Imaging pathway for a child with limp

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Purpose

The limping child or a child with hip pain represents a diagnostic dilemma for the clinician. This can be due to the obvious challenges in communication but also because an altered/antalgic gait and hip pain may result from seemingly distant pathology, e.g. the knee, spine or sacro-iliac joint. Even non-musculoskeletal disorders should be considered as part of the differential diagnosis, e.g. acute appendicitis, in the evaluation of a patient with this common presenting complaint.

While conventional radiographs are a good starting point in most children, an ultrasound will take precedence in a septic child with raised inflammatory markers to exclude septic arthritis. We would like to propose an imaging pathway for children under 5 years who refuse to weight bear or who are reluctant to move the lower limb. Radiologists can refer to this to ensure remote or uncommon pathology is not missed.

Methods and Materials

We have taken examples from our clinicoradiological practice to discuss the indications for investigating the child presenting with a painful gait and/or hip pain. The merits of the imaging modalities and the salient imaging features of the different conditions will also be discussed. An 'imaging pathway' that we currently use in our institution is proposed. This pathway is by no means definitive, but serves as a simple aide memoire to the radiologist and ensures optimal investigation of the presenting complaint.

Results

The Aetiology of Hip pain in Children

Hip pain and limp in the child has many different causes and will vary according to the patient’s age. The possibility of trauma, septic arthritis, osteomyelitis and neoplastic causes need to be considered in all presenting age groups. Furthermore, the astute radiologist should always be alert and mindful of the possibility of non-accidental trauma (NAI). Other common diagnoses can be sought with the patient's age in mind (1,2).

Infants and Toddlers:
This group of patients often present with refusal to weight bear or reluctance to use limb and frequently there is little in the way of localising symptoms and signs. Transient synovitis of the hip, developmental dysplasia of the hip (DDH) should be considered in this group. When hip or pelvic aetiology is excluded it may be necessary to image the whole limb to localise distal pathology.

Older Children

Localisation of symptoms generally becomes easier in the older child with the majority of pathology arising from the hip or pelvis.

In children aged between 4-10 years of age transient synovitis, Legg-Calve-Perthes (Perthes') disease and juvenile idiopathic arthritis form important differentials.

In the adolescent age group, common causes include slipped upper femoral epiphysis (SUFE) and sporting injuries.

Surgical Sieve Approach

A 'surgical sieve' approach to diagnosis is useful (see below). (Entries are not exhaustive.)

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Traumatic</strong></td>
<td>Fractures, dislocations, avulsion injuries, ligament/muscle/tendon injuries, contusions, NAI</td>
</tr>
<tr>
<td><strong>Inflammatory</strong></td>
<td>Acute transient synovitis, Juvenile idiopathic arthritis, Juvenile dermatomyositis, Pigmented villonodular synovitis, Myositis</td>
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<tr>
<td><strong>Infective</strong></td>
<td>Septic arthritis, Osteomyelitis, Discitis, Epidural abscess, Psoas abscess, Soft tissue abscess</td>
</tr>
<tr>
<td>Avascular necrosis (AVN)</td>
<td>Legg-Calve-Perthes disease, Osteochondritis dissecans, Sickle cell anaemia.</td>
</tr>
<tr>
<td>Developmental and other Bone disorders</td>
<td>DDH, SUFE, Fibrous dysplasia (McCune Albright syndrome), Skeletal dysplasias, Limb length discrepancies</td>
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<tr>
<td>Metabolic</td>
<td>Rickets</td>
</tr>
<tr>
<td>Malignant</td>
<td>Ewing's Sarcoma, Osteosarcoma, Metastases (Neuroblastoma), Leukaemia,</td>
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Lymphoma, Langerhans cell histiocytosis (LCH)

Benign lesions
Osteoid osteoma, Osteoblastoma, Bone cyst, Chondroblastoma, Exostosis, Os

Neuromuscular disorders
Ataxia, Brain or spinal cord lesions, Cerebral palsy (subluxation/dislocation),

Miscellaneous
Haemophilia(Haemarthrosis), Hernias, Appendicitis

Other Discriminators and Red Flags

Pain worse at night is classical for osteoid osteoma, whilst pain and stiffness resulting from JIA is usually worse in the mornings. Pelvic and bilateral hip pain could be due to a diverse group of disorders including sacroilitis, spinal pathology, AVN, leukaemia, lymphoma and metastatic disease. Findings such as a palpable mass, continuous pain unrelated to movement and anorexia or weight loss should alert the clinician to the possibility of malignancy. Neurological symptoms, e.g. paraesthesiae and the presence of neurological signs should guide the imaging to include the spine.

