An Insight of Ultrasonographic Findings in Developmental Dysplastic Hip

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Abstract

Background: The exact incidence of DDH is difficult to determine because of a discrepancy in definition of the condition, type of examination used and different levels of skills of clinicians. The incidence ranges from as low as 1 per 1,000 to as high as 34 per 1,000. Higher incidences are reported when ultrasonography is also used in addition to clinical examination. Risk factors include first born status, female sex, positive family history, breech presentation and oligohydramnios. Carter and Wilkinson reported an overall incidence of one per 1,000 live births, with one in 600 girls and one in 4,000 boys having the disorder. Other associated factors include ethnic background (e.g., native Americans who use swaddling that forces the hips into extension and adduction), torticollis and lower limb deformity. Ultrasound screening and monitoring of families with DDH history contributed to early DDH diagnosis and therefore earlier treatment, which over time led to a rapid decrease in THAs. In case of late diagnosis, chances of long-term complications rise exponentially, and this fact leads to a higher possibility of needing surgery. Although the diagnosis of DDH is characteristic for an early age, diagnoses in adolescence or adulthood are not unusual

Keywords: Developmental Dysplastic Hip, Ultrasonography

Introduction

The exact incidence of DDH is difficult to determine because of a discrepancy in definition of the condition, type of examination used and different levels of skills of clinicians. The incidence ranges from as low as 1 per 1,000 to as high as 34 per 1,000. Higher incidences are reported when ultrasonography is also used in addition to clinical examination. Risk factors include first born status, female sex, positive family history, breech presentation and oligohydramnios. Carter and Wilkinson reported an overall incidence of one per 1,000 live births, with one in 600 girls and one in 4,000 boys having the disorder. Other associated factors include ethnic background (e.g., native Americans who use swaddling that forces the hips into extension and adduction), torticollis and lower limb deformity **(1 ,2)**.

Ultrasound screening and monitoring of families with DDH history contributed to early DDH diagnosis and therefore earlier treatment, which over time led to a rapid decrease in THAs. In case of late diagnosis, chances of long-term complications rise exponentially, and this fact leads to a higher possibility of needing surgery. Although the diagnosis of DDH is characteristic for an early age, diagnoses in adolescence or adulthood are not unusual **(3)**.

According to literature, DDH incidence in newborns considerably varies with geographical location from lowest in Africans, to highest in Native Americans and Caucasian population. The global incidence can roughly be estimated to 0.1–6.6 cases per 1000 live births and is responsible for up to 30% of primary THAs in people up to 60 years of age **(4)**. Variations in incidence considering geographical location can be caused by epigenetic factors, consanguinity rates or study limitations, e.g., group size and diagnostic methods used. Compared to the general population in families with DDH history, the incidence was increased sevenfold between siblings and tenfold in the parents of probands. The concordance rate frequency (identical pathology in twins) was 33–41% for identical twins (monozygotic) and 3–8% for dizygotic twins **(5)**. Since there is more knowledge available about this topic, various countries have reported improvement in DDH incidence over the years **(6)**.

Although we do not know the exact etiology of DDH, we know of risk factors, that contribute to the incidence of primary or secondary hip dysplasia. presents these risk factors (genetic, epigenetic, mechanical and other) that include a number of areas that are not statistically significant but may be of clinical importance nevertheless **(7)**.

Ultrasound of
Developmental Dysplastic Hip (DDH)

Hip Ultrasound was the first and most successful application of Ultrasound in the musculoskeletal system. In the late 1970s, Dr. Graf was the first to realize the potential of Ultrasound over plain radiography for visualizing the non-ossified femoral cartilage and introduced the use of static Ultrasound for evaluation of infant hip dislocation. **(8)**.

Ultrasound allows high-resolution, portable, multi-planar and dynamic evaluation of hip joints, making it an easy and widely used examination in infants. **(9) .**

The sensitivity and specificity of Ultrasound for the diagnosis of hip dysplasia is nearly 100%. Ultrasound has become the golden standard for confirming the diagnosis and guiding treatment. Several ultrasound techniques have been promoted but Graf methods have been shown to be superior to others **(10)**.

