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Hip utrasonography in infants and children

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Introduction

Hip USG was the first and most successful application of USG in the musculoskeletal system. In the late 1970s, Dr. Graf was the first to realize the potential of USG over plain radiography for visualizing the non-ossified femoral cartilage [Figure 1] and introduced the use of static USG for evaluation of infant hip dislocation.[1] Real-time and multiplanar USG evaluation of the hip was introduced soon thereafter by Novick G[2] and Harcke *et al*.[3]

USG allows high-resolution, portable, multi-planar and dynamic evaluation of hip joints, making it an easy and widely used examination in infants.[4,5] The sensitivity and specificity of USG for the diagnosis of hip dysplasia is nearly 100%.[6] In the older child, once the ossific nucleus in the head is well-formed, adequate USG imaging of the acetabulum [Figure 2] becomes difficult and radiographic evaluation becomes the preferred method. USG of the hip is thus practical only up to 1 year of age, unless there is delayed ossification of the femoral head.[5,6]

Two factors limit the usefulness of USG in orthopedic disease. First, USG is an operator-dependent modality with a significant learning curve. A sonographer with little experience in doing these examinations will not be accurate in the detection of disease. Secondly, ultrasound waves do not penetrate bony structures adequately, leading to difficulty in assessing bony abnormalities.

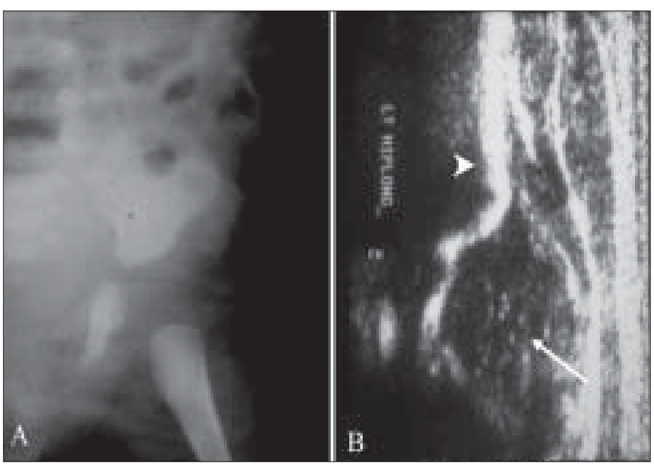

Figure 1 (A, B): Plain radiograph of the left hip (A) in a 4-week neonate shows non-visualization of the femoral head. Coronal USG (B) of the hip shows the femoral head (arrow) and acetabulum (arrowhead)

Developmental dysplasia of the hip: The term "congenital dislocation of the hip" has traditionally been used to describe abnormal infant hips. The currently used term is "developmental dysphasia of the hip (DDH)" and denotes the range of hip abnormalities in the newborn period that may progress to dislocation. DDH is a common disorder that affects 0.8% to 3.5% of children. It occurs more often in girls and usually involves the left hip. Teratogenic dislocations occur in infants with underlying neuromuscular disorders such as myelodysplasia and arthrogryposis, usually occurring in utero and, therefore, are truly congenital. Most cases of DDH occur in neurologically intact infants in the perinatal period and, therefore, are developmental

There is considerable world-wide controversy over routine screening for DDH with USG. Several studies on the efficacy of universal screening of all infants or of all female infants, have shown a higher rate of diagnosis of DDH by USG, as compared to physical examination findings alone. A decrease in the incidence of late hip dislocation has also been shown. Wide screening policies, however, carry the burden of significantly increased follow-up costs and the potential for increased iatrogenic complications (viz. femoral head avascular necrosis). Early physiologic laxity is often seen. The hip may subsequently spontaneously become stable and develop normally or may remain dislocated or dislocate over time and become irreducible. Hips with instability at birth may also develop dysplasia, with or without progressive subluxation.. Hence, the use of USG as a screening test is currently limited to infants at risk for DDH. Risk factors include breech presentation, a family history of DDH, club foot, congenital torticollis and metatarsus adductus. Also, all infants with a positive physical examination should be imaged.[7]

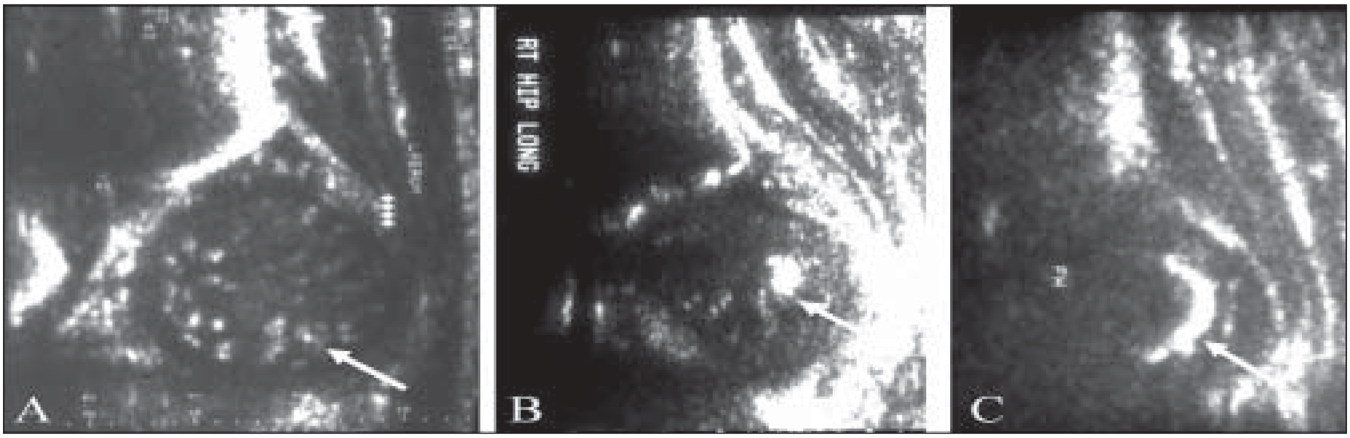

Figure 2 (A-C): Coronal USGs of the hip in a 3-week old neonate (A), 8-week old infant (B) and an 8-month old infant (C), show how the femoral head becomes progressively ossified (arrows), preventing beam penetration with limited visualization of the acetabulum in the older infant

There are no absolute contraindications to the use of USG in the infant hip for DDH, but as discussed above, the study becomes less reliable relative to radiography as ossification of the femoral head progresses. Secondly, due to the presence of physiologic laxity, imaging is usually not performed on patients less than 2 weeks old.[7,8] USG can be used for diagnosis of DDH as well as for monitoring treatment (using customary splint-type devices).

