# INFANT HIP SONOGRAPHY

I. **Patient Preparation:**

A. Patients less than 3 months of age

1. Infant relaxed and cooperative as possible.
2. NPO 2-3 hours prior to exam to allow scanning during or immediately following feeding.
3. Nursing infants may be given glucose and water bottle.
4. Keep warm with blankets, use warm gel and examine neonates in isolette.
5. Infant is bolstered with rolled towels.
6. Clothing from the waist down is removed.

B. Patients greater than 3 months of age

1. Infant may still be NPO prior to exam to allow scanning during or immediately following feeding.
2. Can be entertained with mobiles, toy, Mom and Dad.
3. Can be distracted with bottles and pacifiers.
4. Keep warm with blankets and use warm gel.

II. **Equipment:** Performed with real-time scanner using a linear transducer with a frequency ranging from 5.0-7.5 MHz. The highest frequency transducer that provides adequate penetration of the soft tissues to the depth required should be used.

A. Newborn to 6 weeks - 7.5 MHz
B. 6 weeks and up - 5.0-7.5 MHz depending on depth needed
C. Imaging depth - 4.5 to 6.0 cm

III. **Procedure Protocol:**

**A. Scanning Procedure**

1. Two sonographers available in room is optimal, one technologist performing the dynamic portion of the examination, and one to aid in filming and annotation.
2. The patient's left hip is scanned with the sonographer's right hand, while manipulation of the hip is performed with the left hand.
3. The patient's right hip is scanned with the sonographer's left hand, while manipulation of the hip is performed with the right hand.
4. Image orientation:
   Transverse: orientation is such that lateral is at the top of the image, anterior is to the left and posterior is to the right
   Coronal: orientation is such that lateral is at the top of the image, superior/cranial is to the left and inferior/caudal is to the

right

5. Annotation:
   a. right or left hip
   b. transducer orientation is coronal or transverse with respect to the body/acetabulum
   c. knee position is labeled neutral when the leg is physiologic extension and flexion when flexed at a 90 degree angle

**B. Patient Positioning / Standard Images:**

- *The dynamic ultrasound of the infant hip is performed in real-time while observing the movement of the femoral head within the bony acetabulum.*
- **A *displacement of up to 6mm in infants younger than 2 weeks is considered normal.***
- *Representative images during this procedure are as follows:*

1. Transverse Neutral Position:
   a. The patient is in a supine or slight posterior oblique position away from the side of interest with leg in physiologic extension (neutral physiologic hip position is usually approximately 15 to 20 degrees of hip flexion).
   b. The transducer is oriented in a transverse plane to the torso, and positioned in a lateral approach over the femoral head.
   c. Normal Landmarks: **Lateral -** femoral head centered over the triradiate cartilage
      **Anterior/Medial –** pubis with a bright, short echo
      **Posterior/Medial -** ischium with a bright long echo
      **Triradiate Cartilage –** hypoechoic echo with through transmission centered between bony pubis and ischium

2. Transverse Flexion Position:
   a. The patient is rolled into a slight posterior oblique position away from the side of interest. (LPO for examination of the right hip, RPO for examination of the left hip)
   b. The patient position is supported with a rolled towel.
   c. The leg is flexed to 90 degrees.
   d. The transducer is oriented in a transverse plane to the pelvis/torso, and is placed extremely posterior on the buttocks, directly over the femoral head.
   e. Normal Landmarks: **Anterior –** bright echo from femoral

bony metaphysic/shaft
**Posterior –** bright echo from bony Ischium
(2 landmarks are in a "U" configuration with femoral head within '(U")

3. Transverse Flexion Position with Abduction:
(patient and transducer position as in #2; a deep "U" configuration is maintained)

4. Transverse Flexion Position with Adduction:
(patient and transducer position as in #2; bony femoral metaphysic and ischium now forma more shallow "V" configuration )

5. Transverse Flexion Position with Adduction and Push Maneuver: (patient and transducer position as in #2; a gentle posterior push maneuver is performed on the infant's knee; "V" configuration is maintained)

