

## Role of Ultrasound in Screening of Infantile Developmental Hip Dysplasia

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### Abstract

**Background:** Developmental Dysplasia of Hip (DDH) is the most common congenital musculoskeletal disorder in infants. Undiagnosed DDH result in shortening of the affected limb which affect the child's gait, decreased strength and increased risk of degenerative joint diseases in hip and knee joints. Hip ultrasonography provide an early diagnostic tool for DDH. Ultrasonography can provide detailed imaging of the hip before femoral head ossification.

**Aim of Study:** This study aims to highlight the role of ultrasound as a screening tool for infantile developmental dysplasia of hip joint.

**Patient and Methods:** 50 pediatric patients referred to Mansoura University Hospital and Mansoura University Children Hospital in the period from November 2016 till May 2018. They were 33 females and 17 male patients with their ages below 6 months. The minimum age was 2 weeks and the maximum age was 18 weeks and 3 days with mean of  $11.21 \pm 4.81$  weeks. All patients underwent ultrasonographic examination with measurement of Graf alpha and beta angles.

**Results:** The present study showed that the most prevalent referral cause is the cesarean section (44%) followed by oligohydraminos (22%) and positive family history (16%). The most detected hip type was Graf type I (52% in right hip and 50% in left hip) and the percentage of Graf type II was 44% in right side and 46% in left side while Graf type III was 4% in both sides.

**Conclusion:** Ultrasonography is a good tool for assessment the DDH mostly in high risk cases.

**Key Words:** *Developmental Dysplasia of Hip (DDH) – Ultrasound – Oligohydraminos.*

### Introduction

**DEVELOPMENTAL** Dysplasia of the Hip (DDH) represents a wide range of abnormalities in which the femoral head and acetabulum are in improper placement [1]. The spectrum includes dysplasia,

subluxation, dislocatable and dislocated hips. DDH can lead to premature degenerative joint disease, impaired walking, and chronic pain [2].

The cause of DDH is unknown, with a combination of genetic and environmental factors associated with DDH including family history, fetal crowding, vaginal delivery, breech presentation and female gender [3]. The hips of most newborns should be examined carefully after birth and during infancy to determine whether they are stable, unstable or dislocated. Screening for hip dysplasia may prevent the need for late treatment, which is associated with long term hip deformity, gait disturbance and arthritis [4].

The incidence of DDH ranges from 1-7% in newborns across several populations [5]. Variations exist and may be due to genetic predisposition and cultural practices. The reported incidence has increased significantly since the advent of clinical and sonographic screening, which suggests possible overdiagnosis [2].

The ultrasonographic examination has many advantages. It is safe, inexpensive, and easy to perform and does not involve ionizing radiation. The ultrasound examination enables one to distinguish the cartilaginous elements of the hip joint from the other soft tissue structures surrounding the joint. Ultrasonography can be performed at an earlier age than radiography, whereas reliable radiographic changes require waiting until the infant is 3 to 4 months of age [6].

### Patients and Methods

The current study included 50 cases of high risk infants for developmental dysplasia of the hip. Infants referred from Mansoura University Pediatric

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Hospital and pediatric outpatient clinics to the Radiodiagnosis Department in Mansoura University Hospital and Mansoura University Children Hospital.

All patients were subjected to:

- 1- Clinical assessment: Performed by colleges in pediatrics and orthopedics outpatient clinics.
- 2- Radiological assessment: Static hip ultrasonography.

All patients underwent:

1- History taking:

- A- Perinatal history including: Maternal disease and Oligohydramnios.
- B- Natal history:
  - Type and site of delivery.
  - If delivery is complicated or not).
  - Breech presentation.
  - Large baby.
  - Twins.
- C- Postnatal history: Crying, cyanosis, jaundice, resuscitative measures.
- D- Family history of hip developmental dysplasia.

2- Parents complains:

- A- Limb shortening.
- B- Limitation of hip movement (abduction).
- C- A symmetrical skin folds.
- D- Shortened thigh at one side.
- E- Other congenital anomalies as (foot deformity, torticollis, spina bifida with meningocele).

