The Pediatric Lower Extremity: The Unique Lesions of Childhood

The Pediatric Hip

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Introduction

The hip is a relatively common site for disease and infection throughout childhood. Some conditions may be benign and self-limiting whilst others, if left untreated, can lead to significant joint damage and long-term disability. MR imaging is being increasingly used to assess joint disease in childhood both in acute and chronic conditions. When evaluating the hips, it is important to be aware of the different pathological conditions which can be present, so that imaging can be done appropriately. One of the most important considerations is the age of the child, as conditions significantly vary in their incidence during childhood.

MR Imaging

As with all paediatric MR imaging, it is important that the child is comfortable and still within the magnet. In the younger and uncooperative child, this may need to be achieved with either sedation or general anaesthesia.

If the diagnosis is unknown, but symptoms are unilateral, it is important that both hip joints are imaged, as this may not only provide a useful ‘control’ for the hip under investigation, but in certain conditions, it may detect occult pathology in the contralateral hip.

Sequence Selection

Sequence selection should allow a proper overview of the hip anatomy and detection of any pathological conditions. If certain pathological conditions are suspected then obviously more appropriate and detailed sequences should be used. Any hip imaging protocol will depend on local resources and expertise.

Marrow Imaging

Both T1 and T2 weighted spin echo sequences allow good appreciation of underlying anatomical detail and appearances and development of the
marrow. They allow an assessment of fatty marrow conversion and will also detect areas of signal change within the marrow. STIR and fast spin echo fat saturated T2 weighted images are sensitive in detecting areas of marrow oedema and focal fluid collections within the marrow.

**Cartilage Imaging**

Proton density fast spin echo fat saturated imaging gives good anatomical detail about cartilage and can differentiate between articular and growth cartilage. Spoiled gradient echo imaging allows a volume acquisition of the cartilage and allows finer detail assessment of articular cartilage changes. These sequences are more time consuming.

With increasing technology, there is an ever increasing number of cartilage specific sequences being developed by the machine manufacturers. It is important to evaluate the use of these sequences within one’s own clinical practice as they become available.

**Synovium Imaging**

Post-gadolinium T1 weighted images are the most sensitive in detecting synovium and synovial proliferation. This sensitivity can be increased with subtraction or fat saturation. Fat saturation may be more difficult in a smaller child who lies in an eccentric position within the magnetic field.

**Imaging of Infection**

Infection around the hip joint may be within the bone (osteomyelitis), the joint (septic arthritis) or soft tissues (myositis or cellulitis). Typically, it will result in associated oedema and any other joint effusion or soft tissue swelling. The oedema is best appreciated on STIR or T2 weighted images. Joint effusions will be of high signal intensity on T2 weighted sequences. Post gadolinium sequences are very important to help differentiate synovium form joint fluid and delineating soft tissue collections from generalised oedema. An abscess will appear as a low signal intensity collection with an enhancing rim.

**PATHOLOGICAL CONDITIONS**

**Proximal Focal Femoral Deficiency (PFFD)**

This is a congenital abnormality resulting in abnormal or complete failure of growth and development of the upper femur and acetabulum. There is a spectrum of deformity, ranging from mild shortening with a varus angulation to almost complete absence of the femur except for the distal femoral condyles (accompanied by acetabular dysplasia and abnormality of the lower limb). There is an associated with ipsilateral fibular hemimelia, knee instability (hypoplasia of the cruciates and menisci) and foot anomalies.

Clinically, the thigh is thick and bulky and is held in flexion, abduction and external rotation. Limb length shortening is a common feature. Treatment is
aimed at limb lengthening, improving hip mobility and function and maintaining symmetry,

Imaging is aimed at making the diagnosis which is typically done with radiographs. The important features to recognise are the presence of a femoral capital ossification centre which is not always possible on the initial radiographs.

MR imaging is important to show the cartilage structure of the acetabulum and upper femur and in particular, identifying an unossified femoral head. Any cartilaginous collection between the femoral head and femoral shaft can also be identified. The development of the acetabulum and hip joint is better assessed in the newborn. Muscular development around the hip is important to quantify. Often, the sartorius muscle is enlarged. Other abnormalities of the hip rotators, abductors and obturator muscle groups can also be seen.

Development of Dysplasia of the Hip

The normal development of the hip joint relies on the femoral epiphysis being correctly sited within the acetabulum. The cartilaginous structures of the femoral epiphysis and acetabulum require the close apposition of the other to develop properly. If the femoral epiphysis is subluxed or dislocated out of joint, then there can be long-term developmental problems of the hip joint. The diagnosis is made by clinical screening and ultrasound. The use of MRI is limited in the diagnosis. Treatment options include femoral osteotomies and surgical reduction of the hip joint. Often, MR imaging will be used to assessed post-operative position of the hip, particularly if the femoral epiphysis is unossified in the young child and not visualised on radiographs.

Legg-Calves-Perthes Disease

This is avascular necrosis of the proximal femoral epiphysis. Whilst LCP is idiopathic, avascular necrosis may also be associated with a variety of disorders, such as sickle cell disease, sepsis and juvenile idiopathic arthritis. Children typically present between 3 and 10 years of age with a history of limp, hip pain or reduced movement.

