**Pictorial review: non-traumatic paediatric hip**

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Learning objectives

- To illustrate the spectrum of imaging features of the principal pathologies of non-traumatic paediatric hip.
- To discuss the role of radiologic studies in the management of these disorders, especially the use of CT for the evaluation of closed reduction in development dysplasia.

Background

Hip pain is one of the most frequent musculoskeletal complaints in children. The history and age of the patient help with the diagnosis along with physical examination and imaging studies. Early diagnosis and treatment are important to avoid potential complications.

Common causes of hip pathology include developmental hip dysplasia, Legg-Calvé-Perthes disease, slipped capital femoral epiphysis, septic arthritis and transient synovitis.

Imaging findings OR Procedure details

- DEVELOPMENTAL DYSPLASIA OF THE HIP (DEVELOPMENTAL HIP DYSPLASIA)

Developmental dysplasia of the hip is a relatively common condition. The term refers to an abnormal femoral head- acetabular relationship and developmental.

It typically occurs in the perinatal period. The cause is uncertain but involves a combination of anatomic and hormonally induced joint laxity and an abnormal intrauterine position. Prenatal hip dislocations are uncommon and are usually associated with other anomalies.

1) Demographics and clinical features:

The reported incidence varies between 1.5 and 20 per 1000 births, with the majority (60-80%) of abnormal hips resolving spontaneously within 2-8 weeks (so called immature hip).

Riks factors include: Female infant (M:F ratio 8:1) (whites), family history and breech presentation.
Examination of the hips for dysplasia is part of the routine clinical evaluation of the newborn and instability of the hip may be assessed by the Ortolani and Barlow tests, which are the keystone of clinical screening.

2) Radiologic evaluation:

A) Ultrasound:

Ultrasound is the first line radiologic evaluation in the infant (menor 6 months) prior to ossification of the proximal femoral epiphysis.

If physical examination suggests that a hip is abnormal, or if other risk factors are present, ultrasonography of both hips should be performed.

In 1980, Graf, orthopedic surgeon, published the original paper on examination of the infant hip using US. His method was aimed at morphologic assessment of the femoral head and acetabulum.

Over the next 2 decades or so, several publications detailed various other US methods for assessment of the infant hip (morphological assessment and hip stability), without consensus on the ideal approach. Performance of hip US by personnel with adequate training, experience and a thorough knowledge of its potential pitfalls are essential to the accuracy and validity of the examination. Now, the approach most widely utilized is a combination of morphological assessment of the hip and dynamic assessment of hip stability.

In our institution we use "the dynamic standard minimum sonographic examination" (Graf and Harcke).

- Technique:

The examination is performed with a high-frequency linear array transducer. The infant is placed with the side of interest slightly elevated or in a lateral decubitus position. This technique includes a coronal midacetabular image at rest and a transverse flexion view with stress.

In the static coronal view, which simulates an AP radiograph, the iliac bone should be imaged to form a straight line. The unossified femoral head should rest within the concavity of the acetabulum. The lateral edge of the bony acetabular rim should be sharply angulated Fig. 1 on page 10. When dysplasia is present, this edge is rounded or even flattened Fig. 2 on page 11.
Measurements including # and # angles and femoral head coverage are optional Fig. 1 on page 10. We measure the # angle when the hip is pathological Fig. 3 on page 11. The # angle is the geometric complement of the acetabular angle drawn on an AP radiograph. It is created by two lines drawn on the coronal ultrasonogram: one along the straight edge of the iliac bone, and one along the bony acetabular roof. The normal angle is 60º or greater. In the newborn, angles of approximately 55º are still considered normal.

During the transverse view with the hip in 90º flexion, stress is applied by pushing the femur posteriorly, in an attempt to provoke dislocation (analogous to the Barlow maneuvers) Fig. 4 on page 12.

B) Plain film:

In newborn infants, AP radiography of the hips is no used except to evaluate for associated abnormalities or to exclude other congenital anomalies. However, once the femoral head has ossified sufficiently to hinder a complete ultrasonographic evaluation, imaging evaluation should begin with an AP radiograph.

