Developmental hip dysplasia among asymptomatic infants of less than 6 months by ultrasonographic screening at a University Hospital outpatient clinic

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Background
Developmental dysplasia of the hip (DDH) includes a spectrum of abnormalities ranging from dislocated hip and mild subluxation to fixed dislocation. It is still controversial whether screening for hip dysplasia should be performed for all infants less than 6 months. The Graf method for hip ultrasonography (US) is the most widely used imaging modality. The aim of our present study is documentation of DDH prevalence in apparently healthy infants less than 6 months, who were screened by the hip US to evaluate the value of general or selective screening programs.

Patients and methods
This study was performed at the outpatient clinics of a major University Hospital in the period between January 2018 and January 2019. Asymptomatic infants under the age of 6 months have been subjected to full history taking and US examination. Three hundred and twenty-three hip joints of 170 infants were examined by the US machine, Mindray model DP-2200 using a high-frequency linear transducer.

Results
Normal hips were observed in 252 (78%) hip joints. Immature hips, class IIa, were observed in 47 (14.6%). Twenty-four (7.4%) hips were abnormal (type IIb, IIc, IIIa, and IIIb hips). Abnormal hips include IIb type, 12 (3.7%) joints in 11 infants, IIc type only one (0.3%) joint, IIIa type in four (1.2%) joints in 4four infants, and IIIb type seven (2.2%) joints in five infants.

Conclusion
DDH is a common problem of newborns in our society, so we recommend hip US for the detection and follow-up of DDH in newborns.

Keywords:
developmental dysplasia of the hip, screening, ultrasound

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Introduction

Developmental dysplasia of the hip (DDH) includes a spectrum of abnormalities that include the abnormal shape of the acetabulum (dysplasia) and malposition of the femoral head, ranging from dislocating hip and mild subluxation to fixed dislocation [1].

There is no consensus regarding the use of the US for screening of DDH [2].

Although the exact etiology of DDH is unknown, the final common pathway in the development of the disease is increased hip capsule laxity, which fails to maintain a stable femoroacetabular articulation. Increased laxity is mostly a result of the combination of hormonal, mechanical, and genetic factors [3].

It was reported previously that DDH was the main etiology in about 25% of hip replacement surgeries under the age of 40 years and that the initial age of diagnosis ranged from 0 to 39 years, with a mean of 8 years in these patients [4].

The Graf method for hip ultrasonography (US) is the most widely used imaging modality. If well-defined examination, interpretation, and measurement techniques are accurately followed, it is easy to manage newborn hip problems using the Graf method [5].

The incidence of DDH in our community is not accurately estimated, possibly due to the lack of a screening program. Delayed diagnosis and treatment results in more complex treatment options (Table 1).

Aim

The aim of this study is to screen newborns younger than 6 months presenting for other reasons at the orthopedic clinic of Pediatrics at Assiut University

Hospital and Assiut University Children's Hospital with US of both hips to report the incidence of DDH.

Patients and methods

This study was at the outpatient clinics of a major University Hospital in the period between January 2018 up to January 2019.

The IRB Assiut faculty of Medicine approved the study, IRB no: 17100270.

Asymptomatic infants under the age of 6 months, presenting to the outpatient clinic of pediatric orthopedics for other musculoskeletal problems have been subjected to thorough history taking and US examination. In the presence of any hip pathology, the asymptomatic other hip was included in this study. Three hundred and twenty-three hip joints of 170 infants were examined. The US machine used was Mindray model DP-2200, China, with a high-frequency linear transducer (5–10 MHz).

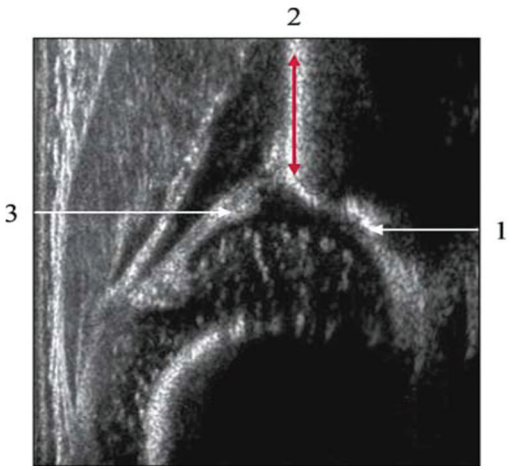
Assessment of both hip joints by the Graf method was implemented. Images only in standard (lateral coronal) planes were used. Alpha and beta angles were used as a quantitative tool for hip joint classification. The technique devised by Graf was meticulously adhered to, but cradle and probe-guiding devices were not used.