6. Coronal Flexion Position:
   a. The patient is rolled into a slight posterior oblique position away from the side of interest. (LPO for examination of the right hip, RPO for examination of the left hip)
   b. The leg is flexed to 90 degrees.
   c. The transducer is placed on the posterolateral portion of the hip and is oriented in a coronal plane to the torso/pelvis at the midacetabular level.
   d. Normal Landmarks: **Superior -** straight (horizontal) iliac line/tip of echogenic labrum (the transducer position should be adjusted at this time so that the margin of the iliac bone appears as a straight, bright, horizontal line); at least 50% of the femoral head should be seen within the acetabulum or medial to the horizontal line drawn from the lateral margin of the iliac bone through the femoral head)
   **Medial -** medial border of acetabulum/ischium
   **Lateral –** femoral head shown at its widest point

7. Coronal Flexion Position/Posterior Lip:
   (patient position is maintained as in #6)
   a. The transducer position begins as in #6, the is moved posteriorly in a coronal plane over the posterior lip of the acetabulum.
   d. Normal Landmarks: **Superior -** straight (horizontal) iliac line **Medial**

– hypoechoic triradiate cartilage **Lateral –** portion of femoral head

**Inferior –** bright echo of bony ischium

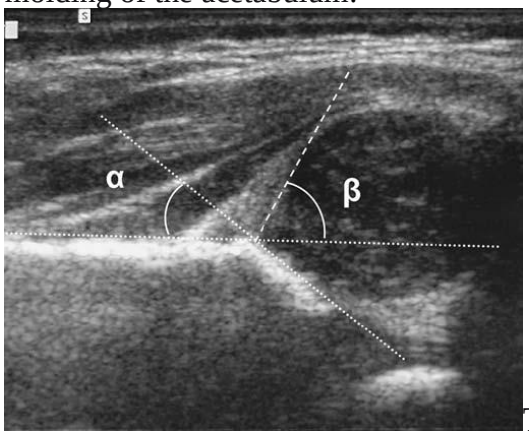
8. Coronal Flexion Position/Posterior Lip with Push Maneuver: (patient and transducer position as in #7)
    a. A gentle posterior push maneuver is performed with the infant's knee.
    b. Normal Landmarks: as in # 7

C. **Acetabular Angle Measurements**

- *measurements for "C thru E" are taken in the coronal flexion position*
- *see attached representative images for "C thru E"*

Alpha Angle

a. indicative of slope of bony acetabulum
b. the wider the angle, the more mature the acetabulum, indicating more extensive femoral head coverage
**c.** full maturity indicated by an angle measuring 60 degrees or larger. In infants less than 3 months of age alpha angle between 50 to 60 degrees is considered physiologic, but needs to be followed for observation; after 3 months of age, this indicates delayed ossification. An alpha angle less than 50 degrees is abnormal at any age and indicates deficient bone molding of the acetabulum.

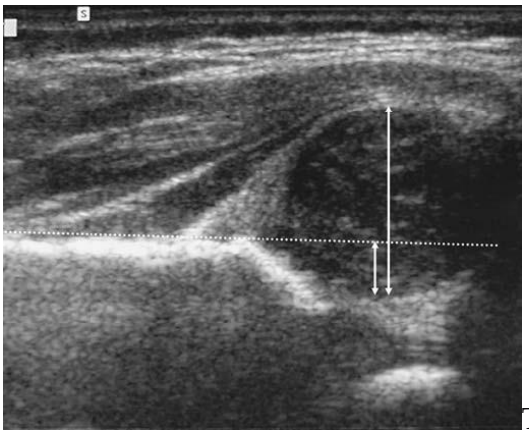
**d.** 

The α angle is the angle between the iliac line and the tangent to the acetabular roof and indicates how mature the acetabulum is. The β angle is formed between the iliac line and a line tangent to the cartilaginous labrum, drawn from the promontory to the edge of the labrum. Like the acetabular coverage, the beta angle shows the displacement of femoral hip. The beta angle should measure less than 55 degrees to be considered normal. If the beta angle is greater than 77 degrees, labral eversion and hip subluxation exist. Intermediate beta angle

values are associated with late ossification and an immature hip.