Imaging in the setting of trauma

Physical examination and the clinical history may allow localisation of pain/injury to a specific area. Targeted radiographs in at least two planes are recommended. Unfortunately, in small children, it is common that the pain cannot be accurately localised to one focal area and this is further compounded by the patient's lack of verbalisation. In these instances, it may be necessary to obtain radiographs from the pelvis to feet. Tibial fractures, e.g. Toddler's fracture (fig.1) are one of the most common diagnoses in this setting. Follow-up radiography may be required in a proportion of patients with continued symptoms in spite of normal radiographs at initial presentation. This may yield for example subtle interval periosteal reaction.

Avulsion injuries involving the immature apophyses of the pelvis are relatively common injuries in athletic adolescents (fig. 2). These result from sudden eccentric contraction of muscle which exerts a distraction force on the immature apophysis where the tendon of the muscle attaches. Ultrasound is also a useful modality in the setting of injury to the muscle and tendon unit.

Imaging and infection

Limping in the presence of one or more of the following clinical/laboratory signs should suggest the possibility of infection (3,4):
• Fever
• Elevated white cell count
• Elevated ESR
• Elevated C-reactive protein

The differential diagnoses in this scenario most commonly include septic arthritis, transient synovitis, osteomyelitis, discitis, and psoas abscess. Neoplastic entities, e.g. leukaemia, osteosarcoma, Ewing's sarcoma and metastases (neuroblastoma) also need to be considered.

Radiographs of the localised area of pain should be obtained. Irregular ill-defined lucencies and periosteal reaction may be seen in both infection and neoplasia. A soft-tissue mass and calcification without a history of trauma suggests the presence of a neoplasm.

If the pain appears localised to the hip, the diagnosis of exclusion is septic arthritis. Hip ultrasound allows quick and accurate diagnosis of a joint effusion. Aspiration and subsequent gram stain and microbiological analysis of the aspirate is the gold standard for differentiating between septic arthritis and transient synovitis.

In cases of osteomyelitis, radiographs are of limited value especially in the evolutionary stage. MRI, is extremely useful in this scenario. Findings include abnormal bone marrow signal, soft-tissue inflammation, abnormal enhancement and intraosseous, subperiosteal, and/or soft-tissue abscess formation. Gadolinium administration may increase the radiologist's confidence in diagnosing infection but we rarely find this necessary in our institution. Bone scans may prove to be a second-line investigation in this setting if for some reason MRI is not possible.

**Imaging in other settings**

**Inflammatory disorders**

Acute transient synovitis represents the most common cause of non-traumatic hip pain in young children aged between 2-9 years (5). The child is usually systemically well and presents with an acutely painful hip effusion. There is usually an antecedent history of an acute viral illness. Ultrasound can be used to identify an effusion and synovial thickening, but cannot reliably differentiate this from a septic arthritis (3) (fig. 5). An aspiration performed simultaneously can be diagnostic and therapeutic. No other imaging is usually required.

Juvenile Idiopathic Arthritis (JIA) may affect the hip or sacro-iliac joints and is frequently bilateral. Presentation is usually in children aged above 4-5 years (6). Radiographs may show erosions and loss of joint space (7). MRI and ultrasound are more sensitive for soft tissue changes and early diagnosis of disease, allowing demonstration of synovitis,
distinguishing pannus from simple effusion and for the identification of erosions (8,9) (fig. 6)

Pigmented villonodular synovitis is rare but can be seen in childhood (10). Synovial thickening and effusion cannot be distinguished from other causes. A biopsy is required for diagnosis.

