IMAGING OF THE ATHLETIC HIP

BEYOND THE LABRUM

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INTRODUCTION

Hip and groin pain are commonly encountered complaints in the field of sports medicine and the diagnosis can be difficult to establish because of the complex interconnected anatomy at the pubic symphysis and around the hip. Groin pain accounts for approximately 5 to 18%[1,2] of all athletic injuries, with kicking sports generally producing most of these injuries[3]. Groin injuries can be disabling, necessitating a protracted time out of competition, and may compromise a professional athlete's career[3]. As with all patients in medicine, the work up should start with a thorough history and physical examination. The history should determine the location, frequency, pattern and radiation of pain and factors that exacerbate or alleviate it. Patients with an acute onset of hip pain will have a different differential diagnosis from those with chronic pain[4]. Occupational and recreational histories, in particular any history of trauma, should also be explored before performing a thorough physical examination which should include measurement of temperature and vital signs, if indicated, to exclude the rare chance of infection[4].

The differential diagnosis of hip and groin pain is broad and includes injury to the acetabular labrum and articular hyaline cartilage of the hip, musculotendinous injury to the adductor and rectus abdominis, osteitis pubis, stress fracture, osteoarthritis, osteonecrosis, posterior inguinal wall deficiency, hernia, tumour and infection. Potential causes of hip discomfort and fever include psoas abscess, prostatitis, pelvic inflammatory disease and urinary tract infection[4].

Diagnostic imaging has the ability to help diagnose these conditions, allowing appropriate and timely initiation of treatment. Imaging of the hip should begin with plain films. More advanced imaging can then be completed with ultrasound, CT, MRI or CT/MRI after intra-articular contrast administration[5]. Given the multiple options for imaging and diagnostic injections, it is important to choose the optimal diagnostic test to address a specific clinical suspicion[6].

IMAGING OPTIONS

Radiographs

After a thorough history and physical examination has been performed, radiography is the first imaging modality in the assessment of hip and groin pathology. Information elicited from the history and physical examination will help direct attention to possible injury and guide appropriate radiological work up. Radiographs give good evaluation of the osseous anatomy and are useful in the

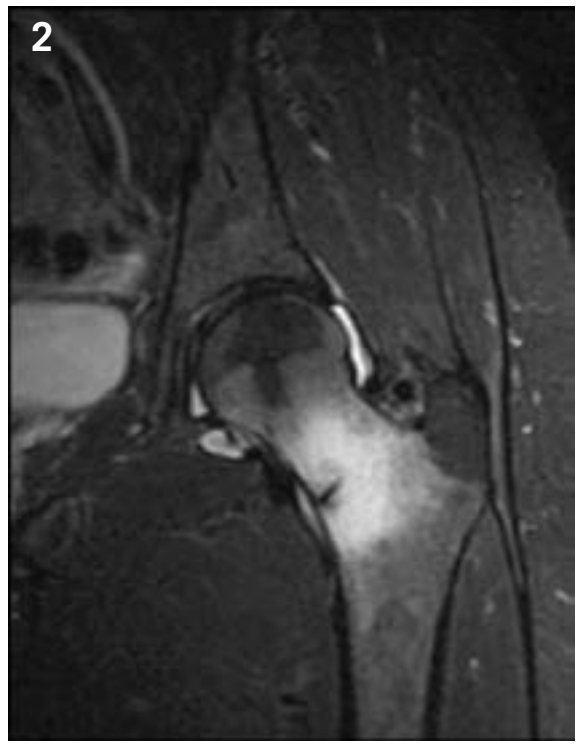


Figure 1: 13-year-old boy with hip pain after injury sustained during a game. Single AP view shows radiographic findings of slipped capital femoral epiphysis (SCFE).
Figure 2: 24-year-old female runner with pain. Coronal fluid sensitive sequence demonstrates stress fracture of the femoral neck with surrounding oedema.

initial diagnostic work up of conditions such as femoroacetabular impingement (FAI), dysplasia, osteoarthritis and stress fractures. Radiographs should include at least two views: an anteroposterior (AP) and lateral view.