**D. Acetabular Coverage of the Femoral Head**

- *cannot be performed in a dislocated hip*

1. calculated by the equation (d/D) x 100; whereas "d" =the space from the iliac line/baseline to the medial aspect of the femoral head and "D" = the maximum diameter of the femoral head
2. a coverage of 58% or more is considered normal
3. a coverage of 33% or less is considered abnormal
4. intermediate values are indeterminate
5. values are not related to patient's age.
6. This measurement is indicative of the acetabular cartilaginous roof coverage and is secondary in significance to the alpha angle.
7.  The acetabular coverage is calculated by drawing a line tangent to the edge of the ilium (the iliac line). The percentage of femoral coverage is found by dividing the distance between this line and the medial aspect of the femoral head by the maximum diameter of the femoral head

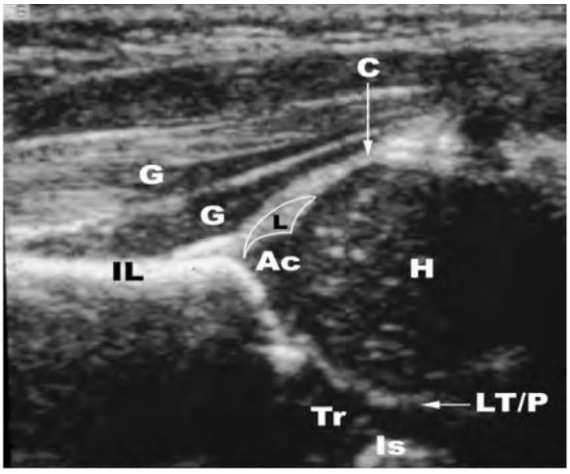
E. **Acetabular Cartilage Thickness**

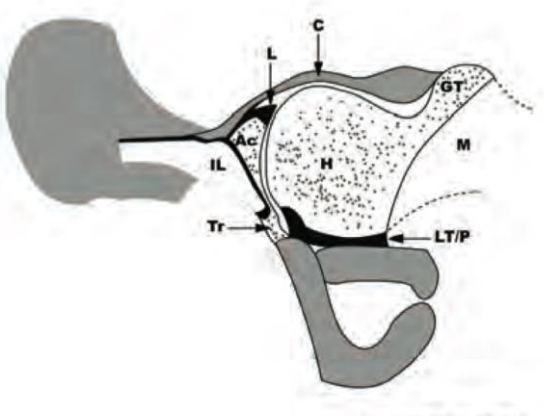
1. increased thickness of cartilaginous acetabular triangle in cases of DDH
2. measurement is made along the iliac baseline
3. measurement is taken from the bony promontory to the upper/superior aspect of the femoral head
4. abnormal values measure above 3.5 mm

F. **Sonographic Evaluation in Restraint Devices**

1. Restraint devices maintain hips in flexion and abduction.

2. Sonographic evaluation is limited to transverse flexion and coronal flexion views.
3. The transverse neutral view is eliminated.
4. Stress maneuvers are only performed upon request, and are usually done at the conclusion of treatment when weaning from the harness is being undertaken.
5. **Avascular Necrosis**
   a. complication of treatment of DDH when positional abduction restraints are used
   b. performed in coronal flexion view with patient in contralateral oblique position
   c. flow evaluated during abduction and adduction
   d. spectral Doppler tracings from vessel within the femoral head, and the terminal medial circumflex artery (MCA) in the superior intertrochanteric notch are performed