It is important to understand the pathophysiology of DDH. There are two major components of DDH: instability and abnormal morphology.[8] Ligamentous instability, resulting in malposition of the femoral head out of the acetabulum is responsible for inadequate development of the acetabulum. Early detection of instability and reduction is therefore important. Once the femoral head is in proper position, it acts as a stimulant and the poorly developed / dysplastic acetabulum shows good molding. If subluxation persists, subsequent irreversible changes take place. The femoral head becomes flattened postero-laterally. The absence of the femoral head leads to a shallow and dysplastic acetabulum. The capsule thickens and the labrum hypertrophies. The space between the femoral head and acetabulum becomes filled with fibro-fatty tissue (pulvinar). The femoral head moves further supero-laterally, the labrum is inverted and is deformed. The capsule thickens and may develop an hour-glass deformity. Femoral head ossification is often delayed. The general consensus is that any diagnosis after the age of three months, is a late diagnosis.

Examination technique: Imaging is conducted with a linear transducer. The sector probe produces images with distortion of the hip and less reproducibility (use of sector probes is restricted to evaluation through small windows in a plaster cast during treatment). A 5 MHz transducer usually has adequate penetration with excellent depiction of the soft tissues. In a neonate, a higher frequency 7MHz transducer is recommended.

There are two distinct methods of examination. The static method introduced by Graf and the dynamic method described by Harcke *et al*.[8] The static method assesses acetabular and femoral head morphology, location of the femoral head, appearance of the labrum and presence of fatty pulvinar in the hip joint. The dynamic method evaluates the stability of the joint. In addition, femoral head coverage measurements have been described by Terjesen.[9-11]

Graf's Technique (Table 1)– The examination is based on a single coronal image of the hip obtained with a linear array transducer with particular attention to the position of the hip. The child is placed in a foam–padded trough in a lateral position and the hip is flexed to 90°. The ultrasound probe is placed in a coronal plane parallel to the spine and a coronal section is obtained though the middle of the acetabular roof.[11,12] This "standard plane" is identified by the presence of the following three points.

1. Lower limb of the bony ilium, in the depth of the acetabular fossa.
2. The middle of the acetabular roof
3. The acetabular labrum

Measurements made on this coronal view are the "alpha" and "beta" angles. Some machines have a software for measuring Graf's angle. The alpha and beta angle

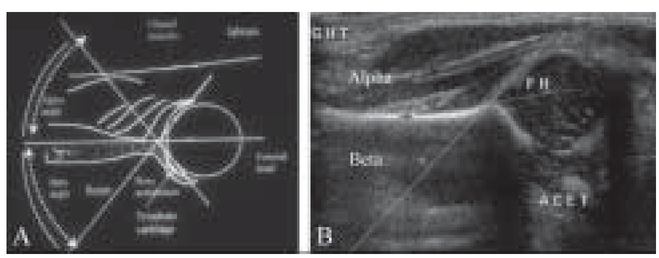

Figure 3 (A,B): Line diagram (A) and coronal USG (B) show how the alpha and beta angles are measured

Table 1: Graf's classification of hip dysplasia

Graf	Sonographic hip type	Bony roof	Ossific rim	Cartilage rim	Alfa angle^{0}
Ia	Mature	Good	Sharp	Long and narrow, extends far over femoral head	>60
Ib	Mature	Good	Usually blunt	Short and broad, but covers femoral head	>60
IIa	Physiological delay in ossification < 3 months (physiological immature but stable hips)	Deficient	Rounded	Covers femoral head	50-59
IIb	Physiological delay in ossification > 3 months (inherently stable)	Deficient	Rounded	Covers femoral head	50-59
IIc	On point of dislocation (unstable, require immediate t/t**)**	Deficient	Rounded / flat	Covers femoral head	43-**49**
IId	On point of dislocation	Severely deficient	Rounded / flat	Compressed	43-49
IIIa	Dislocated (subluxation)	poor	Flat	Displaced upwards and echopoor	<43
IIIb	Dislocated (subluxation)	poor	Flat	Displaced upwards and more reflective than femoral head	<43
IV	Dislocated (complete)	poor	Flat	Interposed	<43

measurements are used to indicate the degree of acetabular development [Figure 3]. A line is drawn parallel to the ossified lateral wall of the ilium (baseline). A second line is drawn along the roof of the cartilaginous acetabulum (from the lateral bony edge of the acetabulum to the labrum) to give the *beta angle*; this denotes the slope of the *cartilaginous* acetabulum. A third line is drawn from the inferior edge of the bony acetabulum, at the triradiate cartilage, to the distal part of the ilium, tangential to the slope of the bony acetabulum (roof line). The angle between the 1st and 3rd lines is the *alpha angle.* The alpha angle denotes the slope of the bony acetabulum. Normally, the alpha angle is greater than 60° and an angle less than 55 is considered abnormal. Graf's classification system grades hips from types 1 through 4, based on acetabular development. In infants less than 2 weeks old, the alpha angle is often 50-60°, but it normalizes on follow-up imaging, without treatment (physiological laxity / subluxation). The beta angle is related to the position of the cartilaginous roof and increases as the subluxed / eccentrically placed femoral head elevates the labrum.

It is important to identify type IIc and beyond (alpha angles less than 50 degree) on USG, as these are unstable hips. It is important to note that these measurements are performed on static images without any stress.

Graf's method is popular in central Europe.[13] This technique requires supervised practical training and several studies have shown poor reproducibility for the placement of these lines, along with an increased interobserver variation, especially for measurements of the *beta angle.*

Femoral Head Coverage (FHC) and d/D Ratio (Table 2): Other techniques of measurement have been described. In the same coronal image, Morin[13] has described femoral head coverage (FHC) or the d/D ratio. A projection of the iliac line through the bony promontory and through the femoral head, gives the percentage coverage of the femoral head [Figure 4]. The lower limit of FHC in infants aged >1month is 50%. In newborns, slightly lower limits have been reported. The reason for this difference is that the FHC increases with age. Since the acetabular fossa cannot be visualized in older children; FHC is used only in the first year of life.[14,15]

Femoral head overage: is given by following formula
a or d (i.e. distance from the medial wall of the acetabulum to the level of the lateral bony rim) x 100
b or D (i.e. distance from the medial wall of the acetabulum to the lateral joint capsule)

Dynamic Technique

This technique is widely used in the United States and is the technique we use in our institution. The examination is conducted in the supine or lateral decubitus position. The

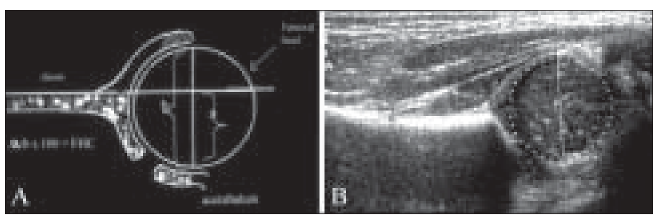

Figure 4 (A,B): Line diagram (A) and coronal USG (B) show how d/D can be measured

Table 2: Terjesen femoral head overage.

