

MRI of the Hip Update

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Hip pain is a common clinical problem with a long list of possible etiologies (Table I). Hip pain can be localized as anterior groin pain, lateral trochanteric or posterior gluteal (buttock) pain. Hip pathology can occur in any of these anatomical regions. More importantly, patterns of pain referral involving the hip can sometimes be clinically confusing. For example, intra-articular hip disease will often produce knee pain while a lumbar disk protrusion with associated sciatica can result in buttock pain without producing low back pain.

The hip was the first joint to be successfully studied with MR imaging. Despite over a decade of experience imaging the hip with MRI, its role as a diagnostic imaging modality in the patient with hip pain continues to evolve. Currently, MR imaging is the modality of choice (following plain radiography) for imaging avascular necrosis, radiographically occult fractures, marrow replacement disorders, musculoskeletal neoplasms, and osteomyelitis involving the hip.

MR IMAGING TECHNIQUE

Optimization of MR imaging parameters requires consideration of many technical factors in the context of the type of abnormality that is clinically suspected. For evaluating the hip, one of four standard protocols is usually utilized. These include a bilateral hip protocol, a unilateral hip protocol, a "rule-out occult fracture" protocol, and a direct MR arthrogram protocol. The technique suggested here is based upon experience with a 1.5 Tesla MRI unit. The bilateral hip protocol incorporates a torso phased array coil. This protocol is

utilized to evaluate patients suspected of having pathology that frequently involves the hips bilaterally such as avascular necrosis. In the coronal plane, a T1 weighted sequence and fast inversion recovery sequence are obtained. In the axial plane, a fast spin echo sequence is obtained utilizing fat suppression. The unilateral hip protocol is utilized for evaluating unilateral hip pain in patients not clinically suspected of having contralateral disease. The torso phased array coil is also utilized; however, the field of view is decreased to 17-20 cm. A T1 weighted sequence is obtained in the coronal plane. A coronal, sagittal and axial fast spin echo sequence without fat suppression is also obtained. If the clinical concern regards a possible radiographically occult fracture of the hip/pelvis, than an abbreviated examination of both hips is performed. The torso phased array coil is again utilized and in the coronal plane both T1 weighted and fast inversion recovery sequences are obtained. Finally, if there is clinical concern for an acetabular labral tear or subtle intra-articular pathology in the hip, than a direct MR arthrogram is performed. Under fluoroscopic guidance, 15 cc of 1:200 dilution of gadolinium contrast agent is intra-articularly injected. Coronal, sagittal, and axial T1 weighted fat suppressed images are then obtained utilizing the torso phased array coil and a 20 cm FOV. A T2 weighted fast spin echo sequence with fat suppression is also obtained in the coronal plane to assess the bone marrow and extra-articular soft tissues. All of the above pulse sequences utilize a 256 x 192 matrix and a 4 mm slice thickness with a 1 mm gap.

More recently, some centers have advocated the use of 512 matrix imaging incorporating

smaller FOV's (15-17 cm), FSE without fat saturation, TR = 4000, TE = 34, ETL = 8, 2-3 NSA, slice thickness = 3.5-4.0 mm, gap = 0 mm. Either a body phased array coil or a shoulder phased array coil can be used. These techniques have been demonstrated to be useful for assessing the acetabular labrum and the articular cartilage. They represent a possible non-invasive alternative to direct MR arthrography in these patients.

AVASCULAR NECROSIS

The most common indication for MRI of the hip is to evaluate for possible avascular necrosis (AVN) of the femoral head. Avascular necrosis, also known as osteonecrosis or aseptic necrosis, is defined as necrosis of the subchondral bone secondary to diminished or disrupted blood supply. While its histopathology is identical to a bone infarct, the characteristic subchondral/epiphyseal location of AVN distinguishes it from the metaphyseal/diaphyseal location of a bone infarct.

Trauma involving the proximal femur or acetabulum may lead to unilateral AVN. Non-traumatic AVN, however, is bilateral in 50-80% of cases. It is important to identify AVN early, prior to the onset of femoral head collapse and fragmentation which requires total hip arthroplasty. Early diagnosis can result in joint-sparing treatments such as steroid therapy reduction, non-weight bearing with crutches, core decompression with or without graft placement, and a variety of inter-trochanteric osteotomies including the rotational osteotomy. Significant controversy remains concerning the operative treatment of early AVN.

The role of MR imaging is to detect AVN before it progresses to cortical collapse. The most accepted MR imaging classification system for AVN of the hip is the Mitchell classification system (Table 2). This system correlates MR imaging appearances with histopathologic features. Many patients with AVN, however, demonstrate heterogeneous MR signal intensity characteristics within the femoral heads which precludes definitive placement into one of the four Mitchell classes. In 80% of the cases of AVN, there is a characteristic "double line" sign on T2 weighted images. This is a specific finding that consists of concentric low- and high-signal intensity rims that surround the area

Table I. Causes of Hip Pain

Musculoskeletal	Non-Musculoskeletal
• Avascular necrosis	• Hernia
• Inflammatory arthritis	• Aneurysm
• Osteoarthritis	• Peripheral Vascular Disease
• Bursitis	• Thrombophlebitis
• Myositis	• Cellulitis
• Traumatic Fracture	• Intraoperative Pathology
• Stress Fracture	• Retroperitoneal Pathology
• Pathologic Fracture	
• Tendonitis	
• Muscle Injury	
• Acetabular Labral Tear	
• Degenerative Disk Disease	

Table 2. MR Staging of Femoral Head AVN

CLASSIFICATION	T1 SIGNAL INTENSITY	T2 SIGNAL INTENSITY	HISTOPATHOLOGY
A.	High	Intermediate	Fat
B.	High	High	Subacute Blood
C.	Low	High	Fluid and/or Edema
D.	Low	Low	Fibrosis

of marrow signal intensity change within the femoral head.