A hip coronal scan that represents the deepest point of the acetabulum is the reference plane for taking measurements. This standard plane can be obtained when the knees are slightly flexed, but can also be obtained in minimal internal rotation or even neutral.

The standard plane is defined by identifying the acetabular labrum tip, a straight iliac line, and the transition from the os ileum to the triradiate cartilage (see Fig. 1). The standard plane can be obtained with the hip in the neutral position (15°–20° flexion) or with the hips flexed. Position, as well as femoral head displacement, is noted. Morphology of the acetabulum is also assessed in the standard plane and validated by measuring the alpha angle of the acetabulum (≥60°). Validation by femoral head coverage and angle measurement is optional.

If identification of anatomical structures cannot be made or the standard plane is missed in the US image, this sonogram becomes of no value and must not be used for diagnosis. The only exceptions are in dislocated hips. In these cases, we can use nonstandard sonograms for evaluation but not for measurement, as the superior, posterior, and lateral femoral head displacement prevents visualization of the femoral head and the acetabular center in the same frontal section.

Figure 1



US image of an infant's hip, coronal plane, showing the three landmarks: (1) correct plane, (2) the lower limb of the os ilium, (3) acetabular labrum [5]. US, ultrasound.

Standard projection is used for hip US to provide easy viewing and interpretation by visualization of images as though they are the anteroposterior views of right hips on a radiograph.

Graf has developed a geometric and morphologic scheme for hip classification including types from types I–IV using an alpha (α) angle that measures the angle of the osseous acetabular roof and the beta (β) angle that represents the position of the echogenic fibrocartilaginous acetabular labrum (Fig. 2):

(1) The baseline starts from the uppermost point of the proximal perichondrium and is caudally drawn tangential to the iliac bone.
(2) The bony roofline starts from the inferior border of the lower limb and is drawn tangentially to the bony roof.
(3) The cartilage roofline is drawn between the bony rim and the center of the labrum. The alpha angle is measured between lines 1 and 2 while the beta angle is measured between lines 1 and 3 [5].

Statistical analysis

Data were collected and analyzed using SPSS (the Statistical Package for the Social Sciences, version 20; IBM, Armonk, New York, USA). Continuous data were expressed in the form of mean ± SD or median (range), while nominal data were expressed in the form of frequency (percentage).

χ^2 test was used to compare the nominal data of different groups in the study while Student's *t* test was used to compare the mean of different two groups and analysis of variance test for more than two groups. The level of confidence was kept at 95% and hence, the *P* value was significant if less than 0.05.

Results

Baseline data of screened infants

The mean age of the enrolled infants was 8.74 ± 6.81 weeks with a range between 1 and 23 weeks. Out of these infants, 93 (54.7%) were males and 77 (45.3%) were females. It was noticed that only two infants had a positive family history of DDH. Breech presentation was seen in seven (4.11%) infants. Forty-two (24.7%) infants were previously admitted to the neonatal intensive care unit without a history of hip problems (Table 2).

Characteristics of the examined hip joints

The mean alpha angle of all examined hip joints was 62.47 ± 8.53° while the mean beta angle was 55.69 ± 8.08° (Table 3).

Based on the age of infants and degree of alpha angle, the examined joints were classified into (Fig. 3) the following:

(1) Normal hip joint, observed in 252 (78%) hip joints; 157 (48.6%) and 95 (29.4%) joints were classified as Ia and Ib, respectively (Fig. 4).
(2) Immature hip joint, observed in 47 (14.6%) hip joints, and all of them were classified as IIa.
(3) Abnormal hip joint, observed in 24 (7.4%) (Table 3, see Fig. 5).