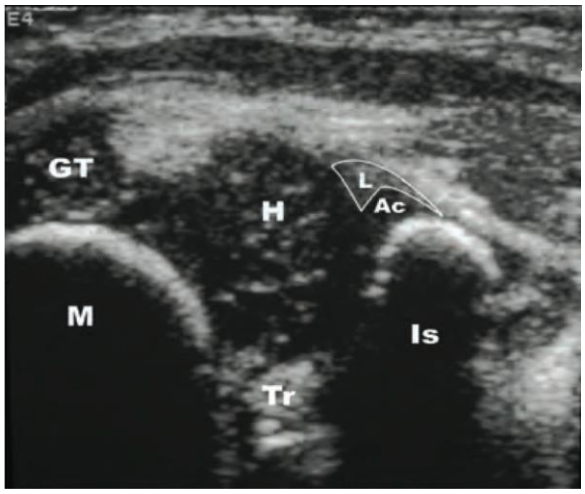



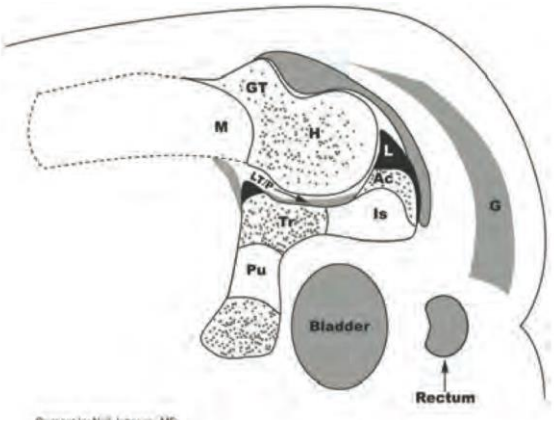

Coronal view of the hip joint in the standard plane with the hip in the physiologic neutral position (usually 15 to 20 degrees of hip flexion)

| | |
|---|---|
| Ac | Acetabular cartilage |
| C | Capsule |
| G | Gluteus muscles |
| GT | Greater trochanter |
| H | Cartilaginous femoral head |
| IL | Ilium |
| Is | Ischium |
| L | Labrum |
| LT/P | Ligamentum teres/pulvinar complex |
| M | Femoral metaphysis |
| Tr | Triradiate cartilage |

The proper coronal view (whether the femur is in the neutral or flexed positions) must contain three elements (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 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. 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. The bony acetabulum is formed by the ilium, ischium and the pubis, separated by the triradiate cartilage.

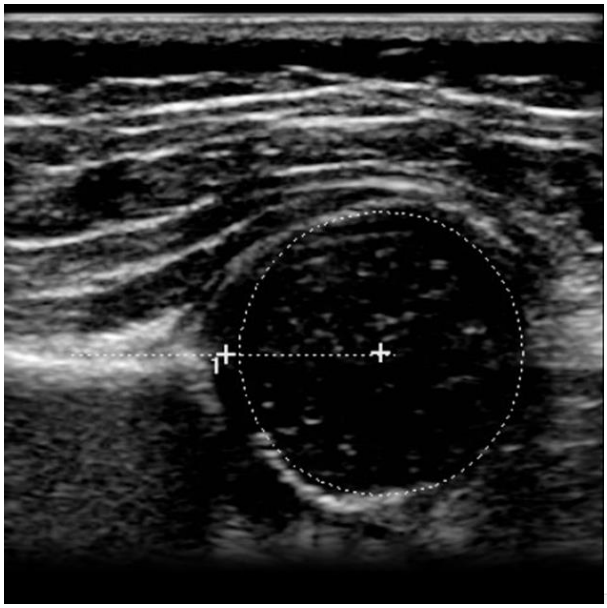



Transverse view of the hip flexed 90 degrees at the hip

| | |
|---|---|
| Ac | Acetabular cartilage |
| G | Gluteus muscles |
| GT | Greater trochanter |
| H | Cartilaginous femoral head |
| Is | Ischium |
| L | Labrum |
| LT/P | Ligamentum teres/pulvinar complex |
| M | Femoral metaphysis |
| Pu | Pubis |
| Tr | Triradiate cartilage |

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.



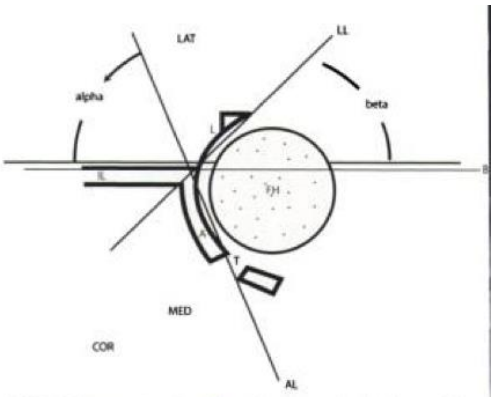



**Fig. 8.7.** Diagram showing hip anatomy on standard coronal ultrasound plane and lines used to evaluate hip dysplasia using the Graf method. The femoral head (*FH*) is centred over the hypoechoic triradiate cartilage (*T*). The promontory is at the junction of the iliac wing (*IL*) and the bony acetabular roof (*A*). *L*, labrum. The alpha angle reflects the depth of the bony acetabular roof and is formed by the intersection of the baseline (*BL*) and acetabular roof line (*AL*). In a normal mature hip the alpha angle is greater than 60°. The beta angle reflects cartilaginous coverage and is formed by the intersection of the baseline with the labral line (*LL*). A normal beta angle is less than 55°

