

Pictorial Review

Radiological approach to a child with hip pain

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Hip pain in a child can be a diagnostic challenge partly because of barriers to communication in the paediatric age group. Pain or limp may result from infective, inflammatory, traumatic, neoplastic, or developmental causes. A meticulous history and detailed clinical examination guide the radiological investigation in the appropriate direction. The age of the child further helps to narrow the differential as certain diseases are more common in certain age groups. In most patients plain radiograph and/or ultrasound is adequate. Ultrasound has the added advantage of being real time and can be used to guide aspiration. Magnetic resonance imaging (MRI) and bone scintigraphy can be used for problem solving, looking for multifocal disease, and staging. Computed tomography (CT) has a limited role to play because of the risks associated with ionizing radiation. In this review we discuss the approach to imaging a child who presents with pain in the hip or with a limp. The various common and rare, but important, diseases are illustrated with examples from our clinical practice.

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Introduction

Hip pain in a child can arise from the hip itself or from remote sites including the spine, abdomen, pelvis, or knee. This, in addition to the barriers to communication in childhood, poses a diagnostic challenge to the clinician. Meticulous history taking, careful clinical examination, and laboratory tests may narrow the differential, but imaging is usually required to locate the cause and guide management. Conventional radiography remains the most commonly used imaging tool followed by ultrasound. Cross-sectional imaging and bone scintigraphy are helpful for problem solving or to demonstrate the extent or stage of disease.

In this paper we review various disease entities that may present with hip pain or limp in children and discuss pathways for appropriate imaging relating to different age groups and diseases.

Common causes and presentation of hip pain in children

The causes of paediatric hip pain vary with age. Although septic arthritis, osteomyelitis, trauma, and neoplastic causes should be sought in every age group, other common diagnoses should be considered with the age of the patient in mind¹ (Table 1).

Infants and toddlers often present with refusal to weight bear or reluctance to use the limb, with little in the way of localizing symptoms and signs. Transient synovitis of the hip, undiagnosed developmental dysplasia of the hip (DDH), and non-accidental injury (NAI) should be considered in this group. When hip or pelvic causes are excluded, it may be necessary to image the whole limb to locate distal disease processes.

In older children, localization of symptoms generally becomes easier with the majority of disease entities arising from the hip or pelvis. In children between 4 and 10 years of age transient synovitis, Legg–Calve–Perthes (Perthes') disease, and juvenile idiopathic arthritis (JIA) form important differentials. In the adolescent age group, common

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Table 1

Common causes of hip pain/limp according to age group of patients.

0–4 years	4–10 years	More than 10 years
Transient synovitis	Transient synovitis	SUFE
Septic arthritis	Septic arthritis	Sports injuries
Toddler's fracture	Perthes' disease	JIA
Osteomyelitis	Osteomyelitis	Septic arthritis
DDH	JIA	Osteomyelitis
Tumour	Tumour	Tumour

causes include slipped upper femoral epiphysis (SUFE) and sporting injuries.

Findings, such as a palpable mass, continuous pain unrelated to movement, and anorexia or weight loss, should increase suspicion of malignancy, whereas neurological signs should guide imaging to include the spine. Pain worse at night is classical for osteoid osteoma, whereas pain resulting from JIA is usually worse in the mornings. Bilateral hip or pelvic pain could be due to a multitude of causes ranging from arthritis, including sacroiliitis (Fig 1), spinal disease, avascular necrosis (AVN), and dysplasias, to more diffuse bone disease, such as leukaemia, lymphoma, and metastatic disease. A surgical sieve approach^{1–4} to diagnosis is illustrated in Table 2.

Investigation pathway

If the child is clinically unwell or has signs of infection, the priority is to exclude septic arthritis. If symptoms are transient, and there are no concerns of infection or malignancy often no further imaging is required. Where symptoms persist, conventional radiography is the initial investigation of choice and is frequently the only imaging technique required. Anteroposterior (AP) views of both hips (+/- lateral) are standard, along with frog-leg lateral views of the pelvis (AP view with hips in abduction and external rotation) instead of the standard lateral view when the differential includes SUFE or Perthes' disease. Imaging both hips is recommended as many common paediatric hip

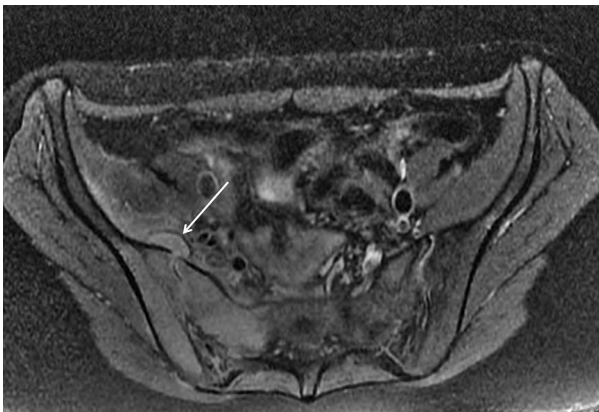


Figure 1 Infective sacroiliitis and abscess. Proton-density, fat-saturated axial MRI image of a young child with right hip pain and initial normal pelvic radiograph shows oedema on both sides of right SI joint and in the iliacus muscle. There is a small collection (arrow) anterior to the SI joint in keeping with an abscess.

Table 2

Surgical sieve approach to hip pain/limp in paediatric patient.

Traumatic	Fractures (displaced and undisplaced; Fig. 3) and avulsion injuries, ligamentous or musculo-tendinous injuries, contusions, stress fractures, toddler's fracture, NAI
Inflammatory	Acute transient synovitis, juvenile idiopathic arthritis, juvenile dermatomyositis, PVNS, myositis
Infective	Septic arthritis, osteomyelitis, discitis, epidural abscess, psoas abscess, appendicitis, soft-tissue abscess
Avascular necrosis (AVN)	Legg–Perthes' disease, osteochondritis dissecans, sickle cell anaemia
Developmental and other Bone disorders	Developmental dysplasia of the hip (DDH), slipped upper femoral epiphysis (SUFE), fibrous dysplasia (McCune–Albright syndrome), skeletal dysplasias, limb length discrepancies
Metabolic	Rickets (looser's zones)
Malignant	Ewing's sarcoma, osteosarcoma, metastases (neuroblastoma), leukaemia, lymphoma, Langerhan's cell histiocytosis (LCH)
Benign lesions	Osteoid osteoma, bone cyst, chondroblastoma, exostosis, osteoblastoma
Neuromuscular disorders	Ataxia, brain or spinal cord lesions, cerebral palsy (subluxation/dislocation),
Other	Haemophilia (haemarthrosis), hernias

disorders are bilateral, although rarely symmetrical, and comparison with the other hip may prove useful in detecting subtle subchondral changes, such as in early Perthes' disease. If two views are to be obtained, the first AP radiograph should be performed without gonadal protection to allow complete evaluation of the remainder of the pelvis, whereas protection should be used for the second frog-leg view. Radiographs are sensitive for detection of fractures, benign and malignant lesions, but less so for early bone destruction or necrosis. They will not detect joint effusions unless they are large, resulting in displacement of fat planes, and are also inadequate at evaluating cartilage and soft tissue.²

Ultrasound is the most common imaging method for a suspected hip effusion. A high-frequency linear probe should be used in the sagittal plane anterior to the femoral neck; comparison with the normal side can be invaluable in assessing small effusions and minor synovial thickening. Unfortunately, ultrasound cannot confidently distinguish reactive effusion from infection, or assess the underlying bone, but it can be used to guide both diagnostic and therapeutic aspiration.