3- Clinical examination: Local examination of the hip joint was performed by pediatrician or pediatric orthopedic surgeon to detect signs of developmental dysplasia of the hip as:

- A- Limited abduction <70 degrees.
- B- Loss of normal mild hip/knee flexion.
- C- External signs as swelling or deformity, detection of areas of tenderness.

4- Ultrasound examination: Ultrasound examination was performed with 12MHz linear probe of General Electric healthcare (GE-S6) apparatus and Philips (IU22) apparatus using: The Graf static method.

The infants were examined in the decubitus position, hips and knees slightly flexed. In coronal view the standard plane is best defined when: A straight iliac bony interface, parallel to the transducer, a bony acetabular promontory, with bright

echoes at the lower end, the cartilaginous acetabular roof with an echogenic tip (fibrocartilaginous tip) at the point of the labrum.

Three lines were drawn:

- 1- The baseline: Runs along the lateral straight portion of the ilium.
- 2- The bony roof line: Is drawn tangentially from the lower limb of the os ilium to the bony rim of the acetabular roof.
- 3- The cartilage roof line: Is drawn from the bony rim through the center of the acetabular labrum.

The alpha ( $\alpha$ ) angle: The angle subtended by baseline through the iliac bone and tangential to the osseous roof of the acetabulum, represents the hard-bony roof and reflects the depth of the acetabulum. The values of the angle were recorded.

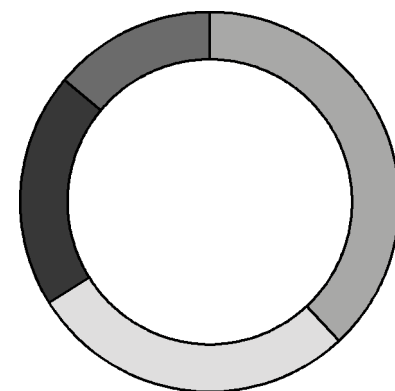
The beta ( $\beta$ ) angle: Subtended by a line drawn through the labrum and the iliac baseline line, represents the cartilaginous roof of the acetabulum and indirectly reflects the position of the femoral head and values of the angle were recorded.

**Results**

This study included 50 pediatric patients referred to Mansoura University Hospital and Mansoura University Children Hospital. They were 33 females and 17 male patients with their ages below 6 months. The minimum age was 2 weeks and the maximum age was 18 weeks and 3 days with mean of  $11.21 \pm 4.81$  weeks (Table 1) and Graph (1).

Table (1): Age and gender of cases

Age	Male	%	Female	%	Total	%
≤3 months	10	20	19	38	29	58
>3 months	7	14	14	28	21	42



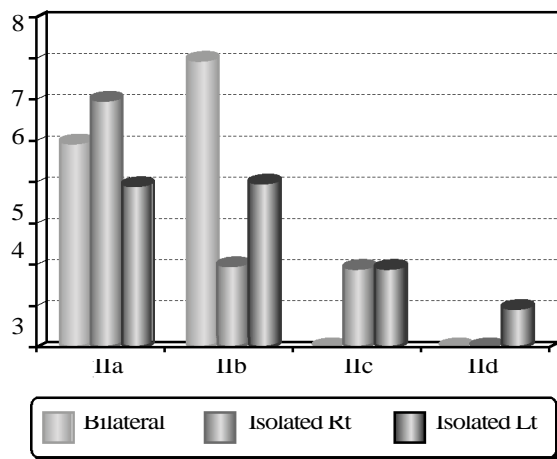
Female ≤3M	Female >3M
Male ≤3M	Male >3M

Graph (1): Age and sex distribution of cases.

The number and percentage of different Graf types in right and left hip joints presented as in (Table 2) and Graph (2).

Table (2): Number and percentages of Graf types (I, II and III) in right and left hips.