Femoral head coverage	Inference
> 50%	Normal
49-40%	Possible dysplasia in newborns
49-40%	Dysplasia in infants greater than 4 months
39-10%	Subluxation
<10%	Dislocation

Table 3: Hip Sonography for Developmental Dysplasia of the Hip[8]

View	Key Feature	Comment
Coronal neutral	Acetabular morphology	Measurement optional
Coronal flexion	Acetabular morphology Stability (if stressed)	Measurement optional Stress optional Used with Pavlik harness
Transverse flexion	Stability	Stress required (except during treatment) Used with Pavlik harness
Transverse neutral	Femoral head position	Optional view

minimum examination includes coronal and transverse images of the hip as well as stress images in the transverse plane. The coronal images can be obtained with the hip in a neutral position or a flexed position with the transducer placed postero-laterally. The transducer is then turned by 90° for the transverse images. With the hip held in flexion, neutral and stress views are obtained. Stress views are achieved by holding the flexed hip in a mild degree of adduction and applying firm but gentle pressure towards the hip joint along the shaft of the femur. The normal hip will stay located within the acetabulum with no evidence of subluxation [Figure 5a], but a dysplastic hip will show subluxation [Figure 5b], during this piston-like stress procedure. This minimum examination may be supplemented with additional optional views including transverse images with the hip in a neutral position and coronal stress views (Table 3)

Anatomy and Interpretation (Table 4): The diagnostic examination of the infant hip incorporates two orthogonal views. In the coronal and transverse views [Figure 6], certain landmarks must be visible and lines drawn from these landmarks help evaluate acetabular development and position of the femoral head.

Coronal View: The femoral head is seen as a hypoechoic rounded structure with fine stippled echoes (egg), contained within the acetabulum (spoon) giving a typical egg in spoon appearance.[13] The bony acetabulum is formed by the ilium, ischium and the pubis, separated by the triradiate cartilage. The landmarks seen in the coronal view [Figure 7] are thus – [1] articular capsule,[2] acetabular labrum,[3] bony

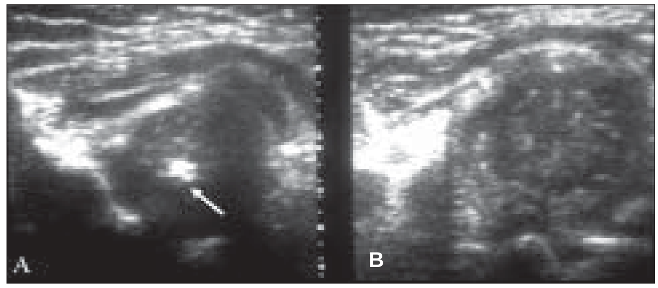

Figure 5 (A,B): Transverse images during stress show a centrally located femoral head in the normal hip (A) with subluxation in the abnormal hip (B). Note the absence of the femoral head ossification centre in the dysplastic left hip, as compared to the normal right (arrow)

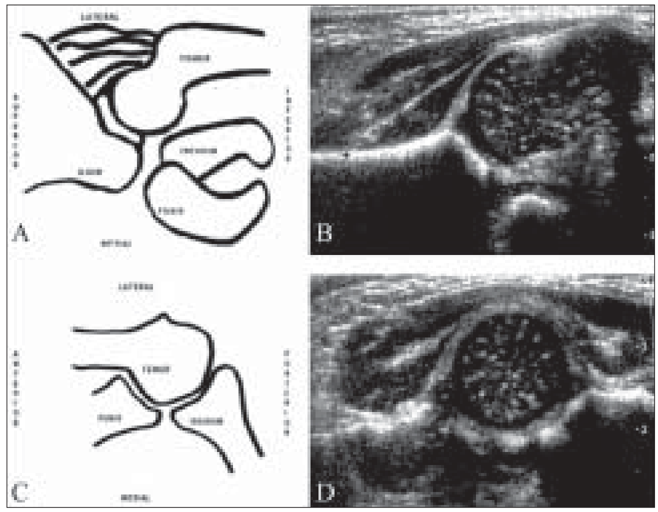

Figure 6 (A-D): Line diagrams in the coronal (A) and transverse (C) positions and their corresponding USG images (B, D). show landmarks which must be visible during scanning

promontory,[4] lower iliac margin,[5] cartilaginous femoral head,[6] "Y" cartilage and greater trochanter.[7]

The proper coronal view, whether the femur is in the neutral or flexed positions, must contain three elements[8] [Figure 8].

1. The echoes from the bony ilium should be parallel to the surface of the transducer.
2. The transition from the os ilium to the triradiate cartilage

Table 4: The position of femoral head

(1) Normal:	It may be further classified as –
(1a) Stable [Figure 8]:	where the head is centrally placed in the acetabulum with more than 50% femoral head coverage.
(1b) Subluxable on application of stress [Figure 9]:	Posterior subluxation due to normal transient ligamentous laxity is evident in the immediate neonatal period. Subluxability should not be seen after 4-6 weeks of life.
(2) Subluxated [Figure 10]:	where the femoral head lies postero-laterally and eccentrically placed in relation to the acetabular cavity, but still below the acetabular labrum with partial contact between the femoral head and acetabulum. (2a) reducible (2b) non-reducible.
(3) Dislocated [Figures 11, 12]:	where the acetabular labrum is inverted and femoral head is out of the acetabular cavity and placed lateral and above the acetabular labrum in the soft tissues, adjacent to the ileum. (3a) reducible (3b) non reducible.

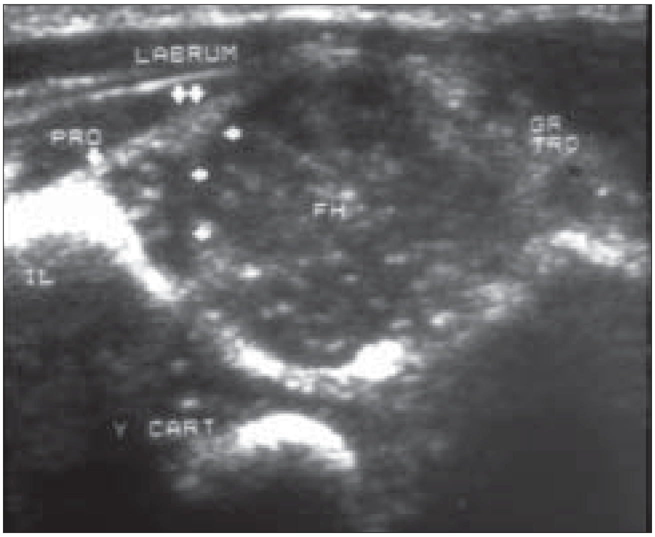

Figure 7: Coronal USG image shows the articular capsule and acetabular labrum (short arrows), bony promontory (PRO), lower iliac margin (IL), femoral head (FH), Y–cartilage and greater trochanter (GR TRO)