Avascular Necrosis

AVN of the femoral head is a condition caused by altered blood supply to the epiphysis which results in progressive destruction of bone. It may follow trauma, infection, chemotherapy and steroid treatment, and sickle cell anaemia (10,11). The idiopathic form, commonly encountered in boys aged 4-10 years, is known as 'Perthes' disease (12). (fig. 7)

Radiography is insensitive at detecting very early change. Findings in the more advanced stage of the disease include fragmentation, flattening and sclerosis of the epiphysis. The 'crescent sign' denotes sub-chondral collapse. (fig. 8) However, MRI has much higher sensitivity in diagnosing and detecting the extent of AVN (13). The typical low signal intensity band in a sub-cortical location is best seen on coronal T1W images.(fig. 9)

Neoplasia

A) Benign Lesions

Osteoid osteoma is a benign skeletal neoplasm, which predominantly occur in the long bones of the lower extremity in children and young males. A history of nocturnal pain with dramatic relief of symptoms with salicylates is typical. Most cases are cortically based and the characteristic radiolucent nidus with surrounding dense reactive sclerosis is seen on radiography. Sub-cortical and intramedullary osteoid osteoma are comparatively less common, with the hip being the commonest site involved (1). These lesions do not induce sclerosis and thus are rarely visible on radiographs (14). CT has high sensitivity for nidus detection and may be required in difficult cases (15) (fig 10). Radionuclide bone scintigrapy is also very sensitive for the detection of osteoid osteoma and shows a double density sign, central intense isotope uptake area in keeping with the nidus, within the area of increased tracer activity (16). The appearances on MRI are rather non-specific.

Other benign tumours including aneurysmal bone cyst, simple bone cyst, chondroblastoma, exostosis and osteoblastoma are other common benign lesions seen in and around the pelvis and hip.

B) Malignant Lesions

Osteosarcoma and Ewing's Sarcoma are the commonest primary malignant bone tumours in children (17). Osteosarcomas are predominantly sited within the metaphysis
of long bones, while Ewing's sarcoma more commonly affects the diaphysis and flat bones of pelvis (18). Radiographic features are usually suggestive of a malignant or aggressive process (19,20). MRI is the modality of choice for assessment of tumour size, bone destruction, local staging and involvement of the soft tissues (21) (fig. 11). Bone scintigraphy can be used to detect distant metastatic lesions (22).

Multiple focal skeletal lesions in children raise the suspicion of a more diffuse process such as metastases, e.g. neuroblastoma, lymphoma, leukaemia (fig. 12) or Langerhans cell histiocytosis (fig. 13)

Developmental & other bone disorders

SUFE is a common hip disorder seen partcularly in tall or overweight adolescent boys aged between 12-15 years (23). It results in posteroomedial displacement of the femoral epiphysis from the metaphysis. It may be bilateral but is rarely symmetrical. Appearances include widening of the growth plate with apparent reduction of the height of the epiphysis. "Klein's line", a line drawn along the lateral cortex of the femoral neck, does not intersect the femoral epiphysis (24). The postero-medial slip of the epiphysis is best appreciated on a frog-leg lateral view (fig. 14). SUFE may result in the later development of osteoarthritis.

DDH is usually diagnosed in the neonates using the 'Graf method' on ultrasound (beyond the scope of this exhibit). Patients may however present late with hip pain and limp, at which time there may be associated hip dislocation, dysplasia and deformity with leg length discrepancy. Ultrasound in this age group is limited as the femoral head becomes progressively ossified over 6 months of age (25). Radiographs are therefore used for diagnosis in this age group.(fig. 15)

Pathological fracture may be the presenting feature of a previously undiagnosed underlying disorders such as osteogenesis imperfecta, skeletal dysplasia, or fibrous dysplasia (FD) (26,27). FD may be mono/polostotic, and causes underlying bone fragility. This may result in acute fracture or multiple successive cortical micro-fractures producing bowing of the proximal femur and "Shepherd's crook" deformity. (fig.16) Radiographs are usually sufficient to make the diagnosis, although CT can provide detailed information on the texture of the bone and extent of the lesion (28).

Metabolic & Nutritional Disorders

Rickets, a disorder of vitamin D metabolism, results in deficient bone mineralization. Radiographic changes are classical and include cupping and fraying of the metaphysis, widening of the physis and irregularity and enlargement of the epiphysis with frayed physeal borders (29). Patients may present with hip pain or limp, which may be due to associated insufficiency fractures/looser's zones in older children (fig. 17) Other rarer causes of inadequate mineralization include hypophosphataemic rickets in which hip pain as a result of deformity may be the presenting feature (fig. 18)
Imaging pathway

In our institution we have found the following imaging pathway (Table 1) useful. It is used in children under five years of age who present with hip pain, limp or refusal to weight bear. It serves as a simple aide memoire and ensures optimal investigation of the child.

