially in athletes. However, at this time there is no evidence to support their use for greater trochanteric pain.[75] Several surgical procedures are available for greater trochanteric pain that is unresponsive to conservative measures, such as iliotibial band release or lengthening, bursectomy, or trochanteric reduction osteotomy.[73,74]

Snapping Hip Syndrome

There is overlap between the treatment of greater trochanteric pain syndrome and extra-articular snapping hip syndrome. Most cases of extra-articular snapping hip can be treated conservatively with activity modification, physical therapy, and antiinflammatory medications. If conservative measures fail, corticosteroid injections targeting either the iliopsoas bursa or underneath the iliotibial band over the greater trochanter may be beneficial.[16] Ultrasonography guidance is often used with these injections because of ease of visualization of muscle tendon junctions and tendon insertion points. Surgical treatments are available for extra-articular snapping hip, if conservative measures and injections fail; however the surgical techniques described are limited because of the limited number of patients requiring surgery.[16]

Muscle Strain/Tear

Muscle strains or tears involving the hip and groin typically involve the hip adductor muscles, as well as the iliopsoas, quadriceps, and hamstring muscles. Initial treatment of muscle strains and partial tears includes rest, ice, compressive wrap, and antiinflammatory medications. Gentle range-of-motion exercises may begin after pain subsides, followed by strengthening exercises and gradual return to activity. Athletes with acute strains typically return to sport within 4 to 8 weeks, with recovery time as long as 6 months with chronic strains.[76] Progression of strains to partial tears, and partial tears to complete tears, may be a consequence of inadequate healing time. Surgical repair is typically indicated with complete tears.

Sports Hernia

Pain associated with posterior abdominal wall insufficiency and abnormalities is initially treated with conservative measures including rest from sport, followed by stretching and strengthening of the hip and lower abdomen.[64,69,76] Antiinflammatory medications are often used. Surgery may be considered after 6 to 8 weeks if these conservative measures fail.[69,76] Both laparoscopic and open surgical techniques have been described, with success in improving symptoms, primarily through reinforcement of the abdominal wall with mesh.[64] Treatment of the coexisting contracted or overdeveloped adductor longus muscle ipsilaterally may also be required via adductor muscle release, particularly if adductor muscle pain is noted.[64]

Osteitis Pubis

The initial treatment of this pubic bone stress injury includes conservative measures, including rest, stretching of the involved muscles/tendons, and antiinflammatory medications. A prolonged healing course of more than 3 months may be required, with occasional recurrence. Corticosteroid injection may be considered if conservative measures fail.[77,78] Surgical intervention, including curettage or wedge resection, may be of benefit if nonoperative measures fail.[76]

PRP

Musculoskeletal and sports medicine applications for the therapeutic use of PRP have received significant attention over the past decade. With regard to hip disorders, PRP has been proposed in the treatment of chronic ligamentous injury, chronic tendinopathy, and muscle tears, especially in the proximal hamstring, gluteal, and adductor muscles.[79] Although regenerative medicine is promising, the scientific literature on PRP remains in its infancy and the optimal injection technique and most efficacious injectate preparation remain uncertain. The role of PRP and other orthobiologics is discussed in further detail by Drs Mautner and Kneer elsewhere in this issue.

SUMMARY

Hip and groin pain is commonly experienced by athletes. The differential diagnosis is extensive and should include both intra-articular and extra-articular sources for pain and dysfunction. Further, evaluation for the underlying disorder can be complicated. A comprehensive history and physical examination can guide the evaluation of hip pain and the potential need for further diagnostics such as imaging or diagnostic hip injection. Treatment of athletes with hip disorders includes education, addressing activities of daily living, pain-modulating medications or modalities, exercise and sports modification, and therapeutic exercise. Advice on a graded return to exercise and sport is imperative for successful outcomes with athletes and reduction of recurrence of symptoms. Surgical techniques for prearthritic hip disorders are expanding and can offer appropriate patients a successful return to athletic endeavors when conservative measures are not effective. Further studies to determine appropriate conservative treatment are vital to improve patient outcomes, offer athletes more choices for treatment, and potentially improve overall surgical outcomes as patient selection becomes more focused.