The AP view of the pelvis should be centred at the level of the hips, allowing for visualisation of both hips providing valuable information regarding symmetry of findings and assessment for acetabular retroversion[6]. This view should be accompanied by at least one lateral view with possibilities including the frog-lateral, cross-table lateral and Dunn lateral views. This allows assessment of abnormal femoral head-neck offset and anterior femoral head coverage[6] and helps show the femoral head-neck junction in profile to exclude the cam lesion in cam-type FAI.

Occasionally, the cause of the patient's pain can be diagnosed with the radiographs alone (Figure 1).

Computed tomography

Multi-detector technology has advanced sufficiently and is now capable of depicting anatomy in multiple planes using 2D reformatted images and in 3D using volume-rendered images. This technology helps make CT an ideal imaging method to characterise the osseous structures about the hip. The 3D surface-rendering images show a detailed topography of both cam and pincer deformities and help the orthopaedic surgeon in preoperative planning[6].

Multiplanar CT can occasionally define a fracture when it is not seen on plain films, as a two-dimensional radiograph may not be taken in coincident plane with the fracture. In the setting of FAI, femoral head-neck offset and osseous deformities can be characterised similar to MRI and radial imaging along the femoral neck axis also shows femoral head-neck bony abnormalities not visible on the routine oblique imaging plane[7]. Images can be reformatted in oblique as well as coronal and sagittal planes and measurements including alpha angle, lateral and anterior centre-edge angles (assessing acetabular coverage), femoral neck-shaft angle, acetabular version and femoral version can be obtained[8].

Given the often young age of athletes, care should be taken to minimise radiation dose through the use of dose reduction algorithms and advanced image reconstruction techniques[9].

Magnetic resonance imaging

Modern high field MRI is an excellent diagnostic modality for the assessment of groin and hip pathology. In the athlete with symptoms that are not really specific, conventional unenhanced MRI may be considered to globally evaluate the hip and pelvis for fracture, muscle or tendon injury, osteitis pubis (bone marrow oedema), sacroiliac joint abnormality or possible tumour[6]. If intra-articular hip pathology is suspected then intra-articular gadolinium (arthrography) is the imaging study of choice. This allows excellent evaluation of the acetabular labrum, ligamentum teres and cartilage. Both conventional MR and MR arthrography have traditionally had limitations in terms of spatial resolution, which made the detection of subtle labral and cartilage pathology challenging, however new MR technology (e.g. 3T) has assisted in reducing this effect.

The ability of MRI to detect the subtle trabecular disruption makes it the imaging modality of choice for evaluation of occult fractures (Figure 2). MRI is superior to CT and radiographs in detection of non-displaced fractures in osteoporotic patients and subtle insufficiency fractures[10]. MRI also offers a more comprehensive and

Figure 3: a) Coronal CTA demonstrates cartilage loss along the weight bearing portion of the joint (black arrow). b) Coronal MRA in the same patient also shows the cartilage loss as well as the labral tear (white arrow). CTA=computed tomography arthrogram, MRA=magnetic resonance imaging arthrogram.

Figure 4: On the left, the bony cam lesion flattening the femoral head-neck junction, with associated bone marrow oedema is identified. On the right (same patient), the typical associated anterior-superior labral tear is seen in the MR arthrogram.

detailed evaluation of the surrounding soft tissues. As with CT, abnormal femoral head-neck offset and osseous deformity can be characterised with MRI, however, there are limitations with regard to measurement of the alpha angle with some variability[11].

New insights into the biomechanics of the hip joint and the rapid development of hip-preserving surgery are changing the way we image the hip joint. Biochemical-based MRI is capable of detecting early cartilaginous degenerative changes and assess cartilage repair. Techniques such as T2 mapping, T1 in the rotating frame (T1rho), sodium MRI and delayed gadolinium-enhanced MRI of cartilage (dGEMRIC) take advantage of changes in the complex biochemical composition of articular cartilage and allow detection of cartilaginous changes earlier than conventional MRI.