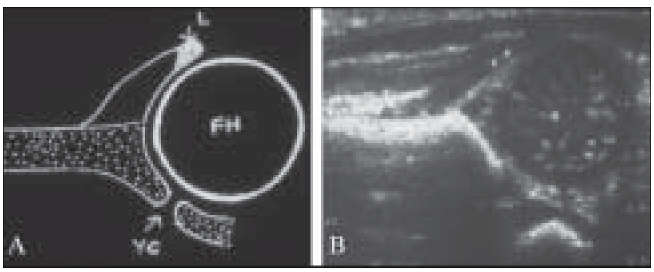

Figure 8 (A,B): Normal hip. Line diagram (A) and coronal USG (B) show the normal landmarks. FH – femoral head, YC – Y-cartilage, L – labrum

must be seen.

3. The echogenic tip of the cartilaginous labrum needs to be present in the same plane that contains the first two elements.

Transverse View: In the transverse view, the first landmark is the rounded hypoechoic femoral head, which is seated in the center of the "U" shaped acetabulum. This is the next landmark, the sides of which are formed by the bony ischium and pubis, which are in turn separated by the hypoechoic central "Y" cartilage. The relative anterior or posterior position of the femoral head with respect to the acetabulum is then documented [Figure 5]. A dynamic evaluation is essential in the initial evaluation of the infant, but its use during treatment with abduction splinting is generally discouraged. While doing a dynamic evaluation, movement of the femoral head out of the acetabulum is analyzed and quantified. The position of the femoral head is studied in three positions; neutral, flexion with adduction and flexion with abduction at rest. The same views are re-evaluated after stress. The application of stress is similar to the provocative Barlow's test i.e. with the hip in flexion and abduction with a gentle posterior push. Reduction of the head is studied in a manner similar to Ortolani's test i.e. gradual abduction of the flexed hip till the head reduces.

The reporting format should therefore include the anatomical description including the normal / dysplastic appearance of the bony and cartilaginous acetabulum, appearance of the femoral head with its shape, size and status of the ossification center. This should be followed by the findings of the dynamic study and a description of the position of the femoral head in relation to the acetabulum at rest and on application of stress (Table 5).

We use a combination of static parameters (alpha angle and percentage coverage of the femoral head), as well as dynamic descriptors i.e. stable vs. unstable; these are the factors which influence decision-making in the treatment of DDH.

The commonest mode of treatment, is the application of a Pavlik harness (spika), in the abducted position. In children with DDH, USG can be used to follow-up and monitor treatment, after three months. It is possible to examination patients in the Pavlik harness, though stress maneuvers

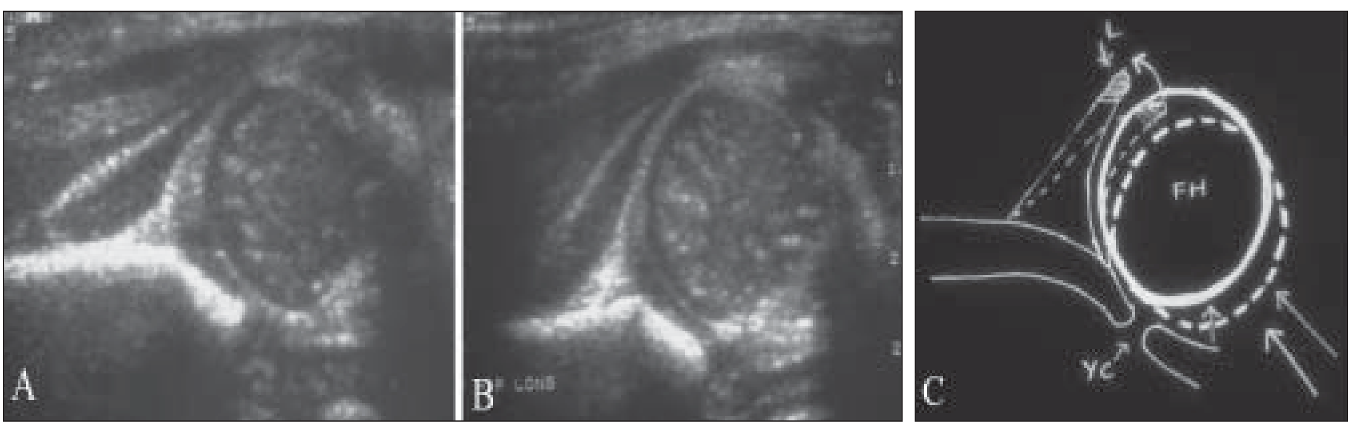

Figure 9 (A-C): Unstable hip. Coronal USG images show that the femoral head is centrally placed in the acetabulum at rest (A), with subluxation after stress (B). The diagram (C) shows the extent of subluxation

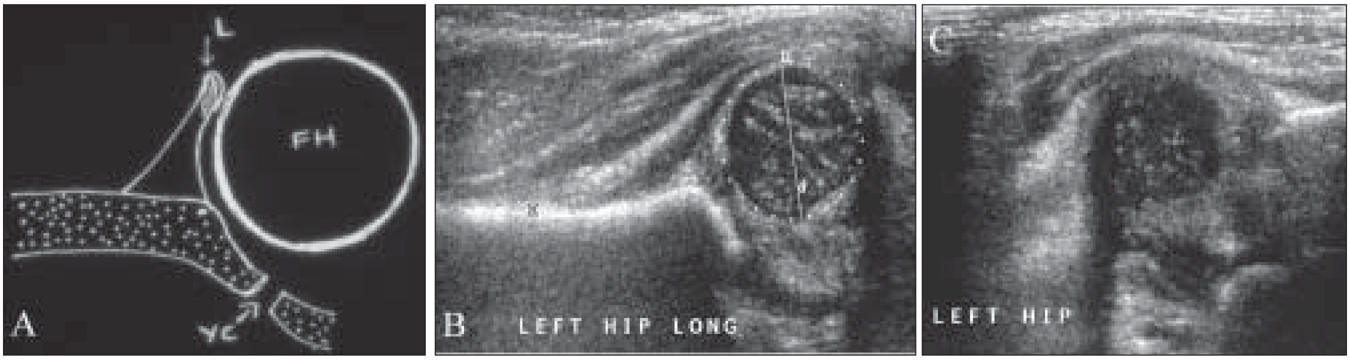

Figure 10: (A-C): Hip subluxation (incomplete dislocation). Diagram (A), coronal USG image (B) and transverse USG image (C), show that the femoral head lies below the labrum with partial contact between the femoral head and acetabulum