Magnetic resonance imaging (MRI) is excellent for visualizing joints, soft tissues, cartilage, and bone marrow. It has high sensitivity and specificity, and is very useful for confirming osteomyelitis, delineating the extent of malignancies, identifying subtle stress fractures, and diagnosing early Perthes' disease or AVN.^{3,4} At least one fluid-sensitive sequence should be performed with a wide field of view to include the pelvis and other hip for comparison; this can be helpful in excluding inflammatory conditions arising from the sacroiliac (SI) joints or spine, which may result in referred pain to the hip and also to detect inflammation elsewhere in the pelvis such as appendicitis or psoas

Table 3

Take home points.

- A meticulous history and detailed clinical examination is necessary to narrow the differential diagnoses
- Suspected septic arthritis should be investigated as an emergency
- Plain film +/- ultrasound remains the main stay of investigation for hip pain in children
- MRI is the next imaging investigation if symptoms localize to hip and pelvis. At least one fluid sensitive sequence should be performed with a wide field of view to include the other hip, pelvis and lower lumbar spine
- Once hip/pelvic causes are excluded bone scintigraphy helps to localize distant/multifocal disease

MRI, magnetic resonance imaging.

abscess. Use of gadolinium can help in differentiating an effusion from synovitis and identifying cystic elements within a solid tumour but we find its use rarely necessary in our practice. Whole body MRI is a useful tool in detecting multifocal disease with the added advantage of lack of

radiation and comparable sensitivity to bone scintigraphy.⁵ As acquisition times are long, sedation or general anaesthesia is frequently required in younger patients to reduce movement artefact.

Bone scintigraphy has an important role in localizing disease, especially when pelvis or hip disease is excluded, and also in the assessment of multifocal disease entities such as NAI, osteomyelitis, and metastatic disease.³ Although the entire skeleton can be imaged simultaneously and it has high sensitivity, the specificity is low. As with MRI sedation is often required in younger children.

Computed tomography (CT) is of limited value because of the risks associated with ionizing radiation. Therefore, its use is limited to assessment of complex bone lesions or identification of a nidus in suspected osteoid osteoma.

Important diagnostic points have been summarized in Table 3. The flow chart (Fig 2) can serve as an *aide memoire* in investigating a young child with hip pain/limp.

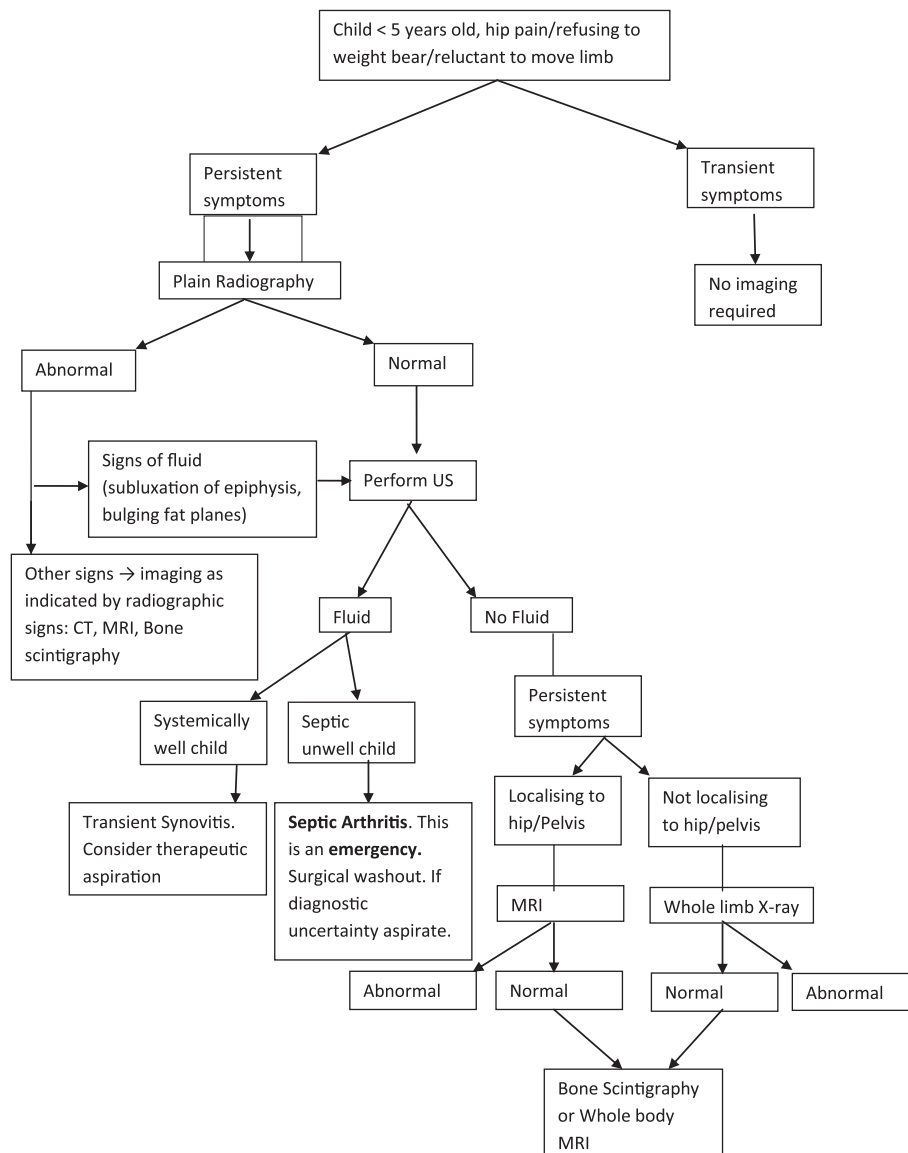


Figure 2 Imaging pathway for children under 5 years refusing to weight bear/reluctant to move limb.

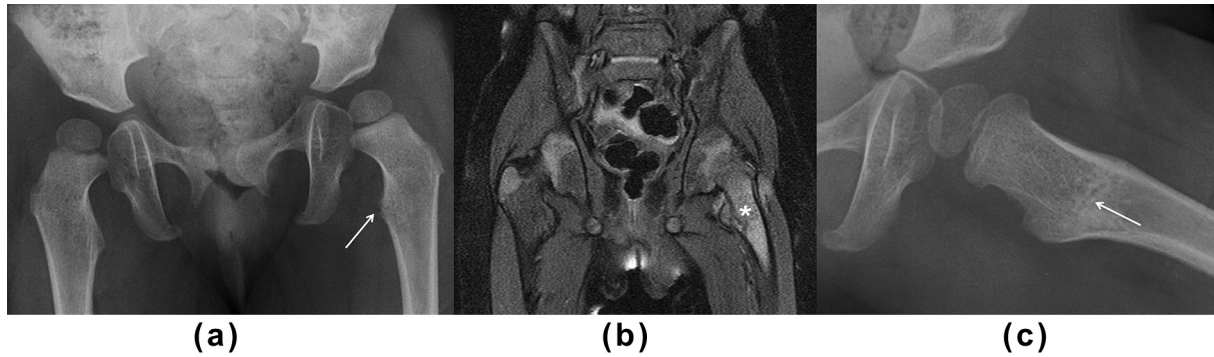


Figure 3 Undisplaced fracture. A young child presented after minor trauma. (a) AP pelvic radiograph shows slight irregularity (arrow) of left lesser trochanter. (b) Proton-density, fat-saturated coronal MRI image showing bone marrow oedema (asterisk) in the trochanteric region and a subtle breach in cortex. (c) Follow-up radiograph confirms a healing undisplaced fracture (arrow).