CT and MR arthrography

When intra-articular pathology is suspected, MR arthrography is the imaging study of choice, in that intra-articular structures including labrum, articular cartilage and ligamentum teres are well-shown and the osseous structures are also characterised[6]. CT arthrography (CTA) allows excellent assessment of the cartilage surface and thickness and can be used when MR is not available or contraindicated. However, CTA cannot assess purely chondral lesions, gives a poor evaluation of the soft tissues and exposes the patient to radiation. MR arthrography was demonstrated to have accuracies as high as 90% in the diagnosis of labral tears[12]. It was also concluded that MR arthrography was better for delineating labral tears than CTA and no statistically significant difference in demonstration of the articular cartilage abnormalities[12] (Figure 3).

At the time of the intra-articular injection of contrast material, we often also inject an anaesthetic agent like ropivicaine. If the patient has relief of pain immediately after the procedure this helps direct the physician to an intra-articular cause for the pain. In addition, after the injection, the patient can also perform the activities that typically produce pain to determine whether there is improvement in symptoms[6]. The agents injected during routine hip arthrography include a mix of gadolinium (1:200 dilution), non-ionic iodinated contrast-material, normal saline and an anaesthetic agent (ropivicaine – which is considered safer than other local agents[13]).

Ultrasound

US is a dynamic imaging modality that is commonly utilised to assess for extra-articular pathology. The success of US varies depending on the training and experience of the person performing the examination, as well as the ultrasound equipment. In patients with sports-related hip pain, ultrasound has an important role in dynamic assessment of snapping iliopsoas tendon[6], joint fluid, bursitis, haematoma and paralabral cyst formation. Ultrasound can also be used to guide intervention

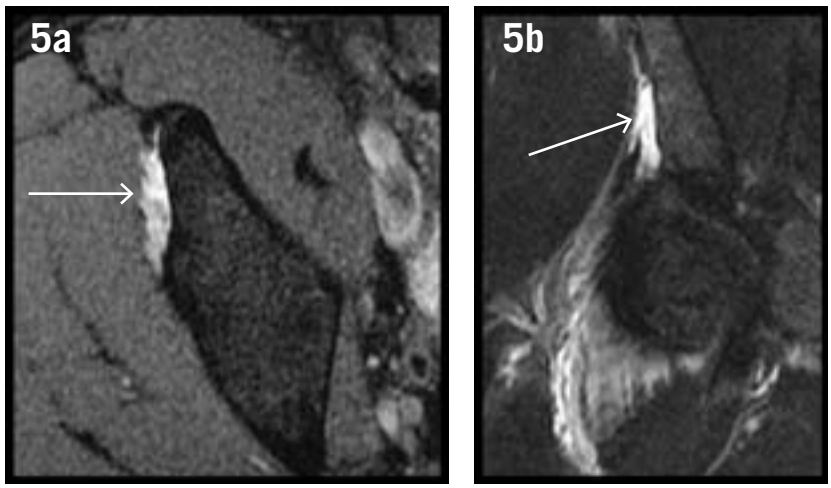
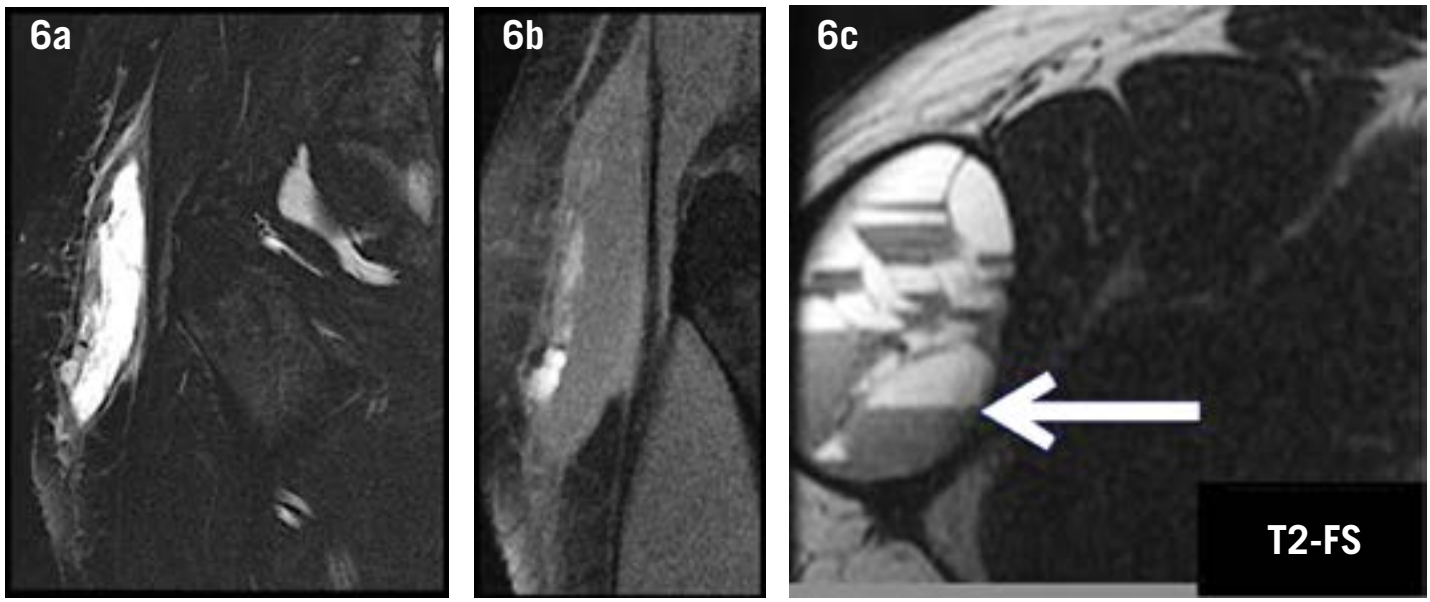