We evaluate the shape of the acetabular roof (normal hip: concave, dysplasia hip: straight), the acetabular sclerosis (normal hip: central, dysplasia hip: lateral), the femoral ossification center (dysplasia hip: small) the proximal femur (dysplasia hip: superolateral displacement) and the following parameters Fig. 5 on page 13.

- Parameters Fig. 6 on page 14:

  - Hilgenreiner's line is drawn horizontally through the superior aspect of both triradiate cartilages.

  - Perkin's line is drawn perpendicular to Hilgenreiner's line, intersecting the lateral most aspect of the acetabular roof.

The Perkins and Hilgenreiner lines divide the hip into quadrants. The unossified femoral head should normally be centered in the inferomedial quadrant.

- Acetabular angle Fig. 7 on page 13 is formed by the intersection between a line drawn tangential to the acetabular roof and Hilgenreiner's line, forming an acute angle. It should be approximately 28º degrees at birth and progressively reduce with maturation of the joint (decrease to 22º by 1 year of age). It is the geometric complement of the # angle measured on ultrasonographic images Fig. 8 on page 15.

- Shenton's line is drawn along the inferior border of the superior pubic ramous and should continue laterally along the inferomedial aspect of the proximal femur as a smooth
line. If there is superolateral migration of the proximal femur due to DDH then this line will be discontinuous.

c) Computed tomography (CT):

CT and magnetic resonance imaging (MRI) may be used to evaluate DDH in patients with casts following surgery or open and closed reduction to confirm that the hip has been successfully reduced. CT and MRI can also be used to evaluate complex hip dislocations, for pre-surgical planning, and for evaluation of avascular necrosis. Arthrography is used primarily in the operating room by the orthopedic surgeon to evaluate lateral displacement of the femoral head and congruity following closed reduction of the hip, and to assess for labral infolding that might prevent proper reduction.

We use CT post reduction in our institution due to its availability, rapidity of acquisition (sedation is not necessary) and lower cost compared with MRI.

This type of CT scan is performed with the patient in a spica cast, either in the frog leg position after open or closed reduction Fig. 9 on page 16. CT is used to assess the position of the femoral metaphysis with respect to the acetabulum. The femoral metaphysis should be directed toward the midportion of its acetabulum. The femoral head may remain slightly posterior in the acetabulum following surgical reduction Fig. 10 on page 17.

We use a low dose radiation protocol (GE LightSpeed VCT 64 Slice CT):

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D) Magnetic resonance imaging (MRI):
MRI has not been routinely used in DDH, but indications are increasing. MRI is attractive because of the lack of ionizing radiation, the visualization of soft tissue structures and the multiplanar capability. The primary disadvantages are the cost and the need for sedation but now can be performed quickly and immobilization in a spica cast often precludes the need for sedation.

With gadolinium enhancement, MRI also offers the ability to determine the extent of hip abduction and the vascularity of the femoral head after reduction in order to identify hips that may be at increased risk of ischemia and development of AVN at a time when it may be reversible.

3-Treatment:

Treatment can be either conservative or surgical.

- Pavlik harness: usually for younger patients (< 6 months of age)
- closed reduction: usually for older patients
- open reduction: much older patient or if closed reduction not successful

- LEGG-CALVÉ-PERTHES DISEASE (LCP)

LCP is idiopathic avascular necrosis of the immature proximal femoral epiphysis.

The cause of the interruption of blood supply to the femoral epiphysis is unknown, although the disease sometimes follows trauma or joint effusion.

1) Demographics and clinical features:

LCP disease affects approximately 5.1-15.6 in 100,000 children (0.005-0.016%). The disease is most commonly seen in white boys between the ages of 3 and 12 years, usually 5-8 years. Although most cases of LCP disease are unilateral, approximately 15% of individuals are affected bilaterally. When bilateral, the involvement of the hips is asymmetric.