Ultrasonography is the recommended imaging modality in infants <4months old because the infant hip is predominantly cartilaginous, precluding clear radiographic visualization. Ultrasonography allows for the visualization of the femoral head location relative to the acetabulum and specific anatomic parameters, such as the depth of the acetabulum and inclination of the acetabular roof. Key ultrasound measures are depicted in **(11).**

Examination technique:

Equipment:

Imaging is conducted with a linear transducer. 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*. (16), (12)**

Static (Graf's) Technique:

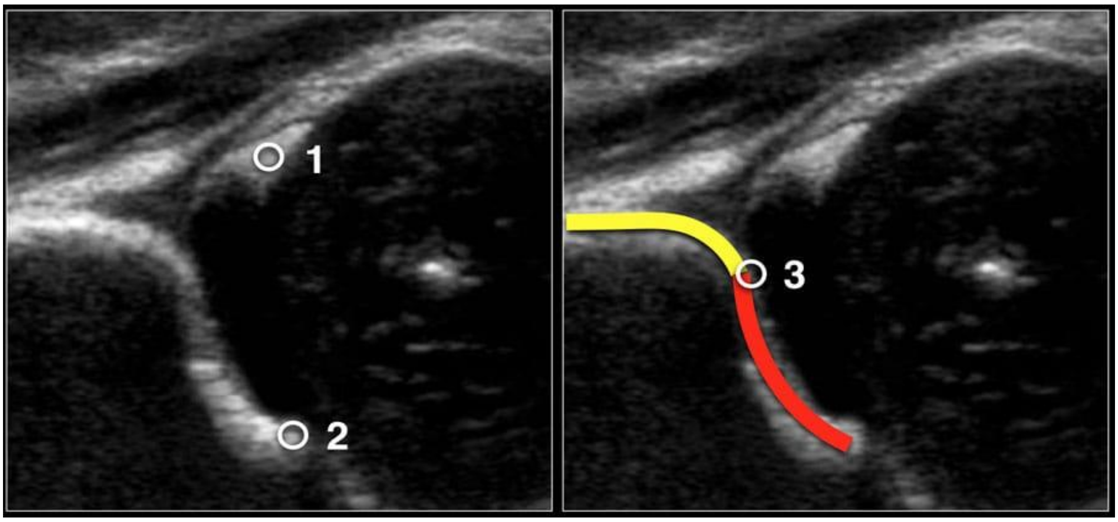
The examination is based on a single coronal image of the hip obtained with a linear array transducer with particular attention to the position of the hip.

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 through the middle of the acetabular roof. **(13)**.

Measurement

This "standard plane" is identified by the presence of the following three points:

1. Center of the labrum
2.The lower limb of the iliac bone.
3.The bony rim of acetabular



Measurements made on this coronal view are the "alpha" and "beta" angles. Some machines have software for measuring Graf's angle. The alpha and beta angle measurements are used to indicate the degree of acetabular development. 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 1[st] and 3[rd] 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. **(12).**