Figure 5: Tear of reflected head of rectus femoris (arrow) seen on axial (left) and coronal (right) STIR images. STIR=short tau inversion-recovery.

Figure 6: Morel-Lavallee lesion (arrow) shown on coronal STIR (left), T1 fat-saturated and FSE T2. Note the anatomic position lateral to tensor fascia lata, and the complex signal characteristics, often including fluid-fluid levels (arrow). STIR=short tau inversion-recovery.



around the hip joint for both diagnostic and therapeutic purposes, alleviating the need for exposure to radiation[12]. The role of ultrasound in the diagnosis of labral pathology is limited given incomplete evaluation of the entire labrum and low accuracy and sensitivity when compared with MR arthrography[15].

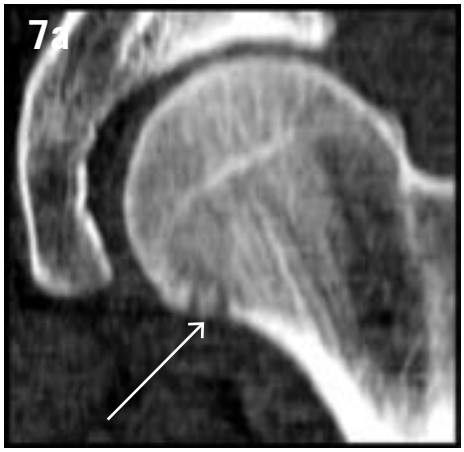
DIFFERENTIAL CONSIDERATIONS AND EXAMPLES

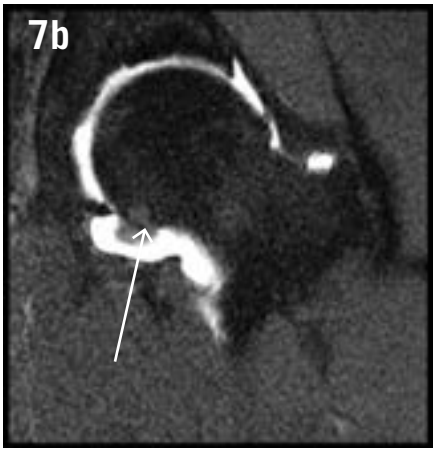
Labral tears are often seen together with FAI, a disorder whose prevalence is estimated at 10 to 15%, and commonly affects individuals of 20 to 50 years of age. Pain is usually exacerbated by sitting or athletic activity, and a positive impingement test should form part of the clinical assessment. Plain films may show signs of cam or pincer impingement, and if surgical intervention is being considered, then an MR arthrogram to demonstrate chondral wear and labral pathology is indicated (Figure 4).