Right Hip type	Number	%	Right Hip type	Number	%
Graf I	26	52	Graf I	25	50
Graf II	22	44	Graf II	23	46
Graf III	2	4	Graf III	2	4
Total right hip	50	100	Total left hip	50	100

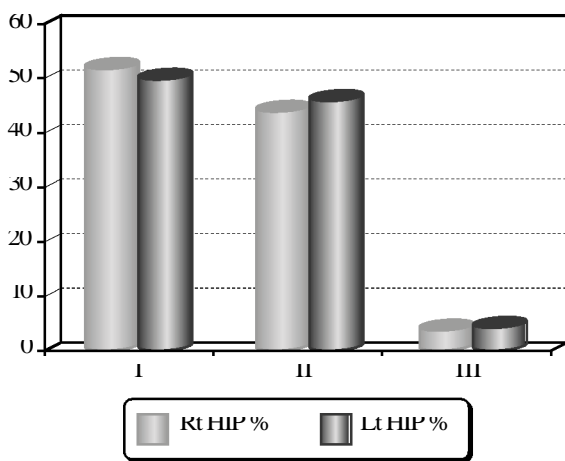


Graph (2): Representation of Graf types in right and left hip joints.

The subtypes of Graf II type of DDH were represented as (Table 3) and Graph (3).

Table (3): Subtypes of Graf type II and its representation (bilateral, right or left).

Graf Type II	IIa	IIb	IIc	IIId	Total
Bilateral	5	7	0	0	12
Isolated Rt	6	2	2	0	10
Isolated Lt	4	4	2	1	11



Graph (3): Subtypes of Graf type II and its representation (bilateral, right or left).

From different hip US referral causes (risk factors) cesarean sections were the most prevalent (44%) and positive Barlow test was the least common referral cause by 4% other referral causes and their percentage were as in (Table 4).

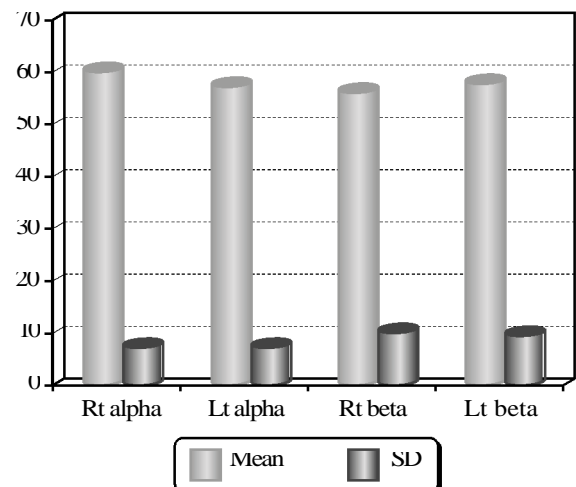
Table (4): Different hip US referral causes and their percentages.

Referral cause	Number	Percentage
• Positive family history of similar condition	8	16
• Associated congenital anomalies	6	12
• Maternal DM	6	12
• Oligohydramnios	11	22
• Cesarean section	22	44
• Limitation of abduction	8	16
• Positive Barlow tests	2	4
• Abnormal skin crease	5	10
• Twin	4	8

The mean value of alpha angle in the right hip joint was  $60.04 \pm 7.71$  and of left hip was  $57.42 \pm 7.30$ , while the value of beta angle in right hip was  $56.08 \pm 10.51$  and in left hip was  $58.24 \pm 9.95$  as in (Table 5) and Graph (4).

Table (5): Mean value of alpha and beta angles in both

US	Side	Mean $\pm$ SD	Range	
			Minimum	Maximum
Alpha angle	Right hip	$60.04 \pm 7.71$	31	75
	Left hip	$57.42 \pm 7.30$	39	68
Beta angle	Right hip	$56.08 \pm 10.51$	38	86
	Left hip	$58.24 \pm 9.95$	39	85



Graph (4): Mean value of alpha and beta angles in both hips.