**Fig. 8.8.** Standard coronal ultrasound of the normal infant hip joint. The promontory is sharply defined and the bony acetabular roof is steep. The ossification centre for the femoral head has not yet developed

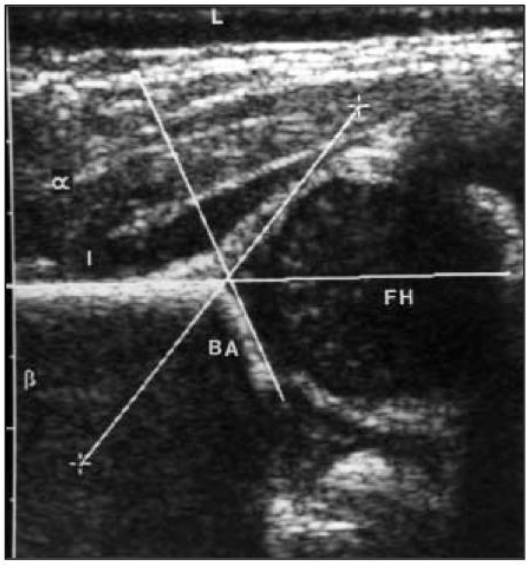



***FIGURE 8.*** *Coronal section in the "standard plane" of a normal hip, oriented in the way the ultrasound equipment displays it. Alpha angle = 67°, Beta angle = 49° = superior, L = lateral, I = ilium, BA = bony acetabulum, FH = femoral head.*

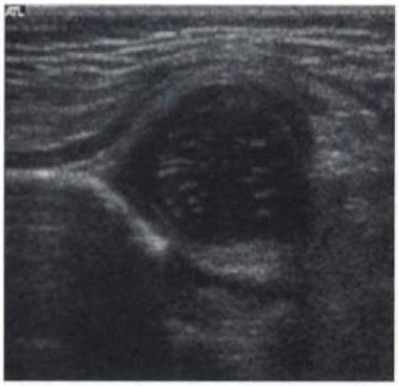


**Fig. 8.9.** Coronal ultrasound of an immature hip with a rounded flattened promontory indicating a shallow acetabulum. Continuation of the baseline here does bisect the femoral head and in this position (adduction) the femoral head is not significantly subluxed

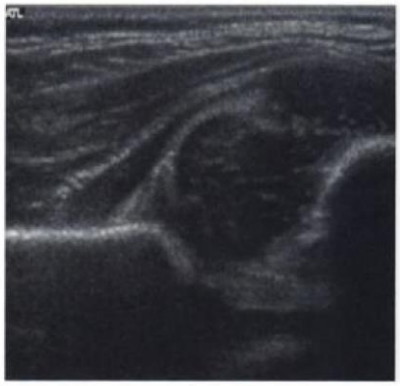


**Fig. 8.10.** Coronal ultrasound of an immature, subluxed hip. The promontory is slightly rounded and approximately 25% of the femoral head is within the bony acetabulum. The left femoral head is decentred

**Fig. 8.11.** Decentred femoral head on coronal ultrasound. Less than 25% acetabular coverage. The femoral head is significantly displaced from the bony acetabular roof with echogenic material interposed. Appearances suggest labral inversion