The most frequent presenting feature is pain with or without a limp.

2) Radiologic evaluation:

A) Plain film:
The initial radiologic evaluation usually includes AP and frog-lateral views of the pelvis and both hips. Because bony resorption and subchondral fracture are usually located anterolaterally, the frog-lateral projection is particularly valuable. The identifiable radiographic stages of the disease include:

**Initial stage** Fig. 11 on page 18

- asymmetric femoral epiphyseal size (smaller on affected side)
- apparent increased density of the femoral head epiphysis
- widening of the medial joint space
- blurring of the physeal plate
- radiolucency of proximal metaphysis

**Collapse and fragmentation stage** Fig. 12 on page 19

- subchondral lucency (crescent sign)
- femoral epiphysis fragments
- femoral head outline is difficult to make out
- mottled density
- thickened trabeculae

**Reparative or reossification stage** Fig. 13 on page 19

- re-ossification begins
- shape of the femoral head becomes better defined
- bone density begins to return

**Remodeled or healed stage**

- changes depend on severity the femoral head may be nearly normal or may demonstrate
- flattening of the articular surface, especially superiorly
- widening of the head and neck of the femur

*B) Scintigraphy:*

During the early stages of the disease the plain films may be normal. At this time bone sintigraphy or MR imaging is helpful in making the diagnosis. With scintigraphy, a focal area of decreased uptake of the isotope is seen within the femoral head. Proper positioning of the hips in the anterior and frog leg positions and pinhole imaging is important to evaluate adequately the femoral heads.

*c) MR imaging:*
MR imaging is a valuable tool in the diagnosis of early or radiographically occult LCP disease. Although MRI and bone scintigraphy findings in LCP disease correlate quite well, MRI depicts the exact extent of femoral head involvement more precisely than pinhole scintigraphs. MRI also does not expose the pediatric patient to the potentially harmful effects of ionizing radiation.

Changes in the femoral head, such as decrease or loss of signal from the ossification center of the femoral head during the early necrotic phase, are shown well with T1- and T2-weighted axial and coronal images. Gradient echo images and T2-weighted images with fat saturation may show early hypertrophy of the acetabular cartilage. Proximal femoral ossific nucleus morphologic changes, such as articular surface flattening changes may also be observed Fig. 14 on page 20.

On occasion, curvilinear subchondral T2-weighted signal hyperintensity and T1-weighted signal hypointensity may be observed in the anterosuperior aspect of the femoral head. This finding, referred to as the crescent sign (or Caffey sign) suggests the presence of a subchondral fracture.

Contrast-enhanced imaging is particularly useful in the assessment of proximal femoral epiphyseal perfusion. Hypoperfusion of the proximal femoral epiphysis may be one of the earliest indicators of LCP disease.

During the revascularization and reparative or healing phases of LCP disease, unenhanced and contrast-enhanced imaging sequences frequently reveal heterogeneous proximal femoral epiphyseal signal, likely reflecting a combination of necrotic changes, revascularization, and reparation.

D) Dynamic MR and arthrography:

Traditionally arthrography performed under general anaesthesia with conventional fluoroscopy is performed to assess congruency between the femoral head and the acetabulum in a variety of positions. MRI is increasingly replacing this, in an effort to eliminate pelvic irradiation.

Both arthrography and dynamic MRI assess three main features:

- deformity for the femoral head (also assessed on static X rays and MRI)
- congruency: how well the femoral head contour matches that of the acetabulum
- containment: the amount of lateral subluxation of the flattened femoral head out of the acetabulum. When severe this may lead to hinge abduction, whereby rather than rotation and medial movement of the femoral head during hip abduction, the flattened head 'hinges' on the lateral lip of the acetabulum, widening the medial joint space
3) Treatment:

The literature regarding the best treatment for LCP is inconclusive. Bracing may be used in milder cases, although varus derotational femoral Fig. 15 on page 20 and acetabular osteotomies may be required to correct more severe abnormal femoroacetabular malalignment. Both or a combination of both have performed for the treatment of LCP disease to improve the containment and coverage of the femoral head.