Images for this section:

Fig. 1: 20 month old child with undisplaced spiral fracture of the distal tibia.
**Fig. 2:** Avulsion injury of the right ischial tuberosity (biceps femoris attachment).
Fig. 3: Septic arthritis. A 17 month old child being unwell and reluctant to use the right leg. Echogenic effusion & synovitis is noted on ultrasound of the right hip.
**Fig. 4**: Osteomyelitis. MRI (PD fat sat axial image). High signal intensity noted in the left adductor muscles and left pubic bones.
Fig. 5: Transient synovitis. Sagittal oblique ultrasound of the hip in a 5 year old with transient synovitis. Note the anechoic effusion and synovial thickening.
**Fig. 6:** Juvenile idiopathic arthritis. AP pelvis X ray of an adolescent girl: Both sacroiliac joints show erosions and sclerosis, worse on right (arrow).
Fig. 7: Perthes disease of the left hip. Note the sclerotic and flattened appearance of the left femoral epiphysis.
Fig. 8: Avascular necrosis. AP pelvis of an adolescent patient: The left femoral epiphysis is slightly irregular and flattened. This patient was on steroids for acute lymphocytic leukaemia.
Fig. 9: Avascular necrosis. T1 weighted image shows serpiginous low signal bands in the sub-chondral bone bilaterally. Further, low signal intensity areas in both proximal femoral diaphysis are due to bone infarcts
**Fig. 10:** Osteoid Osteoma. An adolescent patient presented with nocturnal hip pain. Axial CT scan showing a lucent nidus with central calcification surrounded by sclerosis in the superior pubic ramus.
Fig. 11: Ewing’s Sarcoma Pelvic X ray of an 11 year old child. A Destructive lesion with moth eaten appearance is noted in the right iliac bone (asterix). MRI of the same patient showed heterogeneous signal intensity in soft tissue along with abnormal right iliac bone.

Fig. 12: Leukaemia (Acute lymphocytic leukaemia) AP pelvic x ray of an unwell adolescent with pelvic pain. Multiple lytic lesions are noted diffusely involving the pelvis & proximal femora bilaterally.
Fig. 13: Langerhans Cell Histiocytosis (LCH) AP pelvis in a 12 old month old child reluctant to use the right lower limb. Extensive sclerotic and lucent lesions (asterix) are seen in the right iliac bone. A lucent lesion is also noted in the right proximal femur (arrow).
**Fig. 14:** SUFE: Frog leg lateral radiograph of an 11 year old boy with slipped upper femoral epiphysis of the left hip. Note widening of the physis and posteromedial slip of the femoral head epiphysis.
Fig. 15: Late presentation of Developmental Dysplasia of Hip (DDH): X ray pelvis of a 3 year old child with "waddling gait". There is superolateral displacement of femur with shallow acetabulum. The ipsilateral femoral epiphysis is smaller in size.
Fig. 16: Polyostotic Fibrous Dysplasia (McCune Albright's Syndrome): Ground glass appearance of proximal femora bilaterally with medullary expansion and endosteal scalloping seen on plain radiograph of a young patient. There are multiple insufficiency fractures bilaterally in the proximal femora.
Fig. 17: Rickets: X ray pelvis of a 20 month old child shows generalised osteopenia of the proximal femora, presence of looser's zones and periosteal reaction. The outlines of epiphyses are irregular with fraying of both physeal plates.
Fig. 18: Hypophosphatemic rickets: AP pelvic X ray of an adolescent showing diffusely osteopenic bones with a coxa vara deformity.
Scheme for imaging children under 5 years unable to weight bear / to move limb

Child with hip pain/unable to weight bear/move limb

Persistent Symptoms  Symptoms improve

- Conventional Radiography

  Abnormal  Normal
  
  Abnormal  Normal

  Effusion  Sonography
  
  Subluxation of epiphysis, ruling out fracture planes

  Effusion  No Effusion

  Other signs  Imaging as indicated by radiographic signs

  Well child  Unwell child  Persistent symptoms

  Transient synovitis  Septic arthritis  Localising to hip  Not localising

  Consider therapeutic aspiration

  This is an emergency. Liaise with surgeons for washout or aspiration

  Abnormal  Normal  Normal  Abnormal

  Bone Scintigraphy

  MRI

  Whole limb X-ray
Conclusion

The paediatric patient presenting with persistent hip pain and/or limp needs clinical and radiological partnership to ensure a timely diagnosis. The radiologist's role is crucial in leading the patient on this imaging journey.

References


2. Foster K. The limping child. *Imaging* 2004; 16; 153-160


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