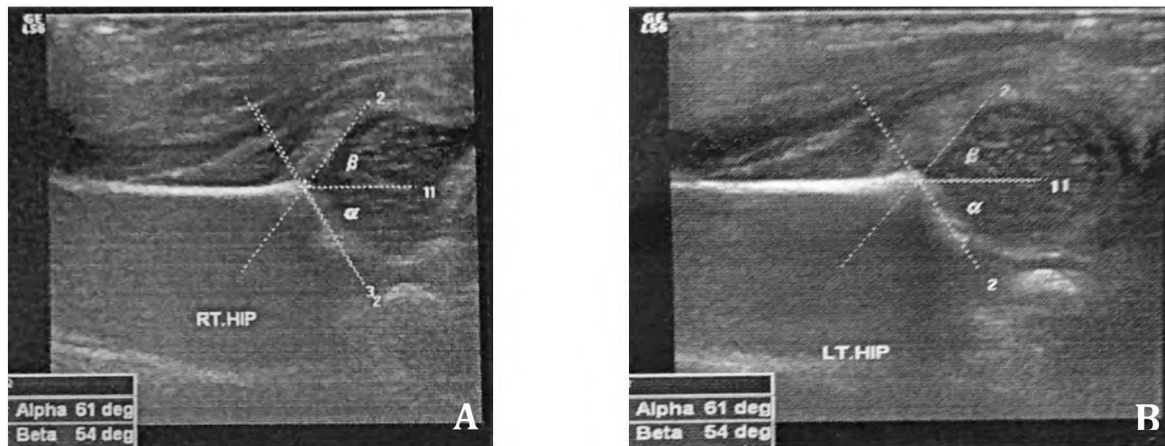


Fig. (1): (A & B): Ultrasound images, coronal scan of a 2 weeks and 1 day old male infant presented with positive family history of developmental dysplasia of hip (DDH): (A) Right hip sonogram showing the femoral head is round and of low echogenicity. Good bony roof and good coverage of femoral head by acetabular cartilage and labrum. The alpha angle (of Graf) measures  $61^\circ$  and the beta angle measures  $54^\circ$  indicating type Ia (mature hip sonogram) Fig. (1A). (B) Left hip sonogram showing the femoral head is round and of low echogenicity. Good bony roof and good coverage of femoral head by acetabular cartilage and labrum. The alpha angle (of Graf) measures  $61^\circ$  and the beta angle measures  $54^\circ$  indicating type Ia (mature hip sonogram) Fig. (1B).

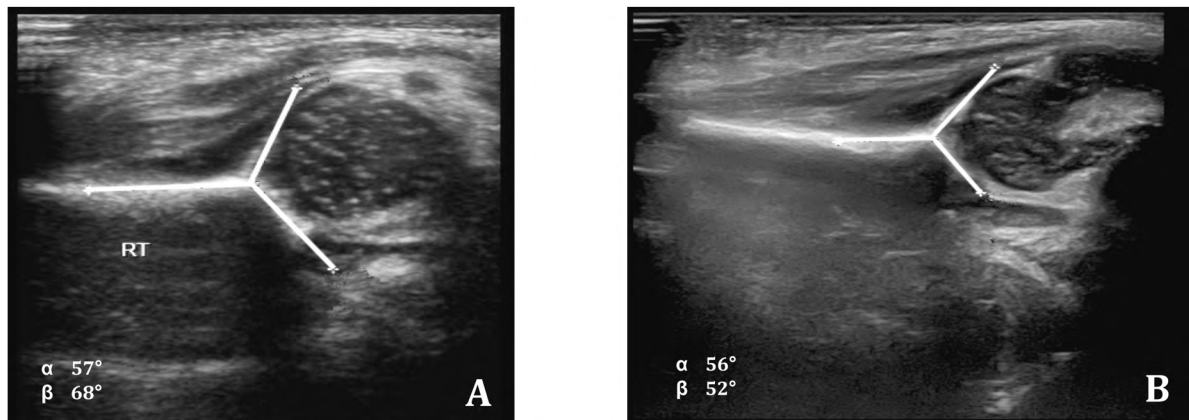


Fig. (2): Ultrasound images, coronal scan of a 16 weeks old female infant presented with limitation of abduction: (A) Right hip sonogram showing the femoral head is round and of speckled echogenicity. Bony acetabular roof is less well formed with blunted to rounded bony angle. Acetabular cartilage and labrum cover the femoral head. The alpha angle (of Graf) measures  $57^\circ$  and the beta angle measures  $68^\circ$  indicating type IIb (delayed in ossification and development) Fig. (2A). (B) Left hip sonogram showing the femoral head is round and of speckled echogenicity. Bony acetabular roof is less well formed with rounded to flat bony angle. Acetabular cartilage and labrum cover the femoral head. The alpha angle (of Graf) measures  $56^\circ$  and the beta angle measures  $52^\circ$  indicating type IIb (delayed in ossification and development) Fig. (2B).