REFERENCES

1. Minnich JM, Hanks JB, Muschaweck U, et al. Sports hernia: diagnosis and treatment highlighting a minimal repair surgical technique. Am J Sports Med 2011;39(6):1341–9.
2. Quinn A. Hip and groin pain: physiotherapy and rehabilitation issues. Open Sports Med J 2010;4:93–107.
3. DeLee JC, Farney WC. Incidence of injury in Texas high school football. Am J Sports Med 1992;20(5):575–80.
4. Yard EE, Schroeder MJ, Fields SK, et al. The epidemiology of United States high school soccer injuries, 2005-2007. Am J Sports Med 2008;36(10):1930–7.
5. Lovell G. The diagnosis of chronic groin pain in athletes: a review of 189 cases. Aust J Sci Med Sport 1995;27(3):76–9.
6. Morelli V, Smith V. Groin injuries in athletes. Am Fam Physician 2001;64(8):1405–14.
7. Stuge B, Garratt A, Krogstad Jenssen H, et al. The pelvic girdle questionnaire: a condition-specific instrument for assessing activity limitations and symptoms in people with pelvic girdle pain. Phys Ther 2011;91(7):1096–108.

8. Vleeming A, Albert HB, Ostgaard HC, et al. European guidelines for the diagnosis and treatment of pelvic girdle pain. Eur Spine J 2008;17(6):794–819. http://dx.doi.org/10.1007/s00586-008-0602-4.
9. Prather H, Hunt D, Fournie A, et al. Early intra-articular hip disease presenting with posterior pelvic and groin pain. PM R 2009;1(9):809–15.
10. Burnett RS, Della Rocca GJ, Prather H, et al. Clinical presentation of patients with tears of the acetabular labrum. J Bone Joint Surg Am 2006;88(7):1448–57.
11. Clohisy JC, Knaus ER, Hunt DM, et al. Clinical presentation of patients with symptomatic anterior hip impingement. Clin Orthop Relat Res 2009;467(3):638–44.
12. Nunley RM, Prather H, Hunt D, et al. Clinical presentation of symptomatic acetabular dysplasia in skeletally mature patients. J Bone Joint Surg Am 2011;93(Suppl 2):17–21.
13. Anderson SA, Keene JS. Results of arthroscopic iliopsoas tendon release in competitive and recreational athletes. Am J Sports Med 2008;36(12):2363–71.
14. Byrd JW. Evaluation and management of the snapping iliopsoas tendon. Instr Course Lect 2006;55:347–55.
15. Sammarco GJ. The dancer's hip. Clin Sports Med 1983;2(3):485–98.
16. Lee KS, Rosas HG, Phancao JP. Snapping hip: imaging and treatment. Semin Musculoskelet Radiol 2013;17(3):286–94.
17. Ilizaliturri VM Jr, Camacho-Galindo J. Endoscopic treatment of snapping hips, iliotibial band, and iliopsoas tendon. Sports Med Arthrosc 2010;18(2):120–7.
18. Plante M, Wallace R, Busconi BD. Clinical diagnosis of hip pain. Clin Sports Med 2011;30(2):225–38.
19. Aalto TJ, Airaksinen O, Harkonen TM, et al. Effect of passive stretch on reproducibility of hip range of motion measurements. Arch Phys Med Rehabil 2005;86(3):549–57.
20. Bierma-Zeinstra SM, Bohnen AM, Ramlal R, et al. Comparison between two devices for measuring hip joint motions. Clin Rehabil 1998;12(6):497–505.
21. Evan R. Illustrated orthopedic physical assessment. 2nd edition. St Louis, MO: Mosby; 2001.
22. Godges JJ, MacRae PG, Engelke KA. Effects of exercise on hip range of motion, trunk muscle performance, and gait economy. Phys Ther 1993;73(7):468–77.
23. Hoppenfeld S. Physical examination of the spine and extremities. Norwalk, CT: Prentice Hall; 1976.
24. Kendall F, McCreary K, Provance P, et al. Muscles: testing and function, with posture and pain. 5th edition. Baltimore, MD: Lippincott Williams & Wilkins; 2005.
25. Magee D. Orthopedic physical assessment. 4th edition. St Louis, MO: WB Saunders; 2002.
26. Simoneau GG, Hoenig KJ, Lepley JE, et al. Influence of hip position and gender on active hip internal and external rotation. J Orthop Sports Phys Ther 1998;28(3):158–64.
27. Prather H, Hunt D, Rho M, et al. Abnormal hip physical examination findings in asymptomatic female soccer athletes. Knee Surg Sports Traumatol Arthrosc 2013. [Epub ahead of print].
28. Hunt D, Clohisy J, Prather H. Acetabular labral tears of the hip in women. Phys Med Rehabil Clin N Am 2007;18(3):497–520, ix–x.
29. Reiman MP, Goode AP, Hegedus EJ, et al. Diagnostic accuracy of clinical tests of the hip: a systematic review with meta-analysis. Br J Sports Med 2013;47(14):893–902.