Prospective studies comparing MRI with nuclear medicine scintigraphy, CT, and plain radiographs for the evaluation of AVN of the hip conclude that MRI is the most sensitive and specific imaging modality. The cost of MR imaging also compares favorably with nuclear medicine scintigraphy. Recent studies also suggest some prognostic value derivable from the size and location of AVN involvement on MR imaging. Specifically, when more than 50% of the weight bearing surface of the femoral head is involved with AVN, this portends a poorer prognosis.

BONE MARROW EDEMA PATTERN

The bone marrow edema pattern is a specific MR finding in the hips which is characterized by diffuse decreased signal intensity on T1 weighted images and increased signal intensity on T2 weighted images. This edema-like pattern involves much of the femoral head including the subchondral bone with extension for a variable distance into the femoral neck and inter-trochanteric regions. No associated double-line sign demarcates the region of involvement. The differential diagnosis for the bone marrow edema pattern includes early AVN, transient osteoporosis, bone contusion, osteomyelitis, and infiltrating neoplasm. Consideration of clinical history and physical examination findings will frequently distinguish between the latter three entities. MR imaging cannot, however, distinguish between early AVN and transient osteoporosis of the hip. This distinction is important clinically since early AVN may be treated with surgical intervention while transient osteoporosis is a self-limited disease process requiring no specific therapy other than supportive measures. Treatment planning may be based on the presence or absence of risk factors for avascular necrosis as well as the presence or absence of osteopenia involving the proximal femur on plain radiographs.

TRAUMA

Osseous and soft tissue injury involving the

hip is a common problem in both athletes and patients who have sustained hip trauma. Several recent MR imaging studies have demonstrated that fractures produce an immediate change in bone marrow signal intensity that is readily identifiable on MR imaging. MRI can therefore be utilized to screen for radiographically occult hip fractures. Non-displaced fractures, stress fractures, and insufficiency fractures in elderly osteopenic patients are particularly amenable to this technique. A screening T1 weighted coronal sequence is usually sufficient for diagnostic purposes providing a rapid, cost-effective method for detection of occult fractures. An additional coronal fast inversion recovery sequence is also helpful in particular to evaluate the adjacent soft tissues. Fractures produce low signal intensity lines on all pulse sequences. This low signal intensity line is surrounded by a variable amount of marrow edema. In the case of stress fractures, the fracture line itself may not always be visible as a discreet low signal intensity line. Instead, only an amorphous region of bone marrow edema may be identified. The accuracy of screening MRI for the diagnosis of radiographically occult hip fractures approaches 100%. This approach to the evaluation of patients with suspected hip fractures has been demonstrated to be a cost-effective alternative to bone scintigraphy.

A spectrum of early MR imaging findings can also be identified following traumatic dislocation of the femoral head. These findings are frequently occult on plain radiographs. MR imaging findings that have been associated with traumatic dislocation of the hip include: joint effusion or hemarthrosis; bone contusion or osteochondral injury involving the femoral head; iliofemoral ligament injury; acetabular lip fractures; and muscle injuries involving the gluteal region, medial facial compartment and anterior facial compartment.

Heterotopic ossification is one of the most common orthopedic complications following spinal cord injury and consists of bone formation in the soft tissues surrounding paralyzed joints. This always occurs below the level of neurologic

impairment and is seen most frequently around the hips (up to 40% of cases). Complications of heterotopic ossification include decubitus ulcers, restricted joint motion, and ankylosis, with subsequent loss of the patient's independence. On MR imaging, there is a similar maturation process compared to myositis ossificans, with heterotopic ossification demonstrating decreasing T2 signal intensity and enhancement with time, but equivalent increasing fat signal intensity and cortical bone formation.

Acetabular labral tears are increasingly being recognized as a cause of intra-articular hip pain. Patients with acetabular labral tears present with symptoms of hip pain, decreased range of motion and clicking. MR arthrography is well suited to the imaging evaluation of the acetabular labrum. On T1 weighted fat suppressed images, the normal acetabular labrum is a triangular low signal intensity structure which is attached to the osseous rim of the acetabulum. The joint capsule inserts at the labral base anteriorly and posteriorly, but it inserts several millimeters above the labrum superiorly. There is a recess between the labrum and capsule that is lined with synovium and normally fills with contrast. On MR arthrography, criteria for labral tears include intrasubstance contrast, absence of the labrum, labral blunting, or irregular margins. Labral detachments are easily recognized by the presence of contrast material tracking into the labral-acetabular junction. This must be distinguished from a normal variant sub-labral sulcus. Concepts regarding the diagnosis and treatment of acetabular labral pathology continue to evolve.

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