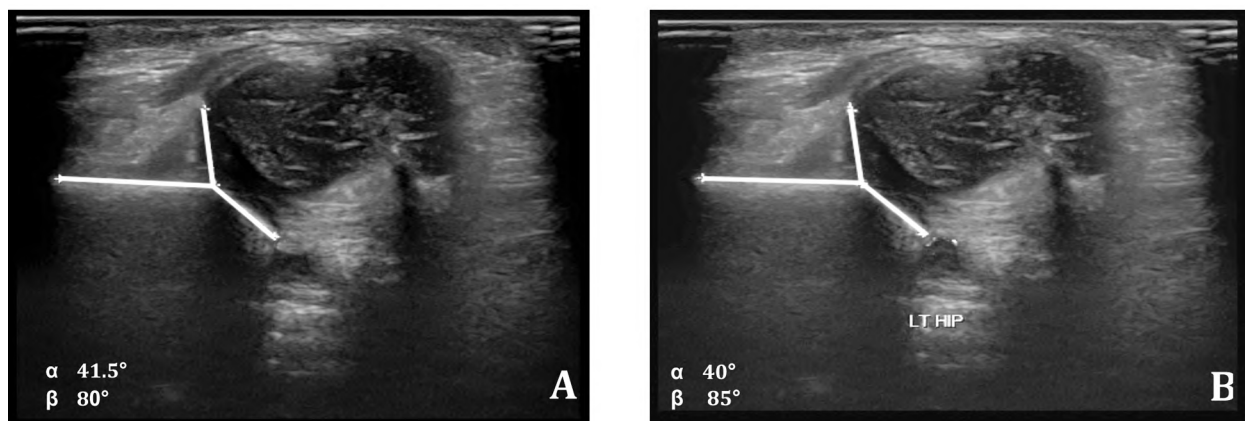


Fig. (3): (A & B) An ultrasound images, coronal scan of a 2 weeks old male infant presented with limitation of abduction and associated congenital anomaly (meningocele): (A) Right hip sonogram showing abnormal dislocated femoral head and of low echogenicity with streaks of high echogenicity. Poor bony roof with flat bony rim. Displaced cartilaginous roof and labrum is moved upward. The alpha angle (of Graf) measures  $41.5^\circ$  and the beta angle measures  $80^\circ$  indicating type III (dislocated hip) Fig. (3A). (B) Left hip sonogram showing abnormal dislocated femoral head and of low echogenicity with streaks of high echogenicity. Poor bony roof with flat bony rim. Displaced cartilaginous roof and labrum is moved upward. The alpha angle (of Graf) measures  $40^\circ$  and the beta angle measures  $85^\circ$  indicating type III (dislocated hip) Fig. (3B).

## Discussion

Developmental Dysplasia of Hip (DDH) is the most common congenital musculoskeletal disorder in infants [7]. DDH refers to a wide spectrum of abnormalities affecting hip joint range from dysplasia passing through subluxation to dislocation [8].

In Developmental Dysplasia of Hip (DDH) the infant born preconditioned to develop a defect but the femoral head usually located in the acetabulum. The most common predisposing factors to develop DDH include joint capsule laxity, antetorsion of femoral neck, altered or delayed ossification of femoral head, shallow acetabulum, fetal non physiological positioning of lower limb and hormonal factors causing connective tissue laxity as relaxin and estrogen [9].

Undiagnosed DDH result in shortening of the affected limb which affect the child's gait, decreased strength and increased risk of degenerative joint diseases in hip and knee joints. Effective treatment of DDH with early noninvasive methods is possible only in early infancy [10].

Hip ultrasonography provide an early diagnostic tool for DDH with lower risk of missing DDH diagnosis less than 0.1% [11]. Ultrasonography can provide detailed imaging of the hip before femoral head ossification by visualizing both the bony and cartilaginous parts of newborn hip joints and the coverage of the femoral head by the cartilaginous acetabulum [12]. Hip ultrasonography has become the most commonly used diagnostic tool for DDH during early infancy and for many years [13].