Age distribution based on the type of the examined hip joint: (mean ± SD).
Normal hip: 9.27 ± 6.67.
Immature hip: 3.42 ± 1.96.
Abnormal hip: 11.91 ± 7.49.

P value less than 0.001, *P* value was significant if less than 0.05.

Age distribution based on the type of examined hip joint

As expected, infants with normal hip joints had significantly higher age compared with those with immature hip joints (9.27 ± 6.67 vs. 3.42 ± 1.96 weeks; $P < 0.001$).

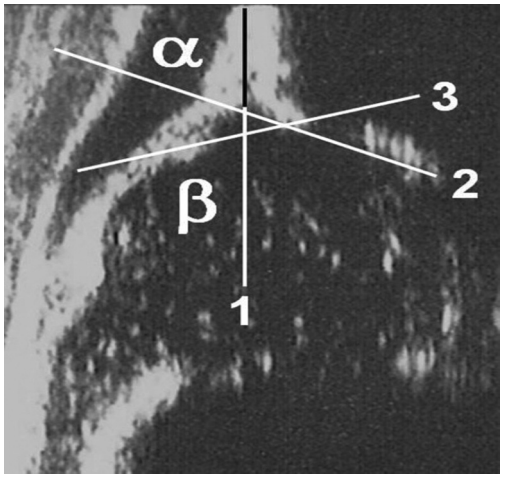
Abnormal hip: 11.91 ± 7.49.

Data expressed as mean ± SD. *P* value was significant if less than 0.05.

Frequency of abnormal hip joint based on sex

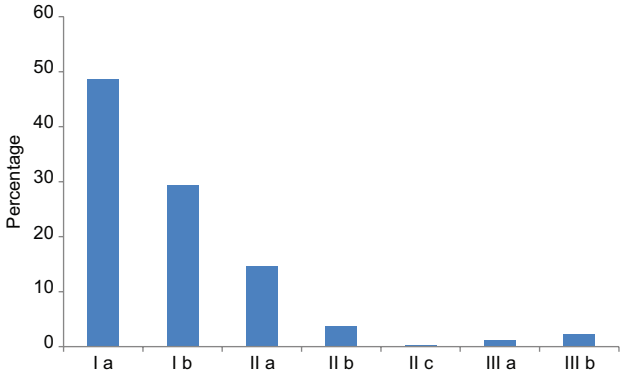
The abnormal hip joint was insignificantly higher among female infants in comparison to male infants [13 (54.2%) vs. 11 (45.8%); $P = 0.05$].

Figure 2



Measurement of the Graf method angles.

Figure 3

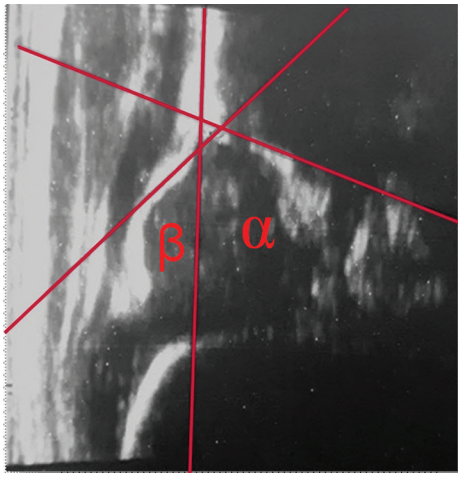


Classification of examined joints based on Graf classification (type).

Table 1 Graf method Classification of developmental dysplasia of the hip [6]