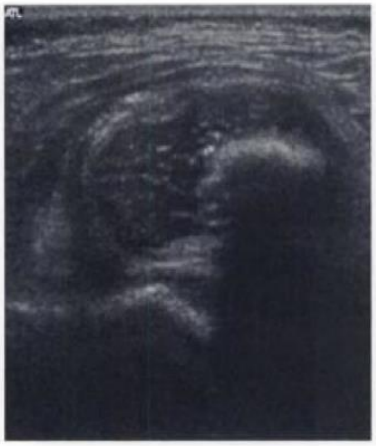
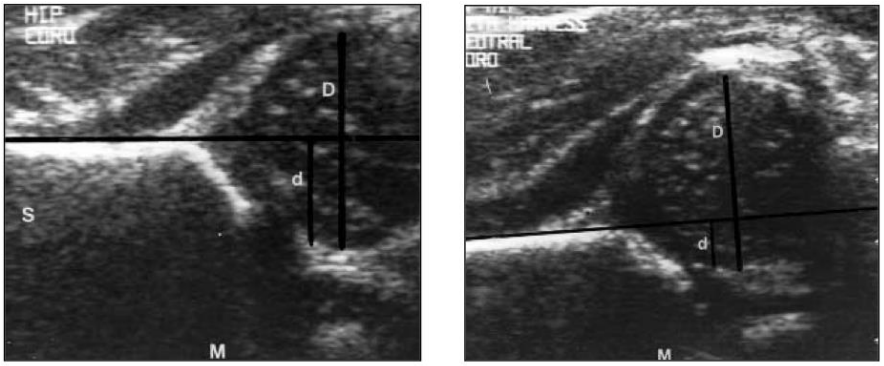


**Fig. 8.12.** Dislocated hip on coronal ultrasound. The femoral head is not aligned with the acetabulum and is seen posterolaterally, beneath the gluteal muscles




A B

***FIGURE 12.*** *Acetabular coverage (AC) of the femoral head. (A) A newborn male with a normal hip. AC = 50%. (B) A 10-day-old female with a subluxed hip. AC = 27%, d = segment of femoral head covered by the acetabulum, D = femoral head diameter, S = superior, M = medial (reprinted, with permission, from: Gerscovich EO: A radiologist's guide to the imaging in the diagnosis and treatment of developmental dysplasia of the hip. II. Ultrasonography: anatomy, technique, acetabular angle measurements, acetabular coverage of femoral head, acetabular cartilage thickness, three-dimensional technique, screening of newborns, study of older children. Skeletal Radiol 26:447-456, 1997).*

## References:

1. The Use of Sonography in Screening for Developmental Dysplasia of the Hip; AJR 1994; 162:399-400
2. Screening Newborns for Developmental Dysplasia of the Hip: The Role of Sonography; AJR 1994: 395-397
3. Sonographic Diagnosis of Developmental Dysplasia of he Hip: Importance of Increased Thickness of Acetabular Cartilage; AJR 993; 161:839-842
4. Performing Dynamic Sonography of the Infant Hip; AJR 1990; 155:837-844
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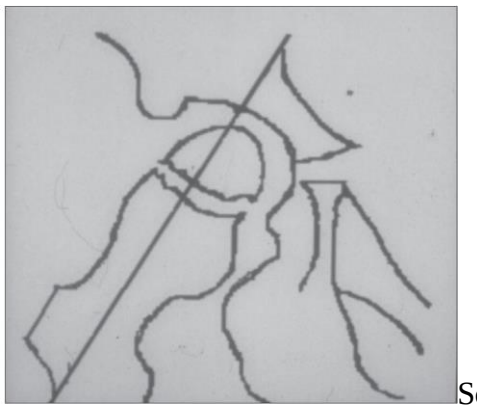
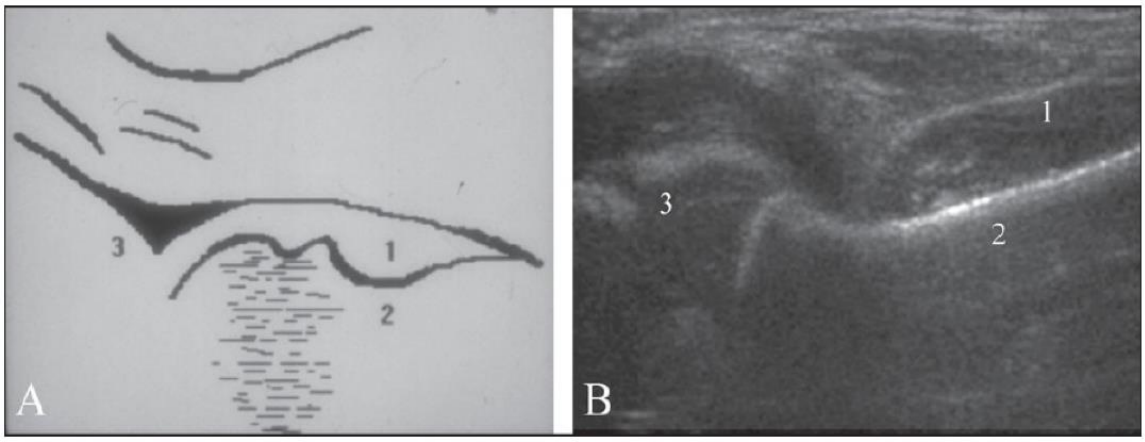
7. A Radiologist's Guide to Imaging in the Diagnosis and Treatment of Developmental Dysplasia of the Hip: I. General considerations, physical examination as applied to real-time Sonography and radiography; Skeletal Radiol (1997) 26: 386-397
8. A Radiologist's Guide to Imaging in the Diagnosis and Treatment of Developmental Dysplasia of the Hip: II. Ultrasonography: anatomy, technique, acetabular angle measurements, acetabular coverage of the femoral head, acetabular cartilage thickness, three-dimensional technique, screening of newborns, study of older children; Skeletal Radiol (1997) 26: 447-456.
9. Clinical Sonography: A Practical Guide; 3' Edition; Saunders R.
10. Diagnostic Ultrasound 2nd Edition-, Rumack C, Wilson S, Carboneau J; pp 1799-1814