Prognosis is influenced primarily by the degree of primary deformity of the femoral head and the secondary osteoarthritic changes that ensue.

- **SLIPPED CAPITAL FEMORAL EPIPHYSIS**

Slipped capital femoral epiphysis (SCFE) is analogous to a Salter-Harris type I physeal fracture involving the proximal femur. The cause of the fracture is unknown, but peripubertal growth spurt, obesity, male, growth hormone treatment, hypothyroidism, hypopituitarism and renal osteodystrophy are predisposing factors. Usually affects 11 to 14 years old and is bilateral in 20-30%.

Approximately half of patients give a history of significant trauma. The most common presenting symptoms are limp and may have hip, groin or knee pain.

The usual initial displacement of the epiphysis is posterior. Radiographs (AP and frog leg) of the hip may show widening and irregularity of the physis with posterior inferior displacement of the femoral head. On the AP view, a line drawn from the superior femoral neck (Klein's line) Fig. 16 on page 21 should intersect some portion if the femoral head (figure'). CT is used in selected cases to demonstrate the degree of posterior slippage and the width of the physis. CT helps to plan the treatment Fig. 17 on page 22.

The most significant complications are chondrolysis and avascular necrosis.

Treatment includes conservative treatment with aims to immobilize hip using hip spica or surgical: femoral pinning Fig. 18 on page 22, femoral osteotomy and epiphysiodesis. Patients require long term follow up as SCFE may develop within 12 to 18 months in the contralateral hip, if prophylactic pinning is not performed.

- **SEPTIC ARTHRITIS**

Septic arthritis is a uncommon infection in children, usually due to pyogenic organism of a joint. It is monoarticular in 90% of cases and it presents with a more acute picture.

In septic arthritis in infants and children, imaging is essential for prompt diagnosis and prevention of complications. The radiologic assessment includes determination of the
presence of an effusion, displacement of pads, and obliteration of soft-tissue planes because of edema. These change are not specific for infection and may result from other inflammations and trauma.

Radiographic evaluation should always include AP views of the pelvis with hips in neutral and frog lateral positions. The distance from the teardrop of the acetabulum to the medial metaphysis of each femoral necks should be measured (asymmetry of 1-2 mm suggests joint effusion) Fig. 19 on page 23. In the ultrasound demonstrates widening of the involved joint space and synovial thickening and debris in the fluid may be seen Fig. 20 on page 23. Ultrasonographically guide aspiration of the hip is considered the gold standard for diagnosis.

Complication of acute septic arthritis include true dislocation, epiphyseal separation, contracture of the joint capsule, joint destruction, subsequent osteomelitis, and, rarely, destruction of the femoral head and neck Fig. 21 on page 24.

Septic arthritis is a surgical emergency and it needs emergency joint washout and antibiotics.

• **TRANSIENT SYNOVITIS**

Transient synovitis is one of the most common causes of hip pain in children. This occurs primarily between the ages of 2 and 10 years (peaking between 5 and 6 years) and it is more common in boys. The mechanism for this is unclear, nonetheless, often preceded by viral infection. Recurs in up to 15% of children, and may affect the same or opposite hip.

Transient synovitis has an acute onset, and spontaneous recovery with no radiological abnormality or systemic upset. Pain usually is minimal, but limping always is present. The clinical is common of the septic arthritis and it is difficult to differentiate.

On radiologic evaluation joint space widening is minimal, and there is no osteopenia or soft-tissue welling Fig. 22 on page 26. Ultrasound demonstrates joint fluid Fig. 23 on page 26. This also can be found in septic arthritis. Transient synovitis is a diagnosis of exclusion.

Images for this section:
**Fig. 1:** Coronal ultrasound image through the left hip joint of an 6-week-old girl born in the breech position. For the US image to be diagnostic, the iliac bone must be straight (long straight arrow) and both the acetabular labrum (curved arrow) and the lower limb of the os ilium (short straight arrow) must be visible.