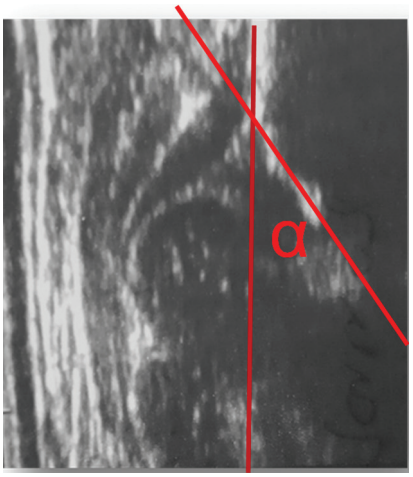
Types	Superior bony rim	Cartilaginous rim	Alpha angle	Beta angle
Ia mature hip (all ages)	Sharp	Thin, triangular, covering the head of the femur	>60	<55
Ib mature hip (all ages)	Blunted	Short, wide base, covering the head of the femur	>60	>55
IIa (up to 12 weeks)	Flattened	Wide, covering the head of the femur	50-59	>55
IIb (>12 weeks)	Flattened	Covering the head of the femur	50-59	>55
IIc	Rounded/flattened	Coverage is borderline	43-49	<77
D	Rounded/flattened	Compressed	43-49	>77
IIIa	Flattened	Compressed cranially but with no structural alterations	<43	>77
IIIb	Flattened	Cranially compressed with structural alterations (echogenic)	<43	>77
IV	Flattened	Caudally compressed	Not measurable	Not measurable

Figure 4



US image of the left hip in the standard plane of a male patient, 10-week-old presented to the outpatient orthopedic clinic at AUCH by congenital talipes equinovarus. He was born by vaginal delivery, had a cephalic presentation, and has no history of admission to NICU or family history of DDH showing: the superior bony rim is sharp. The cartilaginous rim is a thin triangle covering the femoral head. α-angle measures 75°. β angle measures 45°, Graf Type Ia. AUCH, Assiut University Children's Hospital; DDH, developmental dysplasia of the hip; NICU, neonatal intensive care unit; US, ultrasound.

Figure 5



US image of the right hip in the standard plane of a female patient, 7-week-old presented to the outpatient orthopedic clinic at AUCH by the left tibial deformity. She was born by normal vaginal delivery, had a cephalic presentation, and had no history of admission to NICU or family history of DDH showing: DCI is 10%. Flattened superior bony rim is. The cartilaginous rim of the acetabulum is compressed cranially without structural alterations. α-angle measures 35°, Graf Type IIIa. AUCH, Assiut University Children's Hospital; DDH, developmental dysplasia of the hip; NICU, neonatal intensive care unit; US, ultrasound.

Table 2 Baseline data of screened infants

	n=170
Age (weeks)	8.74±6.81
Range	1-23
Sex	
Male	93 (54.7)
Female	77 (45.3)
Family history of DDH	2 (1.2)
Breech presentation	7 (4.11)
Admission to NICU	42 (24.7)

Data expressed as mean±SD, frequency (percentage). DDH, developmental dysplasia of the hip; NICU, neonatal intensive care unit.

Type of examined hip joints based on the side of the joint in the current study

There was no significant difference based on the side of the joint (Table 4).

Discussion

This study is on the percentage of developmental hip dysplasia in asymptomatic infants of less than 6 months.

The US offers many advantages when compared with other imaging modalities as it distinguishes cartilaginous components of the femoral head and acetabulum from other soft tissue structures; allows multiplanar real-time examinations that can determine the femoral head position relative to the acetabulum earlier and at a lower cost than the information obtained by MRI and arthrography.

No ionizing radiation or sedation.

Detect changes in the position of the hip with movement [5].

The mean age of examination of infants in our study was 8 weeks. Imrie *et al.* [7] did US examinations at ~6 weeks of age and Guler *et al.* [8] did US examinations at 4 weeks of age and follow-up mean age of about 5 weeks for Graf IIa hip type (immature hips).

Only two (1.2%) infants in this study had a positive family history of DDH unlike Guler *et al.* [8], which detect 22.5% of infants with positive family history in first-degree relatives.

The percentage of breech presentation in our study was 4.11% but was 12.8% in the Guler *et al.* [8] study conducted in Turkey, which may be due to the large sample size in their cross-sectional prevalence study that included 4782 newborns. Imrie *et al.* [7] selectively screened breech presentation infants in their study of 266 infants.

There was insignificant relation between female sex and incidence of DDH in our study in contrast with Guler *et al.* [8], who found that female sex correlates with immaturity and higher incidence of DDH.