Traumatic causes

An appropriate history is usually available in the majority of patients presenting with traumatic injury. In young children, where there is no clear history of trauma, and depending on fracture configuration and site, NAI may need to be considered. Further discussion of NAI is beyond the scope of this article. Injuries such as tibial toddler fractures may occur with minor injury and due to difficulties in localization may require several imaging investigations.

In adolescents, injuries relating to sporting activities become more common especially apophyseal avulsions [from iliac crest, iliac spines (Fig 4), trochanters, or ischial tuberosity]. Plain radiographs are often diagnostic. MRI is excellent at assessing bone, tendon, and soft tissue, although ultrasound can also be used.⁶

Stress fractures of the femoral neck can occur in athletic teenagers⁷ as a result of repetitive force applied to normal bone.⁸ Plain radiography has low sensitivity especially in the first 2–3 weeks, whereas MRI and bone scintigraphy have sensitivity of up to 100%.⁹

Inflammatory causes

Acute transient synovitis is the most common non-traumatic cause of hip pain in young children. It tends to



Figure 4 Avulsion injury. Radiograph of an athletic adolescent shows avulsion of the anterior inferior iliac spine.

affect children between 2–9 years of age and boys are affected two- to four-times more often. The child is usually systemically well with an acutely painful hip effusion, which may follow an acute viral illness. Where history is typical no imaging may be required; ultrasound can be used to identify the effusion (Fig 5), although is unable to differentiate from septic arthritis.¹⁰ An aspiration performed simultaneously can be diagnostic and therapeutic. MRI is rarely needed but shows a simple joint effusion with no marrow changes.¹¹

JIA may affect the hip or SI joints and may be unilateral, but is frequently bilateral.¹² Presentation is usually in children above age 4–5 years of age. Radiographs may show erosions and loss of joint space (Fig 6).¹³ MRI and ultrasound are more sensitive for soft-tissue changes and early diagnosis of disease, allowing demonstration of synovitis, distinguishing pannus from simple effusion (Fig 6c), and identifying cartilage destruction and cortical erosions.¹⁴

Pigmented villonodular synovitis is rare, but can be seen in childhood.¹⁵ Synovial thickening and effusion cannot be distinguished from other causes and biopsy is required for diagnosis.

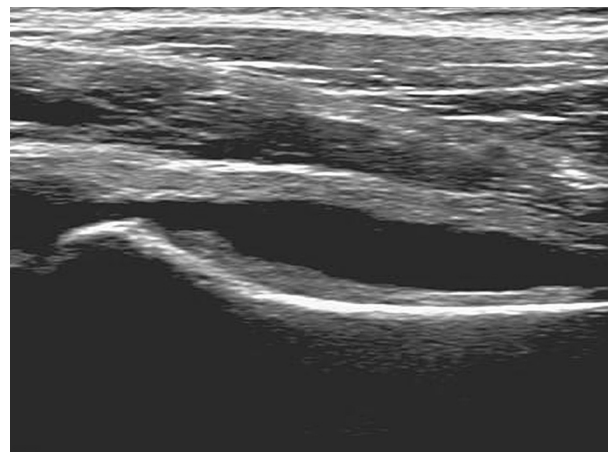


Figure 5 Transient synovitis. Hip ultrasound image of a 5-year-old showing anechoic effusion and synovial thickening in keeping with transient synovitis.

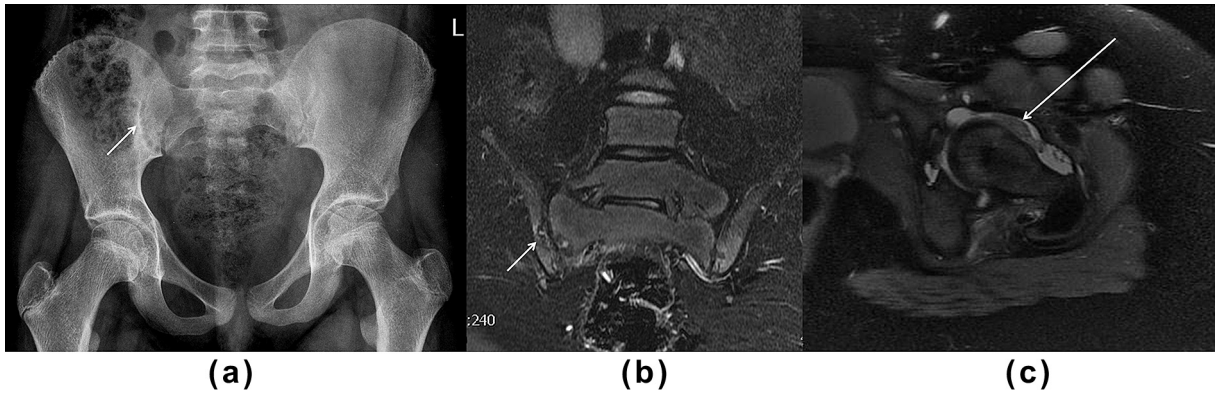


Figure 6 JIA. An adolescent female presented with left hip pain. (a) AP pelvic radiograph shows normal hip joint but sclerosis and erosive changes in bilateral SI joints. (b) Proton-density, fat-saturated coronal MRI image confirms the erosive changes of bilateral SI joint worse on the right (arrow). (c) Short-tau inversion recovery (STIR) axial MRI image showing effusion and pannus (arrow) in the left hip.

Infective causes

Septic arthritis is an emergency. The majority of patients are less than 2 years old¹⁶ and are usually unwell with pain on passive movement of the hip. Delay in diagnosis, particularly in the young child, can result in rapid joint destruction and permanent deformity. Radiographs may

demonstrate displaced fat planes or subluxation in a large effusion (Fig 7). There may be features of associated osteomyelitis. Ultrasound demonstration of joint effusion in an unwell child with raised inflammatory markers is highly suggestive of septic arthritis. Depending on the degree of clinical suspicion, the patient may require ultrasound-guided aspiration or proceed straight to surgical joint

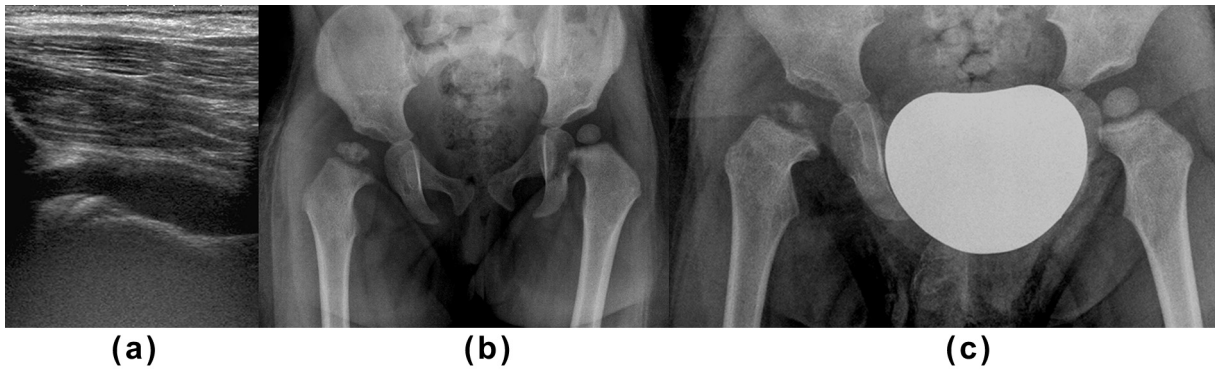


Figure 7 Septic arthritis. (a) Oblique sagittal ultrasound of the hip of a 17-month-old child with septic arthritis shows an echogenic effusion and synovitis. (b) AP radiograph of the pelvis in the same patient shows a large effusion with displaced fat planes, early destruction of the right femoral epiphysis with subluxation. There is irregularity of the metaphysis (infection crosses growth plate) and also irregularity of the acetabular roof. (c) Interval radiograph after 2 weeks shows more marked destruction of the right femoral head epiphysis.