Table 5: Harcke's method of dynamic hip evaluation

To detect subtle instability, done in 4 steps:

1. Coronal neutral position: similar to Graf's method, without angle measurements
2. Coronal flexion: with 90º flexion, identify tri-radiate cartilage (TC), transducer moved anterior to posterior (A-P).
   Normal: when the transducer is posterior to the TC – femoral head (FH) not visible.
   Abnormal head position: when the transducer is posterior to the TC – FH visible
   With knee push-up: hip instability diagnosed by seeing FH move over the posterior edge of the TC.
3. Transverse flexion: with 90° flexion.
   Normal: Head lies above the "U" formed by the anterior and posterior portions of the acetabulum, separated by the TC.
   With knee push-up: instability – gap between the FH and the acetabulum (TC / AP / PP) increases.
   With hip in abduction and pull-down of knee: the dislocated hip is relocated into the acetabulum.
4. Transverse neutral: Normal – FH in the "U" with its centre towards the TC.
   Dislocated – TC cannot be seen in this plane

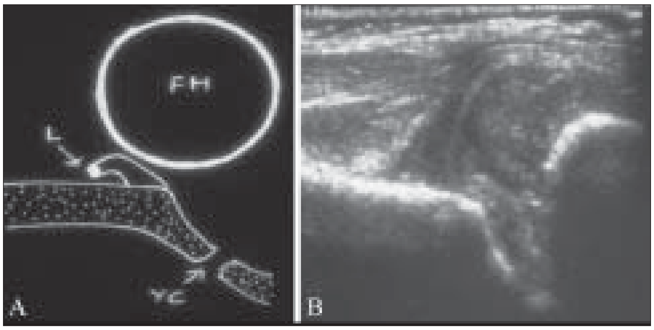

Figure 11 (A,B): Hip dislocation. Diagram (A) and coronal USG (B) show that the femoral head is completely out of the acetabulum, lying in the soft tissues, lateral to the iliac bone

should not be performed, unless specifically requested by the orthopedic surgeon at the end of treatment, to confirm a stable reduction. The improvement in acetabular morphology, as well as the location of the femoral head, can be documented to assist treatment monitoring [Figures 13, 14]. If the patient requires rigid casting for treatment, CT scan and/or MRI is more effective than attempting USG through windows cut in the cast.

USG of the hip is sensitive and specific in the detection of DDH; false-positive and false-negative rates are reported at 1% to 2%. Harcke *et al*,[16] believe that most of their false-negative examinations were due to lack of patient relaxation. In children with arthrogryposis or skeletal dysplasias, confusion can occur due to difficulty in determining the normal landmarks of the proximal femur. USG can also be used to document the presence and location of the femoral head [Figure 15] in proximal focal femoral deficiency (PFFD). The greater trochanter may be mistaken for the femoral head [Figure 16] and MRI may be a necessary

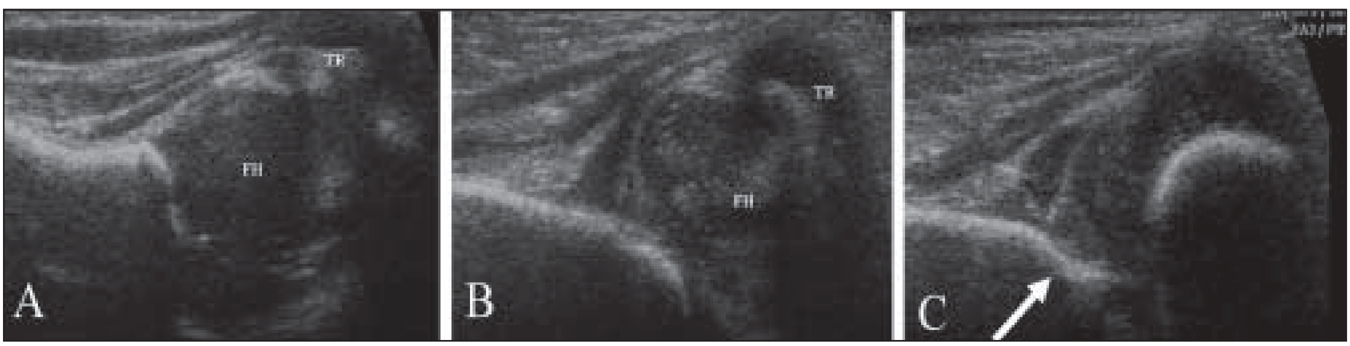

Figure 12 (A-C): Hip dislocation. Coronal USG images of a normal left hip (A) and right hip dislocation (B, C). A concavity (arrow) is seen along the iliac surface due to the pressure of the femoral head, leading to a pseudoacetabulum formation