In our study, we found that among 323 hip joints there were 252 (78%) joints that were normal, 47 (14.6%) hips that were immature, and only 24 (7.5%) hips

Table 3 Characteristics of examined joints

	n=323
Side	
Left	158 (48.9)
Right	165 (51.1)
Alpha angle (°)	62.47±8.53
Beta angle (°)	55.69±8.08
Type of hip joint	
Normal hip	252 (78)
Ia	157 (48.6)
Ib	95 (29.4)
Immature hip	47 (14.6)
IIa	47 (14.6)
Abnormal hip	24 (7.4)
IIb	12 (3.7) in 11 infants
IIc	1 (0.3)
IIIa	4 (1.2) in four infants
IIIb	7 (2.2) in five infants

Data expressed as mean±SD, frequency (percentage).

Table 4 Type of examined hip joints based on the side of the joint in the current study

	Right side	Left side	*P*
Type of joints			
Normal hip	123 (74.5)	129 (81.6)	0.11
Immature hip	25 (15.2)	22 (13.9)	
Abnormal hip	17 (10.3)	7 (4.4)	

Data expressed as frequency (percentage). *P* value was significant if less than 0.05.

that were abnormal. This finding is not contradictory to Roovers *et al*. [9] who found that the prevalence of DDH was 10% in a cross-sectional study on 4782 infants in Istanbul in 2016 and 67 in 1000 infants with US screening on 5170 infants [8] and was 192 in 1000 while clinical as well as US examinations are used on 2066 infants, respectively. But it is about 10 times the figures reported by Holen *et al*. [10] who found that 9.6 in 1000 infants have DDH in a study on 7489 infants using the US only and 8.6 in 1000 infants in another group in the same study, when a clinical examination was combined with US and 7689 infants are included.

The Krolo study in 2003 found that the prevalence of DDH was 32.8 in 1000 infants with US screening on 2010 infants and was 17 in 1000 while clinical as well as US examinations are used on 7158 infants [11].

The Imrie *et al*. [7] study in 2009 chose to screen only infants with breech presentation and found that DDH prevalence was 27% in a study that included 266 breech infants and also the study made by Holen *et al*. [10] which selectively screened breech infants by clinical examination that was confirmed by the dynamic US and found a prevalence of 6.1%.

Because of discrepancy in condition definition, the type of examination used, and different levels of skills of clinicians, the exact incidence of DDH is difficult to be determined [12] as well as the number of examined infants, follow-up programs, and swaddling cultures in rural regions and racial factors [7].

Woolacott and colleagues determined three main findings. The first is there is no sufficient evidence for the diagnostic accuracy of the US as a screening tool. The second is that overtreatment could occur with US screening. Finally, in true dysplastic hips, the intrusiveness of interventions and duration of treatment are significantly lowered with US screening [13].

Now US is the gold standard diagnostic tool of DDH in neonates and younger infants; however, there is no consensus regarding the use of it for screening of DDH [2].

Arti and colleagues in Iran used US for the screening of 5800 newborns who have risk factors or suspicious clinical examination. It was found that 72% of hips (diagnosed by the US as Graf type IIb or more) after US screening had been diagnosed clinically as normal. So it has been concluded that hip US is the gold standard method for DDH evaluation [14].

Koşar and colleagues reported in a study which included 1321 male infants that 28% of cases of DDH may be missed by selective screening programs by the US, so they concluded that all newborns should be examined by the hip US [15].

Conclusion

The relatively high incidence of DDH in asymptomatic infants of less than 6 months old seen at a single outpatient clinic over 1 year might suggest a need for a nationwide screening program.

Being the main cause of total hip replacement surgeries under the age of 40 years, DDH is a disease of great importance.

In our study, we found that among 323 hip joints there were 252 (78%) joints that were normal, 47 (14.6%) hips that were immature, and only 24 (7.4%) hips that were abnormal, which is relatively high compared with other reports.

Based on our findings the following conclusions have been arrived at:

(1) Wide-scale use of US in general screening programs might be appropriate for all live births to secure early diagnosis and management of cases and to avoid lifelong disabilities.

(2) The use of the US as a follow-up tool for immature or dislocated hips under treatment should be implemented to guarantee successful treatment.

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Conflicts of interest
There are no conflicts of interest.

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