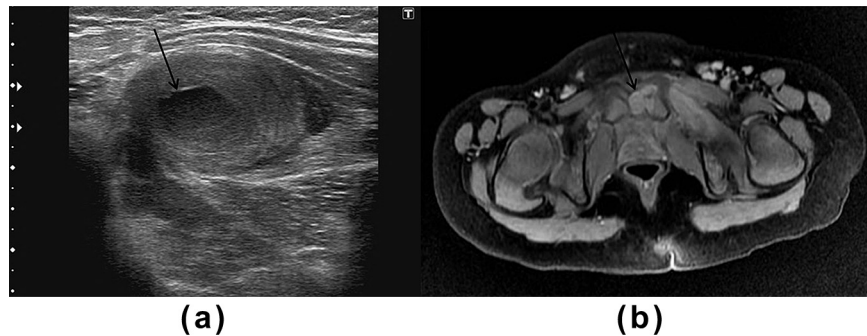


Figure 8 Osteomyelitis. A 2-year-old child presented with hip pain and sepsis. Ultrasound of the hip joint did not show any effusion in the joint. (a) A thick-walled collection (arrow) was seen in the adductor region. (b) Proton-density, fat-saturated axial MRI image shows oedema in the adductor muscles, high signal in the left pubic bone, and a collection (arrow) in the symphysis pubis in keeping with osteomyelitis and abscess.

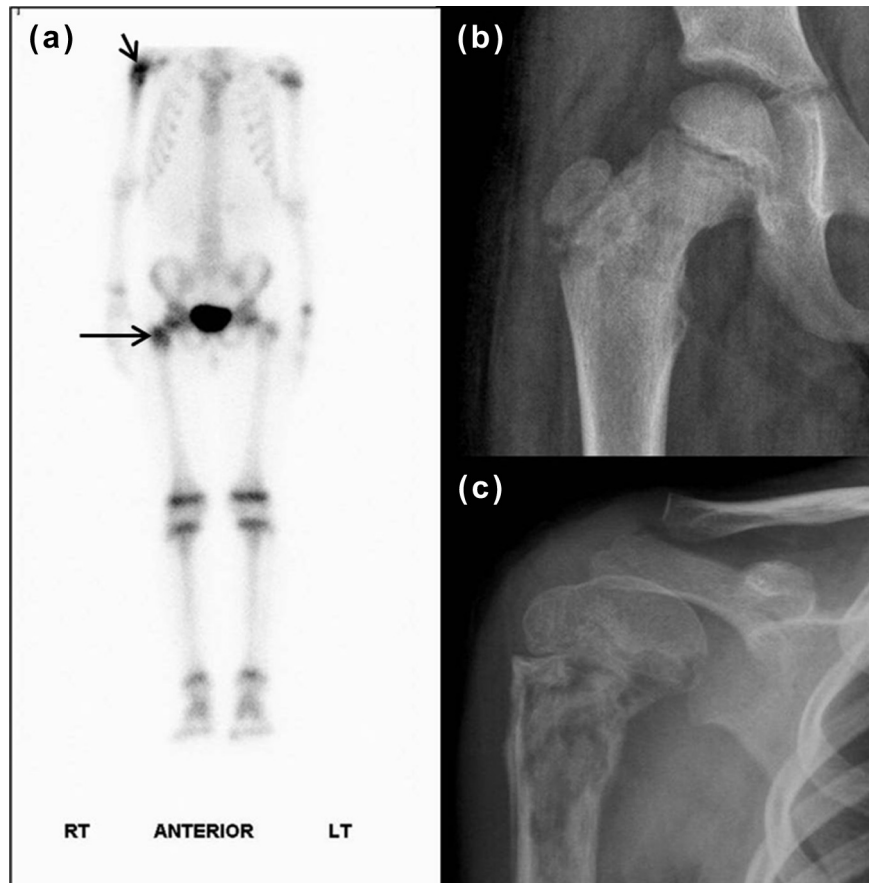


Figure 9 Multifocal osteomyelitis. A 5-year-old child presented with right hip pain and normal radiograph of the pelvis. (a) Bone scintigraphy showed increased tracer uptake in the proximal femur on the right (long arrow) and also in the right humerus (short arrow), which was asymptomatic. (b) Subsequent radiograph of the right hip in 10 days showed an ill-defined destructive lesion in the proximal femoral metaphysis. (c) Radiograph of the right humerus showing the humeral lesion.

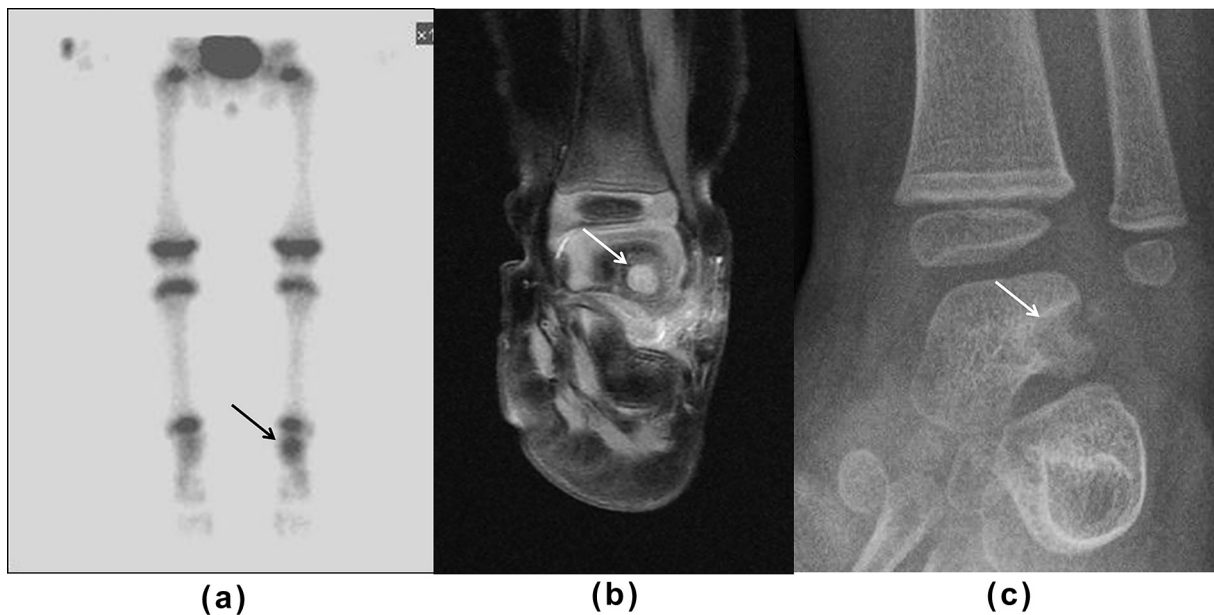


Figure 10 Talar osteomyelitis. A 14-month-old child presented with a limp. The whole limb radiographs were normal. (a) Bone scintigraphy was then performed for localization of the disease, which showed increased tracer uptake in the left talus (arrow). (b) Proton-density, fat-saturated coronal MRI image shows focal collection in the talus (arrow) with oedema in the subtalar space. (c) Subsequent radiograph in the healing phase shows a defect in the talus (arrow) with surrounding sclerosis.