The present study show that Graf type I in the right hip joint was 52% and in left hip was 50% of cases. In male cases Graf type I in right side was 58% and in left side was 70%. In female cases Graf type I was 48.48% in right side and 39.39 in left side. This result was in agreement with Dante et al., [14] who reported that the frequency of normal finding (Graf type I) ranging from 37.3 to 72.1%, Roovers, [15] documented that frequency of type I was 62.4% and Abdullah and Zytoon [16] who reported that type I is the most prevalent in males in females with higher percentage in the right side, 91.3% in males and 78.1% in females.

The present study showed that Graf type II was 44% in the right hip and 46% in left hip with increased affection in females than males. Graf type II in the right side was 22% type IIa, 18% type IIb and 4% type IIc. Graf type II in left side distributed as 18% type IIa, 22% type IIb, 4% type

IIc and 2% type IID. This was in parallel with Dante et al., [14] who demonstrated that type IIa was from 23.6 to 57.6% and type IIc-IIId range between 0.8 to 7.0%. Roovers [15] demonstrated that the frequency of type II was 32% IIa, 1.9% IIb), 0.7%. Type IIc. Omeroglu et al., [13] reported that among the hips they examined there were 86.3% type I, 12.7 % type IIa, 0.4% IIc and 0.5% type IID.

In the present study Graf type III found in 2 cases (bilaterally) which resembles 4%. Jones and Powell [17] reported that type III found in 8% of cases, Dante et al., [14] who demonstrated that type III was 1.1 %, and Roovers, [15] who demonstrated that type III was 0.7%.

The present study demonstrated that the left hip affected more than the right hip this is in parallel with Guille et al., [18] who reported that the left side is involved in 60% of the children, the right side in 20% and 20% have bilateral involvement. The left side is more commonly involved, Storer and Skaggs, [19] who said that left hip is affected in 60% of infants, the right hip in 20%, and both hips in 20% and Abdullah and Zytoon [16] who found that 16% of right hips of studied group were with Graf type-II and 23.7% of left hips of studied group were with Graf type-II (left hip more affected than right hip) this explained by Hip dysplasia, when unilateral (as in 80% cases), is up to four times more likely to affect the left than right hip. This is likely related to the more common fetal positioning (left occiput-anterior) where the fetal left side lies adjacent to the maternal sacrum, resulting in adduction of the left hip [20].

The present study showed that females more affected than males these results were in agreement with Weinstein, [21] who reported that 80% of infants with DDH are females. Paton, [22] who found that incidence of DDH in females seven times to males, De Hundt et al., [23], Ortiz-Neira et al., [24], Abdullah and Zytoon [16] and Woodacre et al., [25]. Women are 2-7 times more likely to have DDH compared with men. Circulating estrogen from maternal and fetal sources likely contributes to ligamentous laxity, and increases DDH risk in women. A higher number of estrogen receptors in DDH patients compared with controls support the role of hormones in DDH development [26].

In the present study the referral causes (risk factors) was 16% for positive family history, 12% for associated family, 12% for maternal DM, 22% for oligohydramnios, 44% for cesarean section,

16% for limited abduction, 4% for Barlow test, 10% for abnormal skin crease and 8% for twin pregnancy.

Prematurity has been associated with a decreased risk of DDH [27]. Higher birth weight have been identified, increased birth weight likely lead to constrictive conditions in utero, causing abnormal hip positioning. Oligohydramnios is associated with a fourfold increase in DDH risk, likely due to similar mechanisms [25].

First-degree relatives have 12 times higher risk over patients without family history [28], positive family history increases the risk of DDH [29]. A positive family history of DDH have each been consistently shown to increase an infant's risk of DDH. Other risk factors for DDH reported include primiparity, oligohydramnios, postmaturity and high birth weight [28]. Abdullah and Zytoon [16] reported that prevalence of the different risk factors among their studied group was (13.7%) for Oligohydramnios, (52.2%) for Caesarean section delivery, (6%) for Clinical suspicion, (14.4%) for breech presentation, (6%) for Twins, (2%) for 1st born/CS (combined risk factors) and (6%) for positive family history.