Classically, radiographs will show fragmentation and flattening of a sclerotic capital femoral epiphysis.

MR imaging is more sensitive within the early stages of the diseases in detecting avascular necrosis.

On T1 weighted images, there is hypointensity along the periphery of the ossific nucleus with further areas of linear hypointensity traversing across the ossification centre. As the disease progresses, the epiphyseal marrow becomes hypointense on both T1 and T2 weighted imaging. There is often fluid within the joint which is of high signal on T2 weighted images. There is associated synovial thickening.
As the disease progresses, marrow signal intensity within the epiphysis may start to return to normal. There may be bone bridges seen crossing the physis which are a predictor of normal growth. The extent of epiphyseal involvement may predict severity, with peripheral involvement being the most severe. A system based on zoned distribution has been described (Cattrall). Gadolinium administration with subtraction techniques have been shown to improve the detection of epiphyseal ischaemia and the analysis of revascularisation patterns.

**Slipped Capital Femoral Epiphysis (SCFE)**

This is displacement of the femoral capital epiphysis in relation to the metaphysis. The displacement is typically posteriorly. The disorder is thought to be analogous to a Salter-Harris type I injury.

It is associated with premature osteoarthritis and modelling deformities of the upper femur. It is common in boys and typically presents around the adolescent growth spurt. It is associated with obesity, endocrine dysfunction, rickets and previous DDH.

Bilateral involvement is common but presentation is usually unilateral with the opposite side being involved within a couple of years.

The radiographic features involve widening of the proximal growth plate, displacement of the capital epiphysis and loss of height of the epiphysis. The features are most marked on a frog lateral projection.

Typically, treatment involves surgical screw fixation and complications include chondrolysis (10%) and avascular necrosis (1%).

MR imaging is not typically used at diagnosis but is important if the diagnosis remains uncertain as treatment of minor slippage has a significantly improved outcome compared to more chronic severe slippage.

MR imaging features of the disorder include physeal widening. This widening is better appreciated on MR imaging than on radiographs. There is often associated marrow oedema around the growth plate. Joint effusion and synovitis are secondary features and not always present. MR imaging can also be used to assess the vascularity of the epiphysis prior to surgical fixation.

Following surgery, MR imaging is useful for detecting avascular necrosis at an early stage and chondrolysis. Chondrolysis is seen as cartilage thinning and is best appreciated on proton density fast spin echo fat saturated sequences or spoiled gradient echo sequences.

**Transient Synovitis and Septic Arthritis**

Transient synovitis is the commonest cause of hip pain in childhood and can mimic the symptoms of LCPD, SCFE and JIA as well as septic arthritis. It is a self-limiting condition of unknown origin. There is synovial proliferation and
effusion within the joint. It must be remembered that both ultrasound and MR imaging are sensitive in detecting effusions but are unable to distinguish between aseptic and infected fluid. Aspiration is required if infection is considered.

Septic arthritis is not uncommon within the hip joint. It may be blood-borne or occur from adjacent osteomyelitis/cellulitis. Untreated septic arthritis can lead to cartilage destruction, bone erosions and significant loss of joint function. It is important that if sepsis is ever considered that prompt joint aspiration and lavage is performed.

Distinguishing between transient synovitis and septic arthritis is often not difficult as a septic joint is held in fixed flexion, the child is pyrexial and is unable to weight bear. In certain circumstances however, differentiation between the conditions can be problematic, particularly, if a child has received antibiotics for another common infection.

Ultrasound and MRI are sensitive in demonstrating joint effusions but cannot distinguish between aseptic and septic effusions. With sepsis, there is often associated marrow oedema, however this is not constant. Synovial proliferation is almost a constant feature of septic arthritis but can occur with transient synovitis.

**Juvenile Idiopathic Arthritis (JIA)**

This is an autoimmune mediated arthritis which causes significant synovial proliferation, joint swelling, reduced joint function and pain. In longstanding disease, there is cartilage and bone destruction, ligamental damage and loss of joint integrity. JIA is an umbrella term for a variety of subcategories of childhood arthritis which vary in the number and location of joints affected, the presence of rheumatoid factor and a variety of other clinical features.

The hip joints are not uncommonly involved. In the acute stage, there will be joint effusions and synovial proliferation. Synovial proliferation is best detected on post-gadolinium T1 fat saturated or subtracted images. There may also be marked marrow oedema. Cartilage damage and bone erosions are later features as are bone remodelling which can lead to coxa valga, coxa magna and protrusio acetabuli.

It is important when assessing the hip joint in JIA to also formally image the sacroiliac joints as the clinical features can be very similar.

**Idiopathic Chrondolysis**

This is a disease of exclusion. It is common in adolescent females and can lead to significant cartilage loss, bone remodelling, joint damage and marked muscle wasting. The radiological features can be similar to both septic arthritis and JIA and it is important that both these conditions are excluded with joint aspiration and biopsy before the diagnosis is made.
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