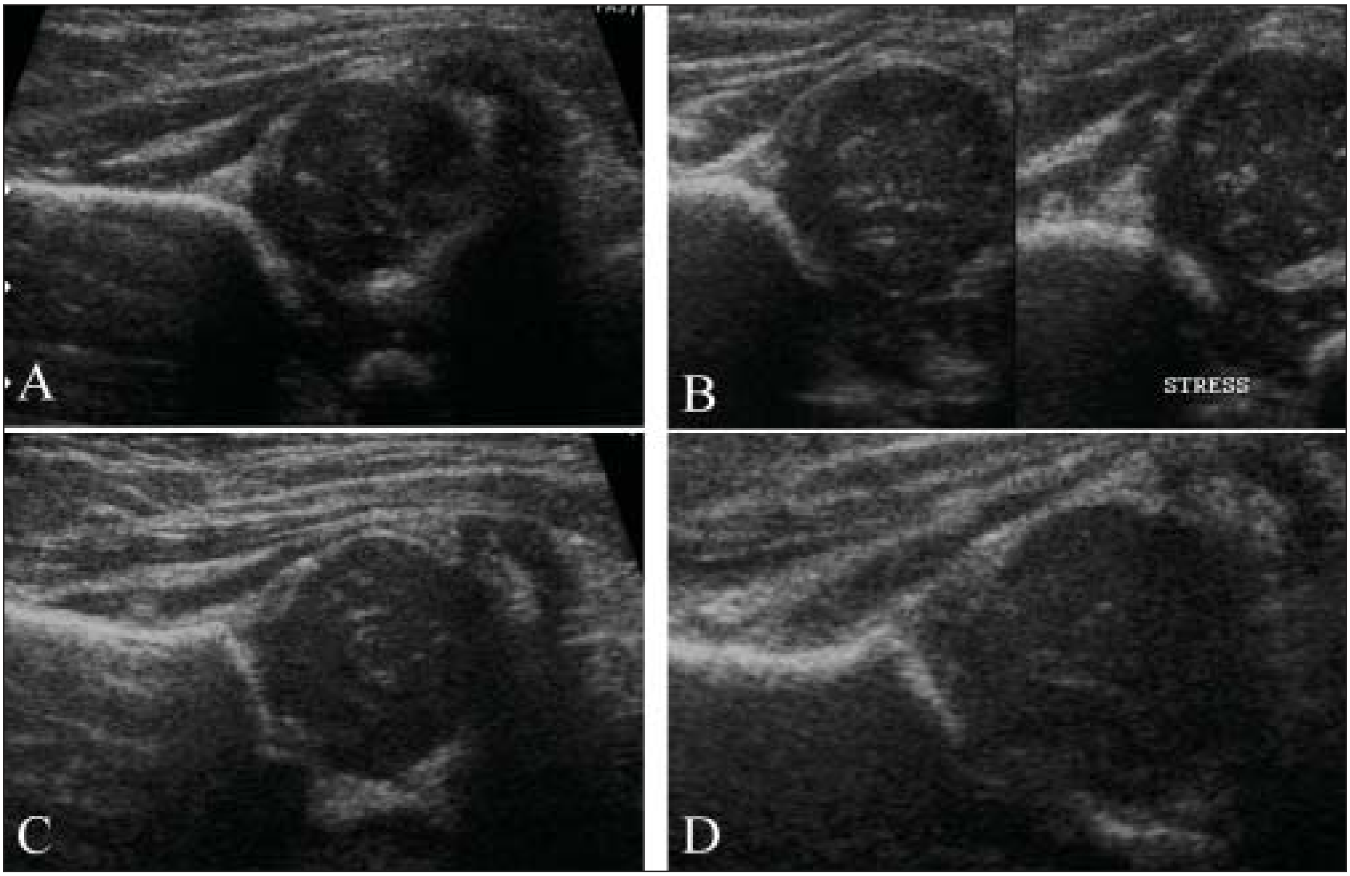

Figure 13 (A-D): Hip dislocation with reduction. Coronal USG of the left hip shows subluxation (A) with stable reduction after 5-weeks in a Pavlik harness (C). Coronal USG of the right hip (B) shows subluxability after stress with stable reduction after 5-weeks in a Pavlik harness. Note the improved acetabular slope after reduction

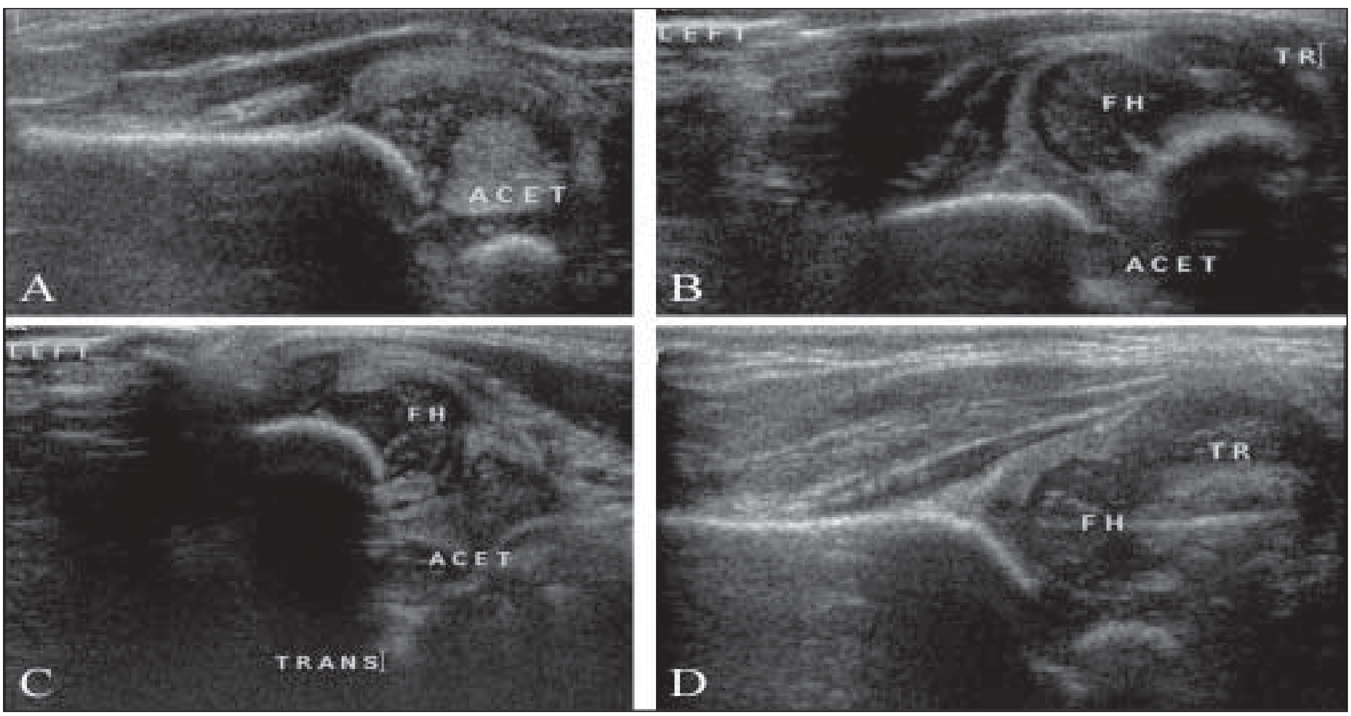

Figure 14 (A-D): Hip dislocation with reduction. Coronal USG image (A) shows an empty acetabular cavity with dislocation of the femoral head seen in the coronal (B) and transverse (C) images. Follow-up coronal USG (D), after 5 weeks in a Pavlik Harness shows stable reduction. Note the improved slope of acetabulum

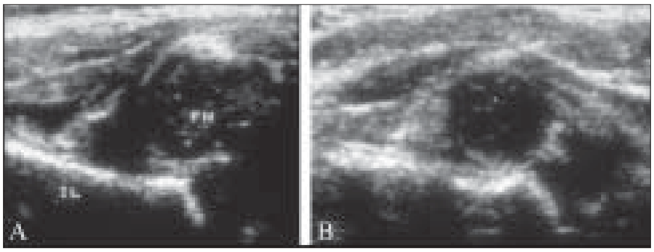

Figure 15 (A,B): PFFD. Coronal USG of the normal left hip (A) and the abnormal right hip (B), showing the smaller right femoral head