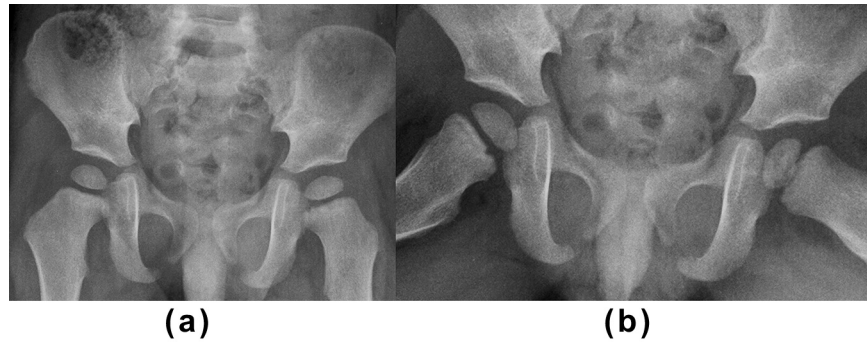


Figure 11 Legg–Calve–Perthes' disease. (a) AP radiograph of the pelvis in a 7-year-old male patient shows subtle irregularity of the left femoral epiphysis. (b) Frog-leg lateral view performed at the same time shows the marked sclerosis and irregularity of the left femoral head.

wash out. Absence of fluid usually excludes septic arthritis.¹⁷ MRI is rarely needed, but has a role in assessing associated osteomyelitis.¹⁸

Osteomyelitis usually affects the metaphyses of long bones, but can extend to involve the epiphysis in young children as a consequence of vessels crossing the growth plate. It may also involve the pelvis and spine, which may result in referred pain to the hip.¹⁹ Early diagnosis and treatment can prevent long-term complications, such as bone necrosis and long-term deformity. Conventional radiography is insensitive to early disease. Periosteal thickening, osteopenia, or loss of normal architecture usually does not become apparent for at least 7–10 days.²⁰ MRI is the imaging technique of choice for diagnosing osteomyelitis due to its high sensitivity and specificity for the detection of early bone marrow change, abscess formation, or soft-tissue extension; the latter may also be shown on ultrasound (Fig 8).²¹ Isotope imaging, with its large field of view, plays an important role in diagnosing multifocal osteomyelitis (Fig 9) and may also identify foci far remote from site of concern (Fig 10).

AVN

AVN of the femoral head is a condition induced by compromised blood supply resulting in progressive destruction of bone. It is most commonly idiopathic (Perthes') but

may be seen following trauma, infection, steroid treatment, and in association with haematological diseases, such as sickle cell anaemia.²² Perthes' disease usually affects children between 4–10 years of age, and is more common in boys.²³ Plain radiography is insensitive at detecting very early changes. The epiphysis may appear small, sclerotic, or flattened with subchondral lucency or more marked fragmentation (Fig 11). Findings, such as sub-chondral collapse, "crescent sign" (Fig 12b), and sclerosis can be subtle and are often better demonstrated on frog-leg lateral view, which should be mandatory. MRI provides more precise localization and extent of involvement and has the highest sensitivity in diagnosing and detecting extent of AVN.²⁴ It enables evaluation of position and size of the femoral head, which is incompletely ossified in this age group.²⁵ A low signal intensity subcortical band is best seen on coronal T1-weighted images (Fig 12c). The disease is bilateral in 10–20% of patients, but is usually metachronous. Where bilaterally symmetrical changes are seen, other disorders, such as hypothyroidism, epiphyseal dysplasias (Fig 13), or alternative underlying causes for AVN should be considered.

Benign tumours

Osteoid osteoma is one of the commonest benign skeletal neoplasms. It predominantly occurs in the long bones

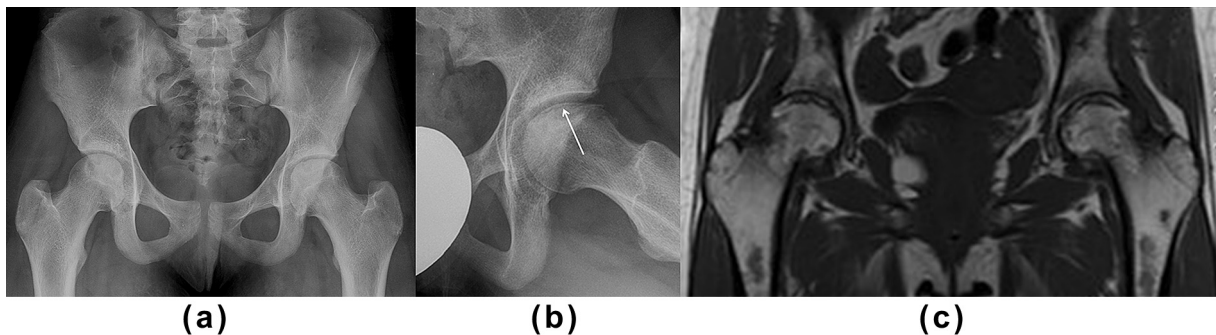


Figure 12 AVN. An adolescent child treated with steroids for acute lymphocytic leukaemia and hip pain. (a) AP radiograph of the pelvis shows subtle irregularity and flattening of the epiphysis on the left. (b) Frog-leg lateral view performed at the same time demonstrates subchondral lucency, the "crescent sign" (arrow). (c) T1 coronal MRI image shows bilateral low-signal subchondral bands along with bone infarcts in the proximal femoral diaphysis bilaterally.



Figure 13 Epiphyseal dysplasia. AP radiograph of an adolescent child shows bilateral symmetrical irregularity and flattening of the epiphysis in keeping with epiphyseal dysplasia.



Figure 15 Simple bone cyst with a fracture. A 9-year-old child presented with left hip pain. Plain radiograph demonstrated a previously undiagnosed simple cyst in the intertrochanteric region with a pathological fracture (arrow) through the lateral edge of the lesion.

of the lower extremity in children and young males between 5–30 years of age.²⁶ A good history of night pain and relief with salicylates narrows the differential, which is further supported by imaging. Most cases are cortically based with a characteristic radiolucent nidus and surrounding area of dense reactive sclerosis. Intramedullary osteoid osteoma are comparatively less common, with the hip being the commonest site involved¹ These lesions do not induce sclerosis and thus are rarely visible on radiographs.²⁷ Although MRI is often recommended in children to avoid unnecessary radiation exposure, the MRI appearance of nidus, particularly when small is very variable and appearances may be non-specific. CT has higher sensitivity for nidus detection (Fig 14) and may be required in difficult cases.²⁸ Bone scintigraphy is 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.²⁹

Aneurysmal bone cyst, simple bone cyst (Fig 15), chondroblastoma (Fig 16),³⁰ exostosis (which may be intra or

extra-articular),³¹ and osteoblastoma³² are other common benign lesions seen in and around the pelvis and hip.

