

Pediatric Hip Imaging - An Overview.

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Abstract

Pathologies of hip require specialized imaging techniques in pediatric age-group not only due to their common occurrence but also due to lack of ossification with consequent suboptimal evaluation on routine radiographs. The common abnormalities affecting pediatric hip joint are septic arthritis and developmental dysplasia. The prime requirement of any imaging technique in pediatric age-group is lack of radiation, noninvasive & inexpensive nature and reproducibility. Though in majority of cases, clinical examination and radiographs are sufficient for management yet in many cases of clinical dilemma, high-resolution ultrasonography and magnetic resonance imaging may be needed for confirmation. This article discusses the role of imaging in major pediatric hip pathologies with their merits and demerits.

Keywords: Pediatric, high-resolution ultrasonography, magnetic resonance imaging, hip

Introduction

Children with hip pathology may present with pain or a limp, a young child with an irritable hip poses a diagnostic challenge. In children, hip pathology is unique because of growing pediatric skeleton as in Perthe's disease, slipped capital femoral epiphysis and apophyseal avulsion fractures, hence their evaluation and management requires thorough history and physical examination.

In children especially less than 5 years where localization of disease may be difficult due to poor communication, imaging plays a vital role in diagnosis of musculoskeletal pathologies. The differential diagnosis can be made on the basis of age and clinical features.

Hip joint is one of the most commonly involved regions in children affected by congenital and acquired pathologies. Imaging of hip can be done with the help of:

1. Conventional radiographs
2. Ultrasonography (USG)
3. Computed Tomography (CT) scan
4. Magnetic Resonance Imaging (MRI)

Two other modalities with limited use in pediatric populations are Arthrography and Radionuclide Bone Scintigraphy.

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High-resolution USG (HRUS) is a noninvasive imaging immensely useful in children in visualisation of muscles, tendons, ligaments, joints, vessels and nerves. It is useful in imaging of painful joints, tendon tears, fluid collections, benign and malignant soft tissue masses, foreign body, fracture and callus formation especially in lower age group as well as joint dislocations.

Another added advantage of HRUS is that it assists in guided therapeutic intervention, as in joint effusion aspiration, soft tissue mass biopsy, fracture / joint relocation, hematoma drainage, etc.

HRUS has limitations in form of operator dependence; limited dynamic examination in painful joint due to suboptimal positioning and requirement of proper machine / infrastructure.

Conventional

Normal anatomy – Hip bone also known as innominate bone is made up of ilium, ischium and pubis bones. Hip joint is ball and socket type of synovial joint, where acetabulum forms socket and head of femur forms the ball of joint. Acetabulum is formed by two-fifth ischium, two-fifth ilium and one-fifth pubis united by the triradiate cartilage (figure 1).

To assess the normal congruency of pediatric hip joint following arbitrary lines need to be assessed carefully on standard anteroposterior (AP) film of pelvis (if possible in standing position) as well as frog's view:

Hilgenreiner line (YY line) - drawn through the center of the triradiate cartilage on both sides.

Perkin's line - drawn through the superior lateral aspect of the acetabulum perpendicular to the YY line

Normal Anatomy: the YY and Perkin's lines intersect each other at right angle in normal hip joint anatomy (figure 2). The acetabular angles (33-38 degrees; higher than 47 degree indicates dysplasia) should be symmetrical on both sides with smooth Shenton line (an imaginary line drawn through the inferior margin of superior pubic ramus or obturator foramen passing continuously & smoothly along the inferior & medial border of neck of femur) (figure 3 & 4).

Klein's line drawn through superior & lateral cortex of femoral neck normally intersects lateral 1/3rd of the femoral epiphysis, whereas in slipped capital upper femoral epiphysis, no part of the epiphysis lies lateral to this line (figure 5).

HRUS

It has achieved acceptance in diagnostic hip radiology not only because of its real time evaluation & lack of radiation but also in cartilage pathologies & its ability to guide effusion-aspiration. Detailed anatomy of hip can be observed by static and dynamic techniques which incorporate motion and stress maneuvers that are based

on accepted clinical methods.

Examination Technique

A linear-array, high-resolution transducer with a frequency of 7.5-10 MHz in infants and 5-7.5 MHz for ages above one year should be used. Sonographically, the normal cartilaginous femoral head and greater trochanter is echopoor with fine-stippled, homogeneous internal echoes. Ossification center for femoral head is highly echogenic and becomes visible by 2-8 months of age.

Bony acetabulum appears as a linear echogenicity with distal acoustic shadowing. Fibrocartilaginous labrum appears as an echogenic triangle, caudal and lateral to the hypoechoic hyaline cartilage.

The joint capsule and ligaments are visualized as echogenic fibrous structures, which are closely approximated and cannot be separated visualised on HRUS.

HRUS hip should be done in two orthogonal planes from lateral approach i.e. coronal and transverse with respect to the bony pelvis. The anterior approach in the parasagittal plane parallel to the femoral neck is used for evaluation of joint effusion (figure 6).



Figure 1: Line diagram of hip bone shows contribution of three bones in formation of acetabulum as well as triradiate cartilage

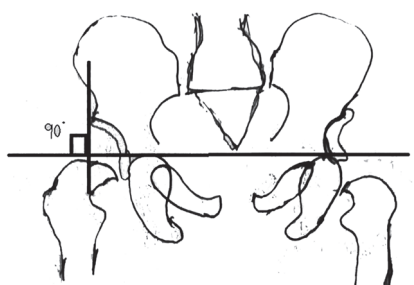


Figure 2: Line diagram of pelvis shows relationship of YY & Perkin's lines in normal pediatric hip.