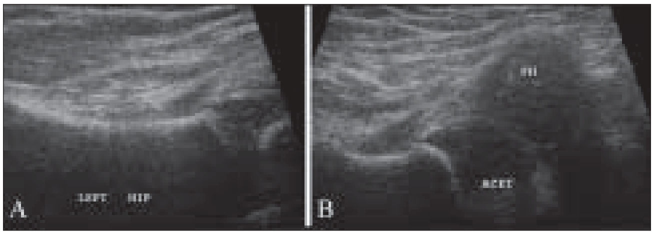

Figure 16 (A,B): PFFD. Coronal USG of the left hip (A) shows absence of the femoral head A more inferior view (B) shows how the greater trochanter (labeled as FH) can be mistaken for the femoral head. Acet - acetabulum

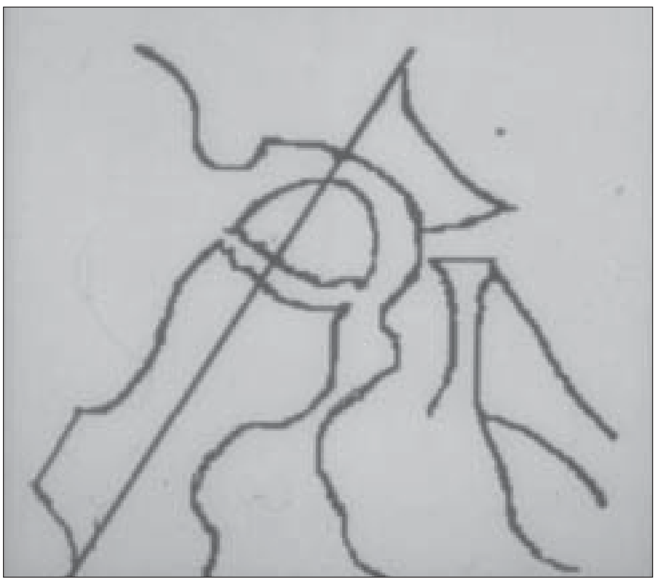

Figure 17: Scanning plane for hip joint effusion detection. The scan plane is oriented along the long axis of the femoral neck. The acetabular brim, femoral head, femoral neck and the ilio-femoral ligament should be included

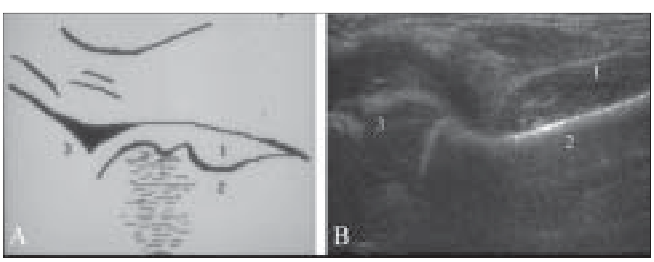

Figure 18 (A,B): Diagram (A) and USG image (B) showing the normal appearance along the long axis of the femoral neck. The landmarks are the acetabular brim,[3] the femoral head and the anterior cortex of the femoral neck[2] and the ilio-femoral ligament[1]

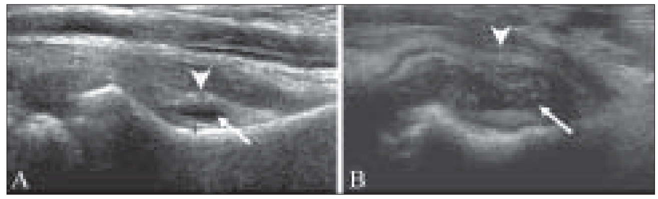

Figure 19 (A,B): Hip effusion. Longitudinal USG images in two different patients show a small effusion (arrow in A) and a large effusion (arrow in B), with synovial thickening, causing anterior bulging of the anterior capsule (arrowheads)

supplemental examination in some cases.

Sonographic evaluation of hip effusion: The radiologic work-up of a child with a painful hip begins with a plain radiograph. The presence of effusion is a valuable but non-specific indicator of joint pathology and is seen in various conditions such as inflammatory processes, trauma, osteonecrosis, reactive synovitis etc. USG can detect very small amounts of intra-articular fluid. It is more sensitive than plain radiographs in diagnosing hip effusions and it rules out other causes such as subcutaneous edema, abscesses, tenosynovitis etc. It is however not always possible to differentiate between septic, traumatic and sterile effusions. Diagnostic and therapeutic aspirations can be undertaken under USG guidance. USG is useful in follow-up; reduction of the quantity of joint effusion is a sign of positive response to therapy.[17-19]

Examination Technique: The patient lies in the supine position with the hip in the neutral position or in 15-20° internal rotation (external rotation and flexion decompress the anterior recess of the joint space leading to false negative results). The scan is oriented along the long axis of the femoral neck [Figure 17], which shows the acetabular brim, femoral head, femoral neck and the ilio-femoral ligament.[17] The contralateral hip is always examined for comparison.

Sonographic appearance of effusion: The anterior cortex of the femoral head and neck are important landmarks [Figure 18]. The joint capsule normally has a concave contour that parallels the femoral neck. In the presence of effusion, the joint capsule / ilio-femoral ligament is displaced anteriorly and the anterior contour becomes convex [Figure 19]. The fluid-filled hypoechoic space seen between the cortex of the femoral neck and the ilio-femoral ligament increases to more 5 mm. Asymmetry of 2 mm or more as compared to the contralateral hip is considered significant [Figure 20]. In a large effusion, fluid may be seen extending above the femoral head. Fluid with internal echoes, synovial irregularity and capsular thickening indicate the presence of septic arthritis [Figure 21A]. Considerable synovial thickening and irregular contours with destruction of the femoral head may also be seen [Figure 21B].

In a neonate, septic arthritis often presents with clinical signs

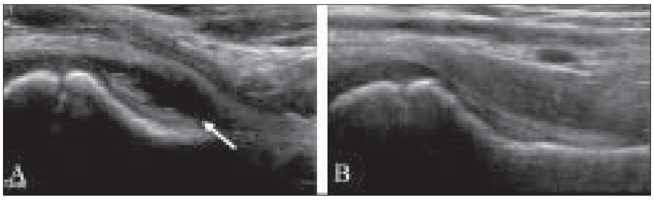

Figure 20 (A,B): Hip effusion. Longitudinal USG image (A), in a patient with effusion, shows an anterior recess of 7.3 mm (arrow). Note the normal contralateral hip (B)

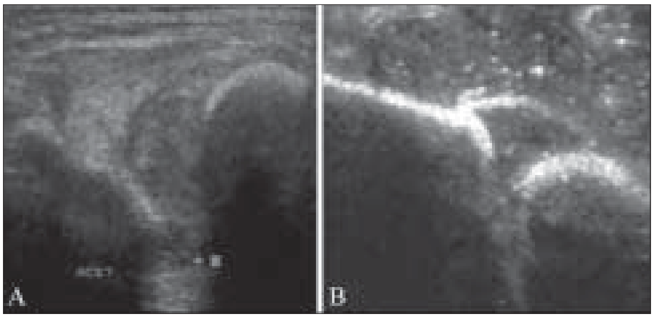

Figure 21 (A,B): Septic arthritis. Longitudinal USG in a patient with mild-to-moderate disease (A) shows synovial thickening and partial destruction of the femoral head. Longitudinal USG in a patient with severe disease (B) shows thick echogenic pus in the joint with complete destruction of femoral head

of subluxation. The presence of joint effusion and synovial thickening helps to make a diagnosis. Septic arthritis may also be associated with osteomyelitis of the femur and may present with a subperiosteal collection and/or a soft tissue abscess [Figure 22]. Absence of internal echoes does not rule out septic arthritis and aspiration of the fluid is mandatory in clinically suspected infective joint disease. If hip aspiration is negative despite a positive sonogram, a larger caliber needle may be required. Anechoic fluid is seen in transient synovitis and usually resolves after 6 weeks.