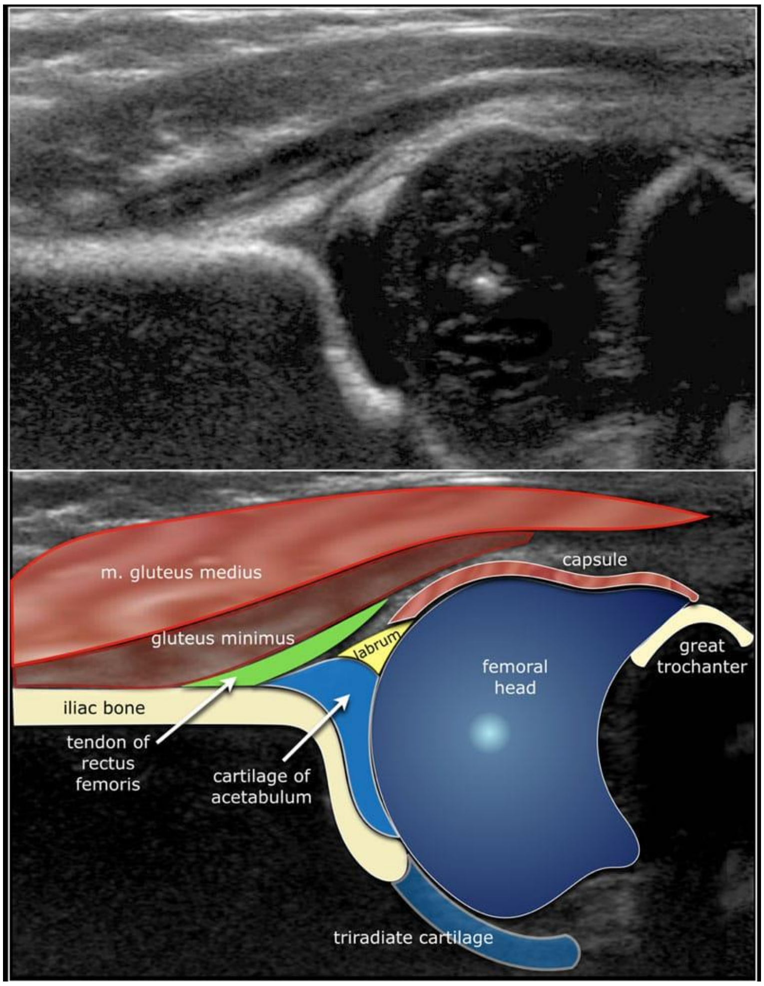


Fig. 1: Anatomy of the coronal plane.

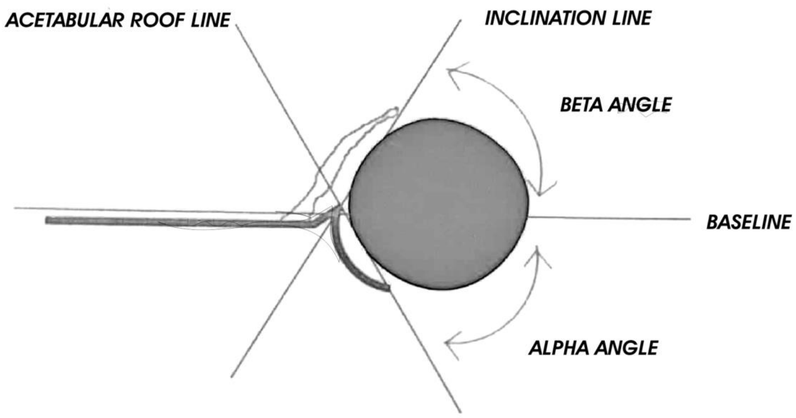


Fig. 2: Calculation of the alpha and beta angles to assess acetabular maturity, a standard coronal image is used. **(8)**

Hip type	Description	Bony roof	Bony rim	Cartilage roof	α angle	β angle	Subtype
Type I	Mature hip	Good	Angular/ blunt	Covers the femoral head	≥60°	<77°	Ia: β ≤ 55° Ib: β >55°
Type IIa	Physiologically immature (age ≤3 months)	Deficient	Rounded	Covers the femoral head	50°-59°	>55°	IIa+: α = 50°-59° (at 6 weeks of age) IIa-: α = 50°-54° (at 6 weeks of age)
Type IIb	Delay of ossification (age >3 months)	Deficient	Rounded	Covers the femoral head	50°-59°	>55°	
Type IIc	Critical hip	Severely deficient	Rounded to flattened	Still covers the femoral head	43°-49°	<77°	IIc stable: under pressure β <77° IIc unstable: under pressure β >77°
Type D	Decentring hip	Severely deficient	Rounded to flattened	Displaced	43°-49°	>77°	
Type III	Dislocated hip	Poor	Flattened	Pressed upwards, perichondrium slopes cranially	<43°		IIIa: hypoechoic cartilage acetabular roof IIIb: hyperechoic cartilage acetabular roof
Type IV	Dislocated hip	Poor	Flattened	Pressed downwards, perichondrium is horizontal or dips caudally	<43°		

(Fig. 3). Graf sonographic grading for DDH **(14).**

Anatomy and Interpretation:

The diagnostic examination of the infant hip incorporates two orthogonal views. In the coronal and transverse views, certain landmarks must be visible, and lines drawn from these landmarks help evaluate acetabular development and position of the femoral head. **(12)**.