30. Fearon AM, Scarvell JM, Neeman T, et al. Greater trochanteric pain syndrome: defining the clinical syndrome. Br J Sports Med 2013;47(10):649–53.
31. Prather H, Harris-Hayes M, Hunt DM, et al. Reliability and agreement of hip range of motion and provocative physical examination tests in asymptomatic volunteers. PM R 2010;2(10):888–95. http://dx.doi.org/10.1016/j.pmrj.2010.05.005.
32. Clohisy JC, Carlisle JC, Beaule PE, et al. A systematic approach to the plain radiographic evaluation of the young adult hip. J Bone Joint Surg Am 2008;90(Suppl 4):47–66.
33. Nepple JJ, Prather H, Trousdale RT, et al. Diagnostic imaging of femoroacetabular impingement. J Am Acad Orthop Surg 2013;21(Suppl 1):S20–6.
34. Carlisle JC, Zebala LP, Shia DS, et al. Reliability of various observers in determining common radiographic parameters of adult hip structural anatomy. Iowa Orthop J 2011;31:52–8.
35. Beck M, Leunig M, Parvizi J, et al. Anterior femoroacetabular impingement: part II. Midterm results of surgical treatment. Clin Orthop Relat Res 2004;418:67–73.
36. Philippon MJ, Schroder ES, Briggs KK. Hip arthroscopy for femoroacetabular impingement in patients aged 50 years or older. Arthroscopy 2012;28(1):59–65.
37. Ito K, Minka MA 2nd, Leunig M, et al. Femoroacetabular impingement and the cam-effect. A MRI-based quantitative anatomical study of the femoral head-neck offset. J Bone Joint Surg Br 2001;83(2):171–6.
38. Rakhra KS, Sheikh AM, Allen D, et al. Comparison of MRI alpha angle measurement planes in femoroacetabular impingement. Clin Orthop Relat Res 2009;467(3):660–5.
39. Meyer DC, Beck M, Ellis T, et al. Comparison of six radiographic projections to assess femoral head/neck asphericity. Clin Orthop Relat Res 2006;445:181–5.
40. Kiuru M, Pihlajamaki HK, Hietanen H, et al. MR imaging, bone scintigraphy, and radiography in bone stress injuries of the pelvis and the lower extremity. Acta Radiol 2008;43(2):207–12.
41. Byrd JW, Jones KS. Diagnostic accuracy of clinical assessment, magnetic resonance imaging, magnetic resonance arthrography, and intra-articular injection in hip arthroscopy patients. Am J Sports Med 2004;32(7):1668–74.
42. Smith TO, Hilton G, Toms AP, et al. The diagnostic accuracy of acetabular labral tears using magnetic resonance imaging and magnetic resonance arthrography: a meta-analysis. Eur Radiol 2011;21(4):863–74.
43. Anderson LA, Peters CL, Park BB, et al. Acetabular cartilage delamination in femoroacetabular impingement. Risk factors and magnetic resonance imaging diagnosis. J Bone Joint Surg Am 2009;91(2):305–13.
44. Leunig M, Podeszwa D, Beck M, et al. Magnetic resonance arthrography of labral disorders in hips with dysplasia and impingement. Clin Orthop Relat Res 2004;418:74–80.
45. Corten K, Ganz R, Chosa E, et al. Bone apposition of the acetabular rim in deep hips: a distinct finding of global pincer impingement. J Bone Joint Surg Am 2011;93(Suppl 2):10–6.
46. Beaule PE, Kim YJ, Rakhra KS, et al. New frontiers in cartilage imaging of the hip. Instr Course Lect 2012;61:253–62.
47. Bittersohl B, Hosalkar HS, Kim YJ, et al. Delayed gadolinium-enhanced magnetic resonance imaging (dGEMRIC) of hip joint cartilage in femoroacetabular impingement (FAI): are pre- and postcontrast imaging both necessary? Magn Reson Med 2009;62(6):1362–7.