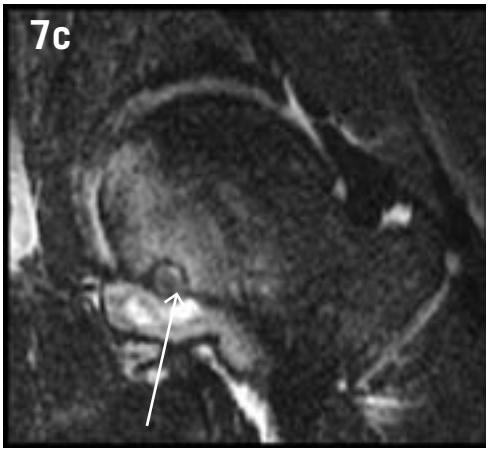
Differential considerations in imaging with respect to groin pain include the relatively common partial or complete muscle tears (Figure 5) with rectus femoris being particularly susceptible as it crosses two joints. Kicking sports in particular are commonly implicated, and the reflected (indirect) head is more commonly injured than the direct head[16].

A relatively newly described entity is the Morel-Lavallée lesion (Figure 6), a de-gloving injury that occurs at fascial planes, most commonly adjacent to the ilio-tibial band, in response to shear force. This haemolymphatic mass typically has complex signal characteristics on MRI (bright T1 signal, fluid-fluid levels) and the location and a history of trauma will help to avoid the pitfall of mistaking the lesion for a sarcoma[17].

> ***Labral tears are often seen together with FAI***







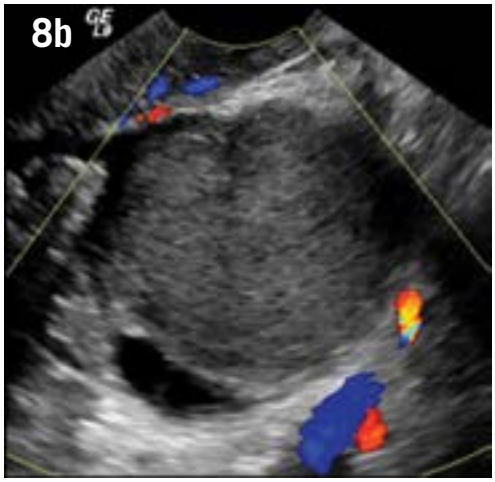


Figure 7: Ostoidosteoma in a patient suspected of having a labral tear. CT (a), MR arthrogram (b) and STIR (c) images demonstrate nidus (arrows) surrounded by bone marrow oedema in the STIR image. STIR=short tau inversion-recovery.

Figure 8: Coronal MR arthrogram (T1-weighted with fat-saturation) showing bright lesion in pelvic midline (arrow) in 26-year-old athlete presenting with query labral tear. Subsequent pelvic ultrasound (b) demonstrates an ovarian lesion with fine internal echoes and increased through transmission, typical of an endometrioma.

Osteoid osteomas present in patients 10 to 30 years old, and are therefore not uncommon in athletes. Most lesions are cortically-based, and consist of a central, dense nidus surrounded by reactive scerlosis and bone marrow oedema (Figure 7). MRI is able to diagnose this abnormality with high sensitivity and specificity, while avoiding the radiation of CT or nuclear medicine bone scans.

There are many other causes of groin pain in athletes, as discussed in the introduction, and it is important that clinicians and radiologists review all aspects of images obtained, not just the hip itself. Moreover, there are additional findings not uncommonly seen within the field view of especially with MR examinations, which, although not necessarily etiologic for the patient's presentation of groin pain, may still be relevant to their overall well-being. Particularly common such examples are gynaecologic findings in young female athletes (Figure 8).

CONCLUSION

Despite the advances made in the field of sports medicine, identifying and treating the cause of hip and groin pain can be a challenge for the treating physician. Modern imaging helps play a role in confirming a clinically suspected diagnosis, determining the extent of injury and excluding other potential causes for the patient's pain. Early diagnosis and treatment can have important implications particularly for athletes; appropriate use of diagnostic imaging combined with a thorough history and physical examination can allow the physician to make an early diagnosis and promptly start appropriate treatment, thus allowing a prompt return to play for the professional or elite amateur athlete.

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