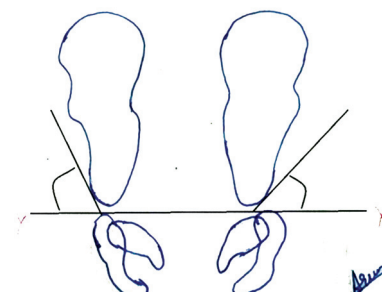


Figure 3: Line diagram of pelvis shows evaluation of acetabular angles with their comparison on two sides of midline.

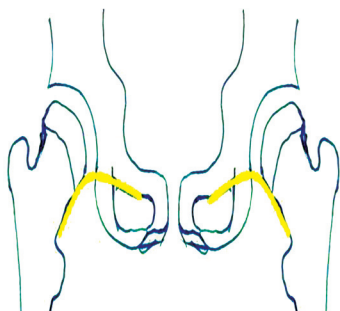


Figure 4: Line diagram of pelvis shows evaluation of Shenton's line with their comparison on two sides of midline.

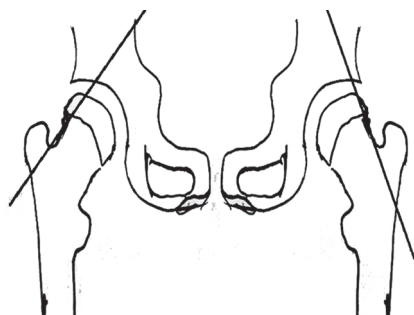


Figure 5: Line diagram of pelvis shows evaluation of Klein's line in slipped capital upper femoral epiphysis.

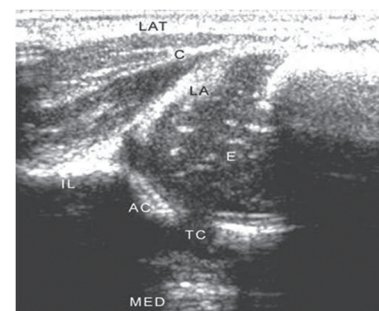


Figure 6: HRUS image of normal hip in coronal view shows normal relationship of acetabulum & femoral head with normal structures [IL (Ilium), AC (Acetabulum), LA (Labrum), C (Capsule), TC (Triradiate cartilage)].

HRUS can detect as little as 1 ml of fluid and all cases of septic arthritis have effusion. On Color Doppler, increased vascularity can be seen on septic arthritis especially on Power Doppler differentiating it from sterile synovitis.

Computed Tomography (CT) scan

Though it is avoided in pediatric population, yet if required should be performed with Pediatric low-dose protocols tailored for individual cases. It is useful in providing bony details.

Magnetic Resonance Imaging (MRI)

MRI with no known deleterious biological effects, lack of radiation, high soft-tissue contrast resolution is superior to any other modality in imaging of musculoskeletal pathologies, hence it is often used as a final or problem solving tool.

The common pediatric hip disorders include:

1. Dislocation (developmental dysplasia of the hip – DDH; traumatic).
2. Hip disorders causing effusion & painful hip (septic arthritis, tubercular arthritis, transient synovitis)
3. Miscellaneous (Legg-Calve-Perthe's disease, slipped capital femoral epiphysis, proximal focal femoral deficiency, rotational deformities)

Imaging in DDH

AP radiograph of pelvis in neutral position with hips slightly flexed in infants (<3-4 months) is usually normal. However, once femoral head ossifies, radiographs become more reliable. The superoinferior and lateral displacement of the femur can be determined by Perkin's line while Shenton's line is disrupted in cases of dislocation.

On HRUS, the baby is positioned in neutral position (hip in approximately 20° of flexion with slight internal rotation) and the transducer is positioned over the greater trochanter and held perpendicular to the skin & parallel to the table to obtain a coronal image of the acetabulum. Then measurement of alpha and beta angles is done to measure the degree of acetabular inclination & lateral subluxation of femoral head respectively (figure 7). Alpha angle should be greater than 60 and Beta angle should be less than 55 for normal hip joint.

CT is primarily useful in postoperative period as it can be performed even when patient is with cast / plaster) and in complex cases for the assessment of concentricity of closed reduction; detection of iliopsoas muscle deformity & intra-articular soft tissue obstacles when the surgical procedures are contemplated and determination

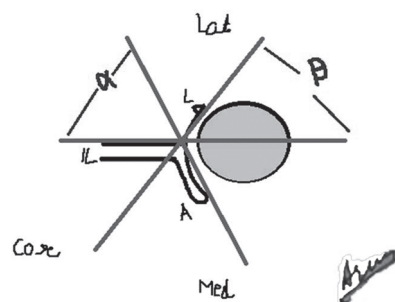


Figure 7: Line diagram of normal hip corresponding to coronal view of HRUS showing calculation of alpha & beta angles in dysplastic disease of hip.

of femoral torsion as well as acetabular configuration.

MRI is used as a problem solving tool in

- (i) Complex dysplasia,
- (ii) Inadequate response to treatment,
- (iii) Late presentation and
- (iv) Teratological dislocation. Axial and coronal T1 weighted MR images are most useful.

The Painful Hip

It is potentially a serious condition and presents a diagnostic challenge since clinical differentiation between septic arthritis; transient synovitis and Perthes' disease may be difficult. The principle concern being able to distinguish sepsis from other conditions as untreated sepsis can destroy the hip within few days making the role of imaging pivotal in the management of such cases. Demonstration of joint effusion with increased vascularity on HRUS suggests septic arthritis that may guide aspiration in equivocal cases.

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