Color Doppler imaging: Color Doppler[20] may be help in assessing the integrity of the blood supply to the proximal femoral epiphysis. Epiphyseal flow can be identified in the normal femoral epiphysis. Diminished or absent flow has been described as a risk factor for avascular necrosis. The deep capsular vessels and ascending cervical artery of the femoral neck can be evaluated on Doppler USG in more than 60% of cases. The resistivity index (RI) is age–independent and independent of the etiology of effusion, though it correlates with the amount of effusion. RI increases with the amount of effusion. A power Doppler USG may reveal increased flow in the capsule in inflammatory arthritis.[12,16-18] However, several studies have also shown that increased

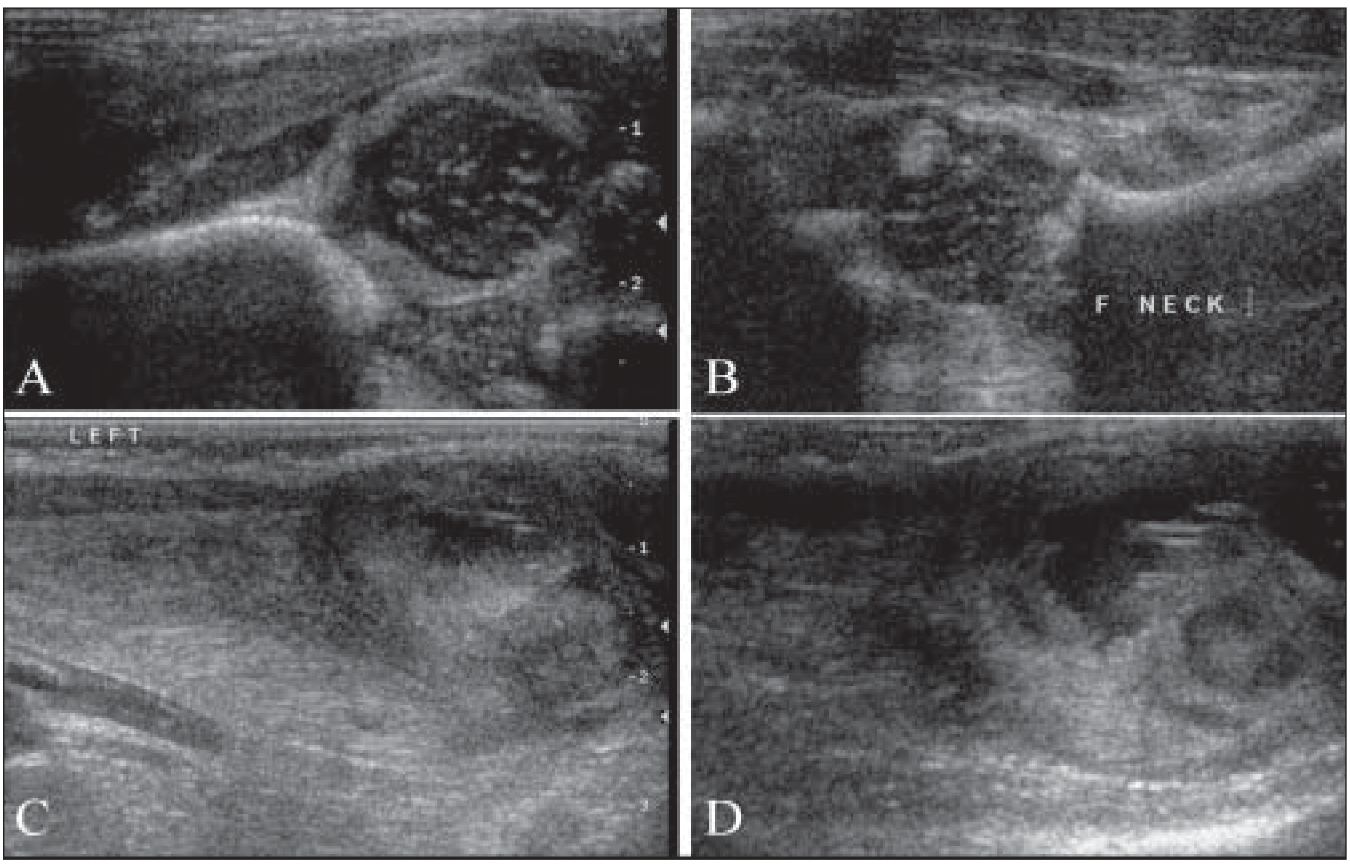

Figure 22 (A-D). Septic arthritis. Coronal USG (A) shows subluxation of the femoral head with synovial thickening. Longitudinal USG (B) shows fluid in the anterior ilio-femoral recess. Femoral osteomyelitis with a subperiosteal collection and soft tissue abscess are also seen (C, D)

flow is not necessarily seen in patients with septic arthritis; hence, a normal flow on power Doppler USG does not exclude septic arthritis and should not preclude aspiration, when clinically warranted.

3D USG: This is a promising technique for evaluating DDH. 3D projection offers imaging in the sagittal and cranio-caudal projections, hence there is better demonstration of the position of the femoral head with respect to the acetabulum. However, the three-dimensional technique is limited by technical factors such as slow data acquisition and suboptimal reconstruction. Therefore, it is not considered practical yet for routine use.

Conclusion

USG is an extremely useful tool for the evaluation of some pediatric hip diseases. In the assessment of infants with DDH, it is the imaging modality of choice; both for diagnosis as well as for the assessment of therapeutic efficacy. Its role in a child with a painful hip is limited to documenting the presence of joint effusion and in guiding aspiration. USG cannot reliably differentiate between sterile and infected effusions and is not a substitute for plain radiographs and bone scan, in the work up of hip pain. Its role in other conditions is limited. The role of color Doppler and 3D USG is at present limited.

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