Malignant tumours

Osteosarcoma and Ewing's sarcoma are the commonest primary malignant bone tumours in children.³³ Osteosarcomas are predominantly sited within the metaphysis of long bones, affecting slightly older children, whereas Ewing's sarcoma more commonly affects the diaphysis and flat bones of pelvis, and tends to occur in a younger age group.³³ Radiographic features are usually suggestive of a malignant or aggressive process (Fig 17a).³⁴ MRI is the

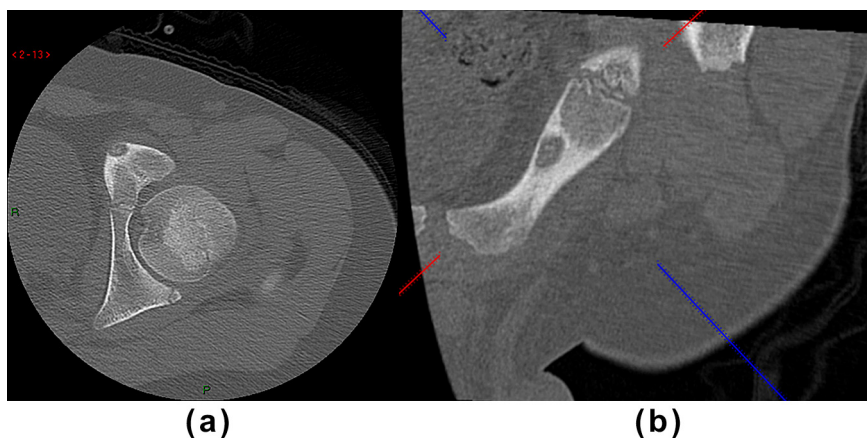


Figure 14 Osteoid osteoma. An adolescent child presented with night pains improving with salicylates. Radiograph (not shown) showed mild sclerosis of the superior pubic ramus on the left. CT images show sclerosis of the superior pubic ramus (a) with a lucent nidus and central sclerosis nicely seen on the multiplanar reformatted image (b). MRI (not shown) demonstrated diffuse bone oedema and the nidus was not identified.

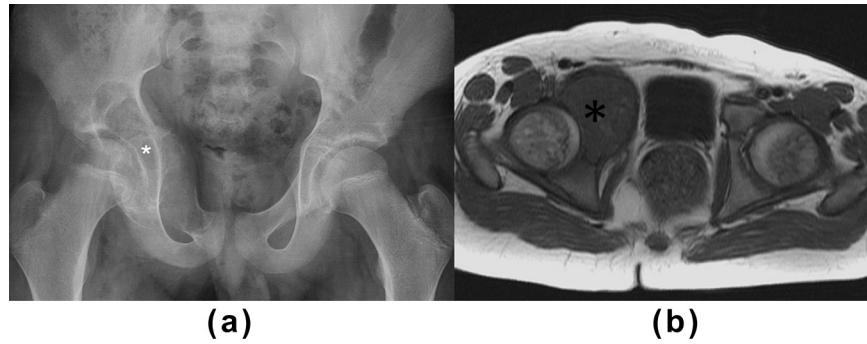


Figure 16 Chondroblastoma. (a) AP radiograph of the pelvis of a 12-year-old child showing a lucent, expansile lesion in the superior pubic ramus extending into the anterior column of the right acetabulum (asterisk). (b) MRI confirmed a well-defined, expansile, acetabular lesion (asterisk) extending into the pelvis.

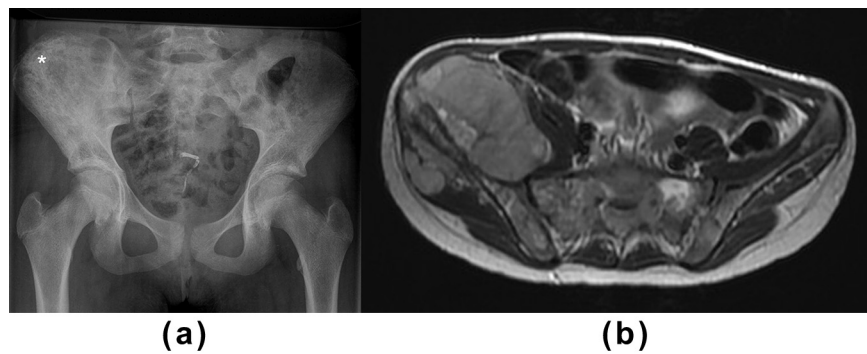


Figure 17 Ewing's sarcoma. (a) AP radiograph of an 11-year-old child shows a destructive lesion of the right iliac bone (asterisk) with a permeative and moth-eaten appearance with no obvious soft-tissue mass. (b) Axial T2-weighted MRI image shows that the radiographic abnormality was associated with a heterogeneous signal intensity large soft-tissue mass, which extended anterior and posterior to the right iliac bone. Extensive metastatic disease was also seen within the sacrum and the spine.

technique of choice for assessment of tumour size, bone destruction, local staging, and assessing soft-tissue involvement (Fig. 17b).³⁵ Bone scintigraphy can be used to detect distant metastatic lesions.³⁶

Multiple focal skeletal lesions in children raise the suspicion of a more diffuse process such as metastases (consider neuroblastoma in young children), lymphoma, leukaemia (Fig. 18a), or Langerhan's cell histiocytosis (LCH).

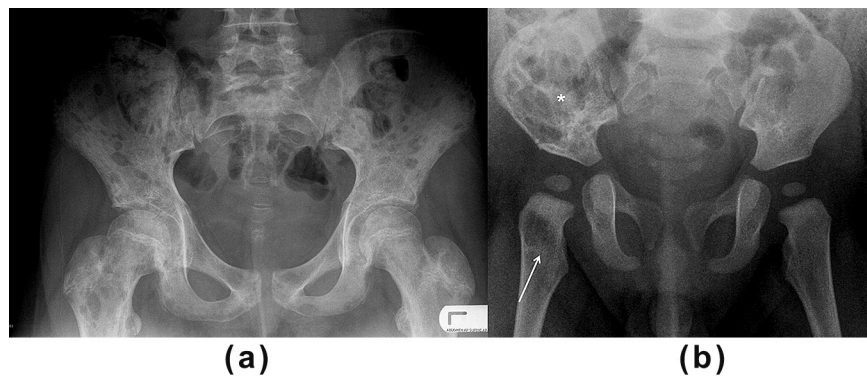


Figure 18 Aggressive bone lesions: leukaemia and LCH. (a) AP radiograph of the pelvis in an adolescent child with pelvic girdle pain and fever shows multiple osteolytic lesions throughout the pelvis and proximal femora. The patient was subsequently diagnosed with acute lymphocytic leukaemia. (b) Radiograph of the pelvis in a 1-year-old child reluctant to use the limb shows an extensive mixed sclerotic and lucent (bubbly) lesion (asterisk) with a well-defined sclerotic rim in the right iliac bone. There is a further lucent lesion in the right proximal femur with a wide zone of transition distally (arrow). These lesions were subsequently diagnosed as LCH.

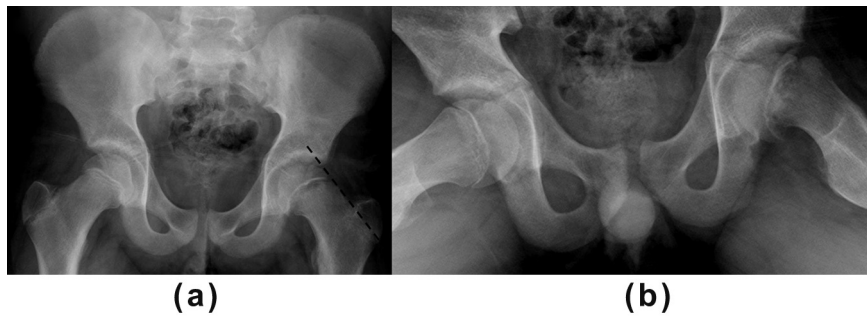


Figure 19 SUFE. (a) AP radiograph of the pelvis in an adolescent child with SUFE of the left hip. Note abnormal widening and blurring of the physis with Klein's line failing to intersect epiphysis. (b) Frog-leg lateral view of the hips in the same patient shows posteroinferior slippage of the left femoral epiphysis.