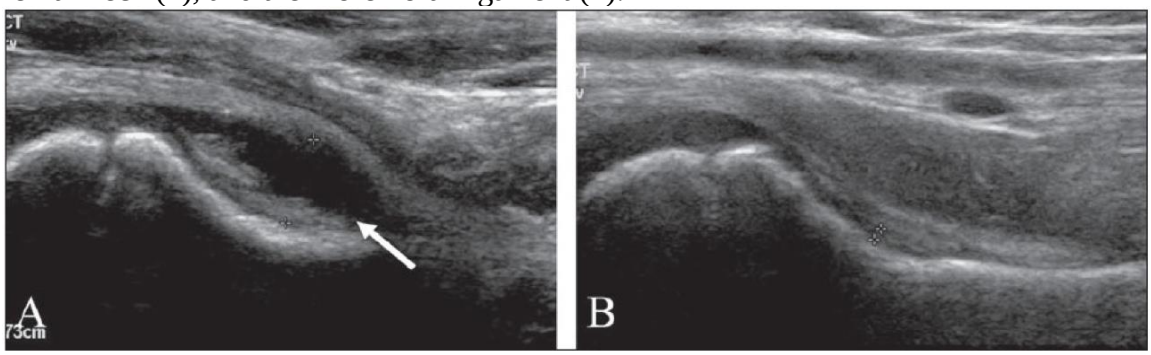
IV. Special circumstances

1. Infant hip effusion
    a. 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.
    b. Ultrsound cannot always possible to differentiate between septic, traumatic and sterile effusions. Diagnostic and therapeutic aspirations can be undertaken under USG guidance
    c. 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 , which shows the acetabular brim, femoral head, femoral neck and the ilio-femoral ligament. The contralateral hip is always examined for comparison
    d. Sonographic appearance of effusion: The anterior cortex of the femoral head and neck are important landmark. 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. 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. 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. Considerable synovial thickening and irregular contours with destruction of the femoral head may also be seen