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. **(15)**
The bony acetabulum is formed by the ilium, ischium and the pubis, separated by the triradiate cartilage. The landmarks seen in the coronal view are thus articular capsule, acetabular labrum, bony promontory, lower iliac margin, cartilaginous femoral head, "Y" cartilage and greater trochanter. **(16)**
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. **(17)**

Fig.4: Technique for coronal (longitudinal view hip US). The child is lying on the side with flexed knee. **(18)**

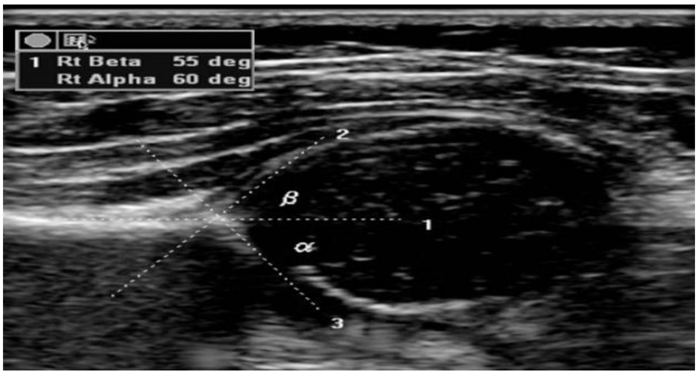


Fig.5: Calculation of the alpha and beta angles to assess acetabular maturity, a standard coronal image is used. **(8)**

The walking child may also present with a Trendelenburg gait (trunk till toward the affected hip when weight is applied) if there is a unilateral dislocation or a waddling gait (trunk tilt toward the weight-bearing side, alternating throughout the gait cycle) if there is bilateral dislocation. For infants who are Ortolanipositive or older children with any of the above examination findings, further diagnostic evaluation can be obtained **(18).**

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The imaging modality can be performed in a static or dynamic manner. In a static study, researchers examine the joint anatomy (ie, the shapes and relations between the femoral head, acetabulum, and labrum). During a dynamic ultrasonography, hip joint stability is assessed by performing the manipulative stress maneuvers under direct imaging observation. Ultrasonography can be used for both initial infant screening of DDH and monitoring of patients with DDH undergoing active treatment. The femoral head ossification nucleus is visible radiographically at ∼4 to 6 months of age. Hence, radiographs are not recommended for DDH evaluations before 4 months of age. After ∼6 months of age, radiographs are the preferred method of evaluating and monitoring DDH after femoral head ossification more reliably appears **(16).**

Ultrasonographic Pathology

US Findings in DDH

Graf's classification includes 4 grades of DDH. However, for practical purposes, the hip joint can be classified as normal, immature, or abnormal. The normal hip has a sharp acetabular roof with an alpha angle of more than 60°. In addition, more than 50% of the femoral head is covered by the acetabular fossa. In children younger than 3 months of age, the hip is classified as immature if the alpha angle is between 50 and 60°. Most of the immature acetabula, the femoral head is covered by the acetabular fossa will revert to normal without treatment. In all other cases, when the acetabular roof becomes rounded, there is 50% of coverage of the femoral head and the alpha angle is 50°, when the child is older than 3 months of age and the alpha angle is 60°, the child should be referred for treatment. When we identify a dislocated hip, we also evaluate if the hip can be reduced using the Ortolani maneuver Our pediatric orthopedists are also interested in knowing if the labrum is everted because this may change the treatment. **(18)**

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