48. Blankenbaker DG, De Smet AA, Keene JS. Sonography of the iliopsoas tendon and injection of the iliopsoas bursa for diagnosis and management of the painful snapping hip. Skeletal Radiol 2006;35(8):565–71.
49. Jin W, Kim KI, Rhyu KH, et al. Sonographic evaluation of anterosuperior hip labral tears with magnetic resonance arthrographic and surgical correlation. J Ultrasound Med 2012;31(3):439–47.
50. Vasudevan JM, Smuck M, Fredericson M. Evaluation of the athlete with buttock pain. Curr Sports Med Rep 2012;11(1):35–42.
51. Wall PD, Fernandez M, Griffin DR, et al. Nonoperative treatment for femoroacetabular impingement: a systematic review of the literature. PM R 2013;5(5):418–26.
52. Hunt D, Prather H, Harris Hayes M, et al. Clinical outcomes analysis of conservative and surgical treatment of patients with clinical indications of prearthritic, intra-articular hip disorders. PM R 2012;4(7):479–87.
53. Lewis CL, Sahrmann SA. Acetabular labral tears. Phys Ther 2006;86:110–21.
54. Piper SL, Kramer JD, Kim HT, et al. Effects of local anesthetics on articular cartilage. Am J Sports Med 2011;39(10):2245–53.
55. Tippett SR. Returning to sports after periacetabular osteotomy for developmental dysplasia of the hip. N Am J Sports Phys Ther 2006;1(1):32–9.
56. van Bergayk AB, Garbuz DS. Quality of life and sports-specific outcomes after Bernese periacetabular osteotomy. J Bone Joint Surg Br 2002;84(3): 339–43.
57. Jackson TJ, Watson J, Lareau JM, et al. Periacetabular osteotomy and arthroscopic labral repair after failed hip arthroscopy due to iatrogenic aggravation of hip dysplasia. Knee Surg Sports Traumatol Arthrosc 2014;22(4):911–4.
58. Vingard E, Sandmark H, Alfredsson L. Musculoskeletal disorders in former athletes. A cohort study in 114 track and field champions. Acta Orthop Scand 1995;66(3):289–91.
59. Marti B, Knobloch M, Tschopp A, et al. Is excessive running predictive of degenerative hip disease? Controlled study of former elite athletes. BMJ 1989; 299(6691):91–3.
60. Nho S, Kymes S, Callaghan J, et al. The burden of hip osteoarthritis in the United States: epidemiologic and economic considerations. J Am Acad Orthop Surg 2013;21(suppl 1):S1–6.
61. Willick SE, Hansen PA. Running and osteoarthritis. Clin Sports Med 2010;29(3): 417–28.
62. Johansson C, Ekenman I, Tornkvist H, et al. Stress fractures of the femoral neck in athletes. The consequence of a delay in diagnosis. Am J Sports Med 1990; 18(5):524–8.
63. Harrast MA, Colonno D. Stress fractures in runners. Clin Sports Med 2010;29(3): 399–416.
64. Anderson K, Strickland SM, Warren R. Hip and groin injuries in athletes. Am J Sports Med 2001;29(4):521–33.
65. Fullerton LR Jr. Femoral neck stress fractures. Sports Med 1990;9(3):192–7.
66. Nattiv A. Stress fractures and bone health in track and field athletes. J Sci Med Sport 2000;3(3):268–79.
67. Bastian JD, Turina M, Siebenrok KA, et al. Long-term outcome after traumatic anterior dislocation of the hip. Arch Orthop Trauma Surg 2011;131(9):1273–8.
68. Kovacevic D, Mariscalco M, Goodwin RC. Injuries about the hip in the adolescent athlete. Sports Med Arthrosc 2011;19(1):64–74.
69. Waite BL, Krabak BJ. Examination and treatment of pediatric injuries of the hip and pelvis. Phys Med Rehabil Clin N Am 2008;19(2):305–18, ix.

70. Brooker AF Jr. The surgical approach to refractory trochanteric bursitis. Johns Hopkins Med J 1979;145(3):98–100.
71. Klauser AS, Martinoli C, Tagliafico A, et al. Greater trochanteric pain syndrome. Semin Musculoskelet Radiol 2013;17(1):43–8.
72. Segal NA, Felson DT, Torner JC, et al. Greater trochanteric pain syndrome: epidemiology and associated factors. Arch Phys Med Rehabil 2007;88(8): 988–92.
73. Del Buono A, Papalia R, Khanduja V, et al. Management of the greater trochanteric pain syndrome: a systematic review. Br Med Bull 2012;102:115–31.
74. Lustenberger DP, Ng VY, Best TM, et al. Efficacy of treatment of trochanteric bursitis: a systematic review. Clin J Sport Med 2011;21(5):447–53.
75. Moraes VY, Lenza M, Tamaoki MJ, et al. Platelet-rich therapies for musculoskeletal soft tissue injuries. Cochrane Database Syst Rev 2013;(12):CD010071. http://dx.doi.org/10.1002/14651858.CD010071.pub2.
76. Tammareddi K, Morelli V, Reyes M Jr. The athlete's hip and groin. Prim Care 2013;40(2):313–33.
77. Holt MA, Keene JS, Graf BK, et al. Treatment of osteitis pubis in athletes. Results of corticosteroid injections. Am J Sports Med 1995;23(5):601–6.
78. O'Connell MJ, Powell T, McCaffrey NM, et al. Symphyseal cleft injection in the diagnosis and treatment of osteitis pubis in athletes. AJR Am J Roentgenol 2002;179(4):955–9.
79. Nguyen RT, Borg-Stein J, McInnis K. Applications of platelet-rich plasma in musculoskeletal and sports medicine: an evidence-based approach. PM R 2011;3(3):226–50.