Figure 20 DDH. AP radiograph of the pelvis and femora in a 3-year-old child shows superolateral dislocation of the left hip. Note the dysplastic and shallow left acetabulum and the absence of ossification of the left femoral epiphysis.

LCH represents a spectrum of disorders affecting children of all ages, ranging from solitary bone lesions (eosinophilic granuloma) to multiple lesions and more diffuse skeletal and multisystem involvement.³⁷ Radiographic abnormalities include diffuse osteopenia; well-defined, benign-appearing lesions; and more destructive defects, which may be solitary or widespread (Fig. 18b).³⁸ Whole-body MRI and skeletal survey can help reveal multifocal sites of active disease.^{39,40} MRI is useful to assess bone marrow and soft-tissue involvement.⁴¹

Developmental and other bone disorders

SUFE is the commonest adolescent hip disorder and results from the posteromedial displacement of the femoral epiphysis from the metaphysis. Patients are usually between 12–15 years, boys are more commonly affected than girls, and are frequently taller or overweight.⁴² It may be bilateral in 20–30% of cases, but is rarely symmetrical. Presentation may be acute, with radiographic findings that can initially be subtle, making it essential to perform both AP and frog-leg lateral views for full assessment (Fig 19). Appearances include widening of the growth plate with



Figure 21 Rickets and hypophosphataemic rickets. (a) AP radiograph of the pelvis in a 20-month-old child refusing to weight bear and diagnosed with rickets shows diffuse osteopenia of the proximal femora with metaphyseal irregularity, looser's zone and periosteal reaction. There is blurring of the outline of the epiphysis and frayed physis bilaterally. (b) AP radiograph of the pelvis in a 14-year-old child with hypophosphataemic rickets presenting late with hip pain shows diffuse osteopenia and coxa vara deformity due to bone softening.



Figure 22 Polyostotic fibrous dysplasia. Presenting radiograph of the pelvis and femora of an 8-year-old child with polyostotic fibrous dysplasia showing shepherd's crook deformity, endosteal scalloping, expansile and ground glass appearance of both proximal femora, with multiple transverse insufficiency fractures (arrow showing one of the fractures) of the right proximal femoral diaphysis.

apparent reduction of the height of the epiphysis, visible medial slip, and loss of "Klein's line" (a line drawn along the lateral cortex of the femoral neck, which should intersect a segment of the superior epiphysis).⁴³ More chronic cases may present with complications or long-term sequelae such as AVN, hip deformity, or osteoarthritis.

DDH is usually diagnosed in early infancy, but patients may present late with hip pain and limp, at which time there may be associated hip dislocation, dysplasia, and deformity with leg length discrepancy (Fig 20). The femoral head becomes progressively ossified over 6 months of age, limiting the use of ultrasound.⁴⁴ Radiographs are used for

diagnosis in this age group, with the frog-leg lateral view important for evaluation of reducibility.

Metabolic and other bone disorders

Rickets is a disorder of vitamin D metabolism resulting in inadequate mineralization. Radiological changes are most evident within the metaphyses, which are the sites of most rapid growth, with classical appearances including metaphyseal widening, cupping and fraying. Irregularity and enlargement of the epiphysis with frayed physeal borders can also be seen.⁴⁵ Patients may present with hip pain or limp, which may be due to associated insufficiency fractures/looser's zones in older children (Fig 21a). Other rarer causes of inadequate mineralization include hypophosphataemic rickets in which hip pain as a result of deformity may be the chief complaint (Fig 22b).

Pathological fracture may be the presenting feature of a previously undiagnosed underlying disorder, such as osteogenesis imperfecta, skeletal dysplasia, or fibrous dysplasia (FD).⁴⁶ FD may be mono/polyostotic, 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 22). 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.⁴⁷

Other causes

Other hip/pelvic diseases that could result in pain include haemarthrosis (haemophilia), herniae (both inguinal and femoral),⁴⁸ neuromuscular disorders and soft-tissue disorders, such as juvenile dermatomyositis.⁴⁹ Often remote disease, such as psoas disease (abscess and tumour; Fig 23), pelvic abscess, and appendicitis, and spinal disease (discitis, epidural abscess⁵⁰) may present with hip pain.

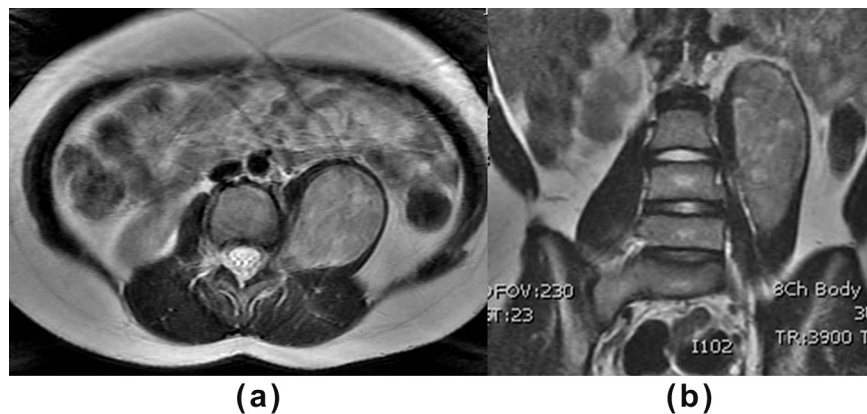


Figure 23 Neuroblastoma. A 6-year-old child presented with left hip pain. Ultrasound (not shown) showed a possible left paraspinal mass. (a) T2-weighted axial MRI image confirms the presence of a left paraspinal mass, extending into the neural foramina and displacing and splaying psoas laterally. (b) T2-weighted coronal MRI image shows left paraspinal mass displacing psoas. This was subsequently proven to be a neuroblastoma at biopsy.

Conclusion

Hip pain or rapid-onset limp in children is not uncommon. It results from many different diseases arising from the hip joint itself or referred from more remote sources. In this review we have illustrated the common and also some of the rarer causes that we have experienced in our practice. The radiologist should work very closely with the clinician to decide on the appropriate investigation pathway to arrive at a diagnosis. Therefore, it is vital for a radiologist to be familiar not only with the spectrum of diseases that can result in hip pain or limp in children, but also with the relative merits of each investigative method to arrive at a timely diagnosis.