The present study showed that the most common risk factor was cesarean section this was in agreement with Sutton, [30] found that children born by caesarean section are more likely to have associated instability and dislocations and Abdullah and Zytoon [16] who reported that the most prevalent risk factor in our group was Caesarean section delivery (52.2%), but in disagreement with Dante et al., [14] who reported that the most frequent risk factor was family history followed by oligohydramnios.

The present study showed higher prevalence of cases with DDH as we target the high risk infants, this in parallel with American Institute of Ultrasound in Medicine, [31] which reported that screening of all newborns with ultrasonography led to a high rate of reexaminations and ultrasound screening should not be performed before 3-4 week of age in infants with clinical signs or risk factors for DDH because of the normal physiologic laxity that resolves spontaneously by 6 week of age.

Omeroglu, [13] reported that hip ultrasonography is currently the most accurate diagnostic tool in developmental DDH during early infancy. Besides, either the universal or the selective ultrasonographic newborn hip screening programmes have notably decreased the rate of late detected and surgically treated DDH cases. Abdullah and Zytoon [16] recommended that ultrasound screening of DDH

should be done for all high risk infants, they said that it is better to do examination after 4-6 weeks as before that will often reveal minor degrees of dysplasia that resolve spontaneously and do not need treatment. (Swarp et al., [8] reported that all infants may be examined but selective screening with imaging should be performed for abnormal physical exams or high risk infants.

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## دور الأشعة بالموجات فوق الصوتية في فحص الأطفال حديثي الولادة لتشخيص خلع مفصل الورك التطوري

الخلفية: يعتبر النمو الشاذ التطوري لمفصل الورك أكثر العيوب الخلقية انتشاراً في الجهاز العضلي الهيكلي في الأطفال. عدم تشخيص النمو الشاذ التطوري لمفصل الورك يؤدي إلى قصر طول الطرف المصاب، ضعف قوته مما يؤدي إلى تأثر المشية ومرض المفاصل التنكسية في مفصل الورك والركبة. تعتبر الأشعة بالموجات فوق الصوتية أداة تشخيص مبكرة للنمو الشاذ التطوري لمفصل الورك حيث أنها تبين تفاصيل مفصل الورك قبل ظهور مركز التعظم في رأس عظمة الفخذ.

الغرض من الدراسة: تسليط الضوء على دور أشعة بالموجات فوق الصوتية لفحص شذوذ النمو التطوري لمفصل الورك في الأطفال.

المرضى والأساليب: تم إحالة ٥٠ مريضاً من الأطفال إلى مستشفى المنصورة الجامعي ومستشفى الأطفال بجامعة المنصورة في الفترة من نوفمبر ٢٠١٦ إلى مايو ٢٠١٨ كانوا ٣٣ من الإناث و ١٧ من الذكور الذين تقل أعمارهم عن ٦ أشهر. كان الحد الأدنى للسن أسبوعين وكان الحد الأقصى للعمر ١٨ أسبوعاً و ٣ أيام بمتوسط  $4.81 \pm 11.21$  أسبوعاً. خضع جميع المرضى لفحص بالموجات فوق الصوتية مع قياس زوايا غراف ألفا والبيتا.

النتائج: أظهرت الدراسة الحالية أن السبب الأكثر شيوعاً للإحالة هو الولادة القيصرية (٤٤٪) يليها نقص السائل الامنيوسي (٢٢٪) والتاريخ العائلي الإيجابي (١٦٪). كان النوع الأكثر ملاحظة لمفصل الورك هو (جراف ١) حيث كانت نسبته ٥٢٪ في الورك الأيمن و ٥٠٪ في الورك الأيسر. أما (جراف ٢) كانت نسبته ٤٤٪ في الجانب الأيمن و ٤٦٪ في الجانب الأيسر بينما (جراف ٣) كان ٤٪ في كلا الجانبين.

الخلاصة: الموجات فوق الصوتية هي أداة جيدة لتقييم شذوذ النمو التطور لمفصل الفخذ بالخاص في الحالات عالية المخاطر للإصابة.