**Fig. 2:** a. Coronal ultrasound image of the right hip joint of the same patient as in Fig.1. Bony acetabulum is well developed with an angular bony rim. b. Coronal view of the right dysplasia hip. Bony acetabulum is deficient developed with an angular round rim (long straight arrow and curved arrow) and the pulvinar hypertrophy (short straight arrow). The femoral head coverage is deficient.
Fig. 3: Coronal view of the left hip joint of a 5-week-old girl, with a normal clinical hip examination, whose mother had a history of DDH. The bony rim of the acetabulum is rounded, $\# 47^\circ$. 

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**Fig. 4:** Dynamic standard minimum sonographic examination: transverse flexion view of the hip joint with stress. a. Normal hip b. Dysplasia hip. The femoral head has moved laterally relative to the acetabulum. (M femoral metaphysis, I ischium).

**Fig. 5:** Developmental dysplasia of the left hip. The femoral ossification center is small. There is disruption of the arc of Shenton's line. The bony acetabular roof is straightened. The proximal femur is displaced superolaterally.
Fig. 7: Acetabular angle of DDH.
Fig. 6: Parameters. Radiography of the hip for DDH.
Fig. 8: Acetabular and # angles.
Fig. 9: Computed tomography scan shows a mildly posteriorly displaced left hip after closed reduction. Air is seen in the soft tissues from the procedure.
**Fig. 10:** MIP and VR images. Computed tomography scan after closed reduction of the same patient as in Fig.9.
**Fig. 11**: A 5-year-old girl with left hip pain. Early Perthes. a. Frontal radiograph and b. frog-lateral view show flattening of the femoral head, widening of the medial joint space and radiolucency of proximal metaphysis.

**Fig. 12**: A 6-year-old girl with left hip pain. a. Frontal radiograph and b. frog-lateral view show the left proximal epiphysis is fragmented and irregularly ossified. The metaphysis is lucent.
Fig. 13: An 8-year-old boy with right hip pain and limp. Frontal radiograph shows widening of the femoral neck and bone density of the femoral head begins to return.

Fig. 14: A 7-year-old boy with right hip pain. Coronal T1 weighted and STIR images showing altered signal of the left femoral head and small joint effusion in keeping with Perthes.
Fig. 15: Femoral osteotomy.
Fig. 16: A 14-year-old boy had left hip pain for 3 days. He had nephropathy and obesity. Frontal radiograph shows a normal Klein’s line in right hip and a SCFE in left hip.

Fig. 17: Chronic SCFE in 12-year-old girl. Axial CT scan pre-surgical demonstrates the posterior component of the epiphyseal slip better. The physis is widened.
**Fig. 18:** Surgical treatment of SCFE. Frontal (a) and axial (b) radiographies show a femoral pinning.

**Fig. 19:** A 1-year-old boy had left hip pain and limp for 2 weeks. Frontal radiograph demonstrates hip joint effusion. There is widening of the distance from the acetabular teardrop to the medial femoral metaphysis on the left compared to that on the right.
Fig. 20: Longitudinal anterior sonogram of the same patient as in Fig.19 of both hips demonstrates bulging of the left joint space.
**Fig. 21:** Frontal radiographs a) obtained five months after Fig.20 demonstrates disappearance of left femoral head. b) and c) Obtained four and six months later, demonstrates reappearance of femoral head.

**Fig. 22:** Transient Synovitis. A 4-year-old boy had right hip pain for 2 weeks. Frontal radiograph shows subtle widening of the right hip joint space.
**Fig. 23:** Longitudinal sonogram of the right hip of the same patient as in Fig.22 demonstrates bulging of the joint space and confirms left joint effusion.
Conclusion

We present a pictorial review aimed mainly at radiologists in training. This review demonstrates a range of common abnormalities of the hip in childhood. Plain film, ultrasound, CT, MR, and nuclear medicine play an important role in the diagnosis and management.

References


Personal Information