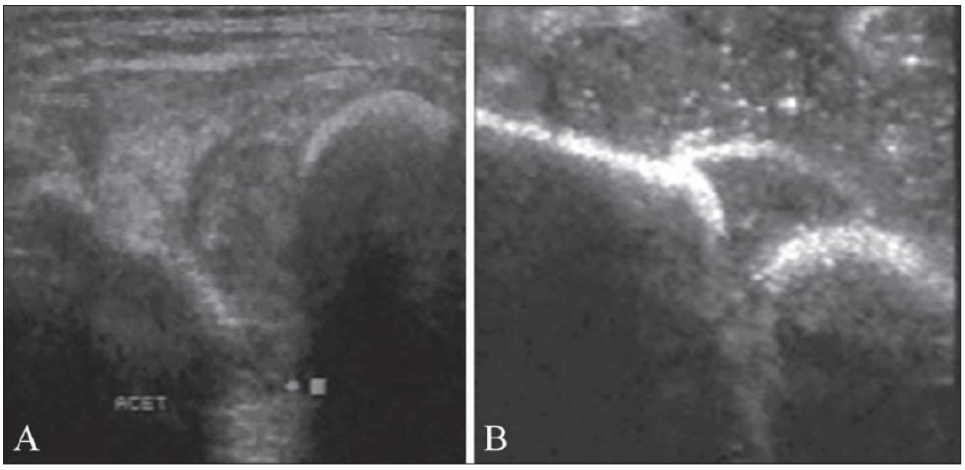
e.  Scanning plane for hip effusion detection. The acetabular brim, femoral head, femoral neck and the ilio-femoral ligament should be included.

f. 

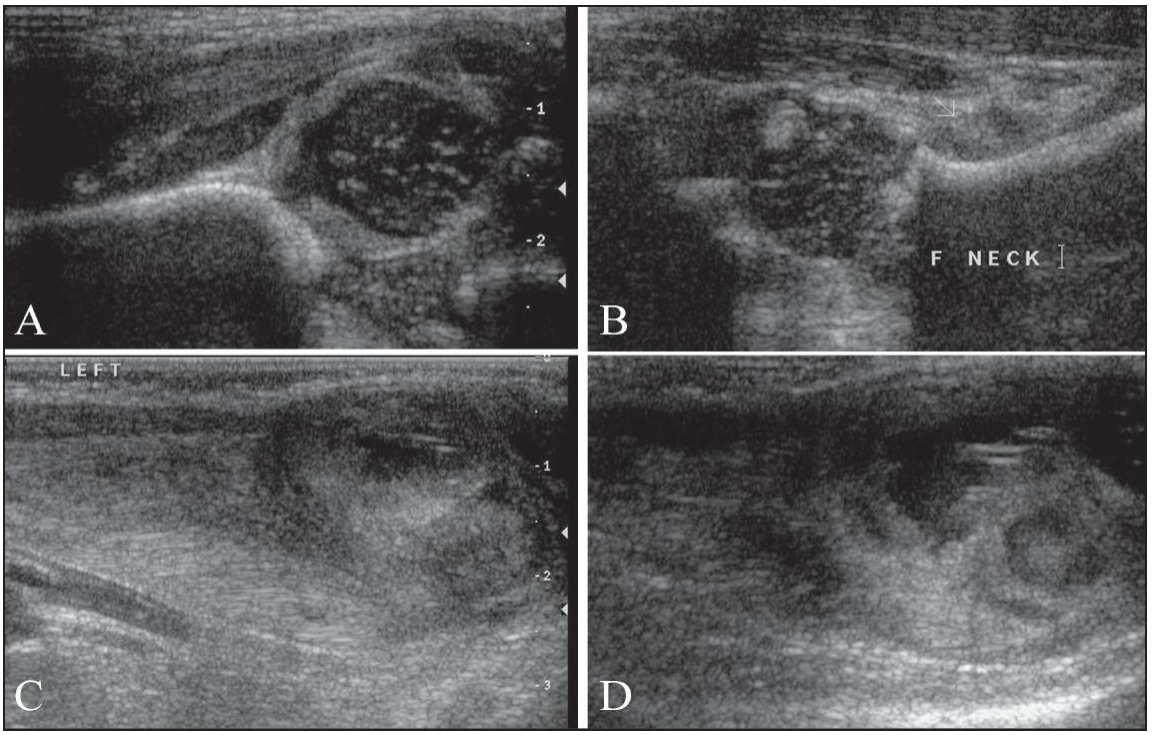
Normal appearance of the long axis of the femur neck. The landmarks are the acetabular brim, the femur head (3), and the anterior cortex of the femur neck (2), and the iliofemoral ligament (1).

g. 

In the patient with a hip effusion (A), shows an anterior recess of 7.3mm(arrow). Note the normal contralateral hip (B).

h. 

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

i. 

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)

j. In a neonate, septic arthritis often presents with clinical signs 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. 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.