References

- Myers MT, Thompson GH. Imaging the child with a limp. *Pediatr Clin North Am* 1997;**44**:637–58.
- Fordham L, Auringer ST, Frush DP. Pediatric imaging perspective: acute limp. *J Pediatr* 1998;**132**:906–8.
- Sawyer JR, Kapoor M. The limping child: a systematic approach to diagnosis. *Am Fam Physician* 2009;**79**:215–24.
- Flynn JM, Widmann RF. The limping child: evaluation and diagnosis. *J Am Acad Orthop Surg* 2001;**9**:89–98.
- Eustace SJ, Nelson E. Whole body magnetic resonance imaging. *BMJ* 2004;**328**(7453):1387–8.
- Bencardino JT, Kassarian A, Palmer WE. Magnetic resonance imaging of the hip: sports-related injuries. *Top Magn Reson Imaging* 2003;**14**:145–60.
- Lassus J, Tulikoura I, Kontinen YT, et al. Bone stress injuries of the lower extremity: a review. *Acta Orthop Scand* 2002;**73**:359–68.
- Polacek M, Smabrekke A. Displaced stress fracture of the femoral neck in young active adults. *BMJ Case Rep* 2010 Oct 6;**2010**.
- Murray SR, Reeder MT, Udermann BE, et al. High-risk stress fractures: pathogenesis, evaluation, and treatment. *Compr Ther* 2006;**32**:20–5.
- Miralles M, Gonzalez G, Pulpeiro JR, et al. Sonography of the painful hip in children: 500 consecutive cases. *AJR Am J Roentgenol* 1989;**152**:579–82.
- Ranner G, Ebner F, Fotter R, et al. Magnetic resonance imaging in children with acute hip pain. *Pediatr Radiol* 1989;**20**:67–71.
- Prakken B, Albani S, Martini A. Juvenile idiopathic arthritis. *Lancet* 2011;**377**:2138–49.
- Doria AS, Kiss MH, Lotito AP, et al. Juvenile rheumatoid arthritis of the knee: evaluation with contrast-enhanced color Doppler ultrasound. *Pediatr Radiol* 2001;**31**:524–31.
- Johnson K. Imaging of juvenile idiopathic arthritis. *Pediatr Radiol* 2006;**36**:743–58.
- Patel AM, Brown AG, Galambos C, et al. Pediatric pigmented villonodular synovitis mimicking a septic hip. *J Clin Rheumatol* 2010;**16**:71–3.
- Al Saadi MM, Al Zamil FA, Bokhary NA, et al. Acute septic arthritis in children. *Pediatr Int* 2009;**51**:377–80.
- Jaramillo D, Treves ST, Kasser JR, et al. Osteomyelitis and septic arthritis in children: appropriate use of imaging to guide treatment. *AJR Am J Roentgenol* 1995;**165**:399–403.
- Kim EY, Kwack KS, Cho JH, et al. Usefulness of dynamic contrast-enhanced MRI in differentiating between septic arthritis and transient synovitis in the hip joint. *AJR Am J Roentgenol* 2012;**198**:428–33.
- Pineda C, Espinosa R, Pena A. Radiographic imaging in osteomyelitis: the role of plain radiography, computed tomography, ultrasonography, magnetic resonance imaging, and scintigraphy. *Semin Plast Surg* 2009;**23**:80–9.
- Kothari NA, Pelchovitz DJ, Meyer JS. Imaging of musculoskeletal infections. *Radiol Clin North Am* 2001;**39**:653–71.
- van Schuppen J, van Doorn MM, van Rijn RR. Childhood osteomyelitis: imaging characteristics. *Insights Imaging* 2012;**3**:519–33.
- da Silva Junior GB, Daher Ede F, da Rocha FA. Osteoarticular involvement in sickle cell disease. *Rev Bras Hematol Hemoter* 2012;**34**:156–64.
- Ferey S, Merzoug V. The acutely limping child [in French]. *J Radiol* 2011;**92**:495–505.
- Karantanas AH, Drakonaki EE. The role of MR imaging in avascular necrosis of the femoral head. *Semin Musculoskelet Radiol* 2011;**15**:281–300.
- Yoo WJ, Kim YJ, Menezes NM, et al. Diffusion-weighted MRI reveals epiphyseal and metaphyseal abnormalities in Legg–Calve–Perthes' disease: a pilot study. *Clin Orthop Relat Res* 2011;**469**:2881–8.
- Kransdorf MJ, Stull MA, Gilkey FW, et al. Osteoid osteoma. *RadioGraphics* 1991;**11**:671–96.
- Klein MH, Shankman S. Osteoid osteoma: radiologic and pathologic correlation. *Skeletal Radiol* 1992;**21**:23–31.
- Davies M, Cassar-Pullicino VN, Davies AM, et al. The diagnostic accuracy of MR imaging in osteoid osteoma. *Skeletal Radiol* 2002;**31**:559–69.
- Chai JW, Hong SH, Choi JY, et al. Radiologic diagnosis of osteoid osteoma: from simple to challenging findings. *RadioGraphics* 2010;**30**:737–49.
- Ramappa AJ, Lee FY, Tang P, et al. Chondroblastoma of bone. *J Bone Joint Surg Am* 2000;**82-A**:1140–5.
- Ofiram E, Porat S. Progressive subluxation of the hip joint in a child with hereditary multiple exostosis. *J Pediatr Orthop B* 2004;**13**:371–3.
- von Chamier G, Holl-Wieden A, Stenzel M, et al. Pitfalls in diagnostics of hip pain: osteoid osteoma and osteoblastoma. *Rheumatol Int* 2010;**30**:395–400.
- Picci P. Osteosarcoma (osteogenic sarcoma). *Orphanet J Rare Dis* 2007;**2**:6.
- Rajiah P, Ilasslan H, Sundaram M. Imaging of primary malignant bone tumors (nonhematological). *Radiol Clin North Am* 2011;**49**:1135–61 v.
- Kuleta-Bosak E, Kluczevska E, Machnik-Broncel J, et al. Suitability of imaging methods (x-ray, CT, MRI) in the diagnostics of Ewing's sarcoma in children — analysis of own material. *Pol J Radiol* 2010;**75**:18–28.
- Cummings JE, Ellzey JA, Heck RK. Imaging of bone sarcomas. *J Natl Compr Canc Netw* 2007;**5**:438–47.
- Buckwalter JA, Brandser E, Robinson RA. The variable presentation and natural history of Langerhans cell histiocytosis. *Iowa Orthop J* 1999;**19**:99–105.
- Hindman BW, Thomas RD, Young LW, et al. Langerhans cell histiocytosis: unusual skeletal manifestations observed in thirty-four cases. *Skeletal Radiol* 1998;**27**:177–81.
- Van Nieuwenhuysse JP, Clapuyt P, Malghem J, et al. Radiographic skeletal survey and radionuclide bone scan in Langerhans cell histiocytosis of bone. *Pediatr Radiol* 1996;**26**:734–8.
- Goo HW, Yang DH, Ra YS, et al. Whole-body MRI of Langerhans cell histiocytosis: comparison with radiography and bone scintigraphy. *Pediatr Radiol* 2006;**36**:1019–31.
- Herman TE, Siegel MJ. Langerhans cell histiocytosis: radiographic images in pediatrics. *Clin Pediatr (Phila)* 2009;**48**:228–31.
- Loder RT, Aronsson DD, Weinstein SL, et al. Slipped capital femoral epiphysis. *Instr Course Lect* 2008;**57**:473–98.
- Zilkens C, Bittersohl B, Jager M, et al. Significance of clinical and radiographic findings in young adults after slipped capital femoral epiphysis. *Int Orthop* 2011;**35**:1295–301.
- Roposch A, Wright JG. Increased diagnostic information and understanding disease: uncertainty in the diagnosis of developmental hip dysplasia. *Radiology* 2007;**242**:355–9.
- Ozkan B. Nutritional rickets. *J Clin Res Pediatr Endocrinol* 2010;**2**:137–43.
- Dumitrescu CE, Collins MT. McCune–Albright syndrome. *Orphanet J Rare Dis* 2008;**3**:12.
- Sandhu SV, Sandhu JS, Sabharwal A. Clinoradiologic perspective of a severe case of polyostotic fibrous dysplasia. *J Oral Maxillofac Pathol* 2012;**16**:301–5.
- Holzheimer RG, Gresser U. Inguinal hernia vs. arthritis of the hip in sporting adolescents—case report and review of the literature. *Eur J Med Res* 2007;**12**:314–9.
- Schlesinger AE, Hernandez RJ. Diseases of the musculoskeletal system in children: imaging with CT, sonography, and MR. *AJR Am J Roentgenol* 1992;**158**:729–41.
- Bair-Merritt MH, Chung C, Collier A. Spinal epidural abscess in a young child. *Pediatrics* 2000;**106**:E39.