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Original Article

Optimal Timing of Ultrasound for the Diagnosis of Developmental Hip Dysplasia in Infants: 1st or 5th Week?

Şima Turcan[1], Mustafa Özdemir[2], Fatma Ayça Edis-Özdemir[2]

[1]Department of Radiology, Niğde Ömer Halisdemir University School of Medicine, Niğde, Turkey

[2]Department of Radiology, Yüksek İhtisas Post-Graduate Teaching and Research Hospital, Ankara, Turkey

ABSTRACT

Objective: Ultrasonography (US) is a useful, easy, and accurate screening method for the diagnosis of neonatal developmental dysplasia of the hip. The purpose of this prospective and cross-sectional study is to determine the optimal timing of US for the evaluation of the hip joints in newborns.

Methods: We enrolled consecutive 27 [18 girls (66.7%) and nine boys (33.3%)] newborns in this study. Two experienced radiologists (Ş.T. and M.Ö.) performed standard hip US examinations at the 1st and 5th weeks of age according to the method described by Graf. We assessed the relationship between femur head and acetabulum and compared the results of evaluation obtained between the 1st and 5th weeks. Additionally, we evaluated the agreement between the two radiologists.

Results: None of the babies were found to have subluxation or dislocation by clinical examination. The US measurements regarding the ossification and the diameter of femur head, bony, and cartilaginous roof at the 1st and 5th weeks were similar (for all infants, $P > .05$). In our series, no hip was defined as Graf's type IIb or higher. In total, four (14.8%) right hips and six (22.2%) left hips (total 10 hips) were classified as Graf's type IIa (physiologically immature) at the 1st week of evaluation. A total of seven hips spontaneously returned to their normal positions during the following 4 weeks. However, two (7.4%) right and one (3.7%) left hip joints were still classified as type IIa at the 5th week of evaluation. Graf type of hips was reported as similar in all the infants by the 1st and 5th week of measurements ($n = 54$, $P > .05$, for each). There was no interobserver variability between the two radiologists with respect to Graf's classification ($\kappa > 0.81$). The blunt/round shape of acetabular rim defined in 10 hips at the 1st week was improved to an angular shape in the eight hips at the 5th week ($P = .008$).

Conclusion: Early US screening along with normal physical examination can diagnose some hip disorders in babies. Most of the abnormal findings detected at the 1st week of US screening recovered spontaneously at the 5th week. Infants with normal US measurements at the 1st week may be excluded from the follow-up, and those with suboptimal findings may be monitored by physical examination and repeated US scans.

Keywords: Hip dysplasia, optimal timing, ultrasound

INTRODUCTION

Developmental dysplasia of the hip (DDH) is one of the most common causes of musculoskeletal disabilities in children. The abnormal development of the femoral head and acetabulum covers a wide spectrum of anatomical abnormalities from thin acetabular dysplasia to nonreducing hip dislocation. Because the disease is mainly a developmental defect, the former term "congenital dysplasia of the hip" was discarded.[1] The incidence varies from 1 to 20 cases per 1,000 live births depending on some factors such as the examination methods and timing of assessment.[2] Most studies report that girls are more affected than boys, and the left hip is more frequently dysplastic than the right one.[2–8]

The etiopathogenesis of DDH is multifactorial. Some risk factors such as female gender, a positive family history, primiparity, presence of a large fetus or multiple fetuses, presentation of breech, oligohydramnios, neuromuscular diseases, or other musculoskeletal disorders have been described for DDH. Additionally, it has been reported that joint laxity increases in infants who are exposed to maternal estrogens in the perinatal period.[2,3]

An accurate and timely diagnosis and treatment improve the clinical outcomes for this disorder.[9–12] The instability examination defining functional or morphological hip defects should be performed shortly after birth. The American Academy of Pediatrics recommends that all newborns should be clinically

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ORCID iDs of the authors: Ş.T. http://orcid.org/0000-0002-1786-9330; M.Ö. http://orcid.org/0000-0001-9513-6768; F.A.E.-Ö. http://orcid.org/0000-0002-0172-6837.

Corresponding Author: Şima Turcan **E-mail:** simaturcan@hotmail.com.

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assessed for DDH in the first few days of life.[13] The physical examination, including asymmetric folding, abduction restriction, and provocative testing, such as Piston test and Ortolani and Barlow maneuvers, still hold a diagnostic value.[11,14,15] However, these methods can only detect subluxation or dislocation. Moreover, it is reported that neonatologists cannot detect about half of the unstable hips by using these examinations.[16] At this point, ultrasonography (US) can be considered as a useful, easy, and accurate screening method for the diagnosis of neonatal DDH. The relationship between the femur head and acetabulum can be assessed by standard static,[17–19] early dynamic, or modified dynamic US methods.[20–22] US allows the visualization of the cartilage parts that are not visible on plain radiographs and can effectively distinguish mild instability or acetabular immaturity.[23,24]

Two different screening programs can be planned by using sonographic imaging of the hip: selective programs screen newborns with identified risk factors or those with abnormal clinical examinations, and universal programs screen all the newborns.[13] However, the optimal timing of the US scan remains a controversial matter. Underdiagnosis can lead to complicated and debilitating hip deformities in infancy and childhood, whereas overdiagnosis may result in an unnecessary follow-up and increased parental concerns.[25,26]

The purpose of this article is to compare the results of 1st and 5th weeks of US findings of newborns.

METHODS

We conducted this study in accordance with the principles of Helsinki Declaration in the Niğde Hospital of Ömer Halisdemir University, Turkey. Children's legal guardians provided an informed consent for participation, and Erciyes University, Faculty of Medicine, Kayseri Turkey "Clinic Investigations Of Ethics Committee" dated February 9, 2018 with decision no. 2018/73 was approved this study's protocol and design.

We planned a universal screening by US and enrolled 27 [18 (66.7%) girls and nine (33.3%) boys] consecutive infants in this study. There was no preterm birth (defined as a baby born before 37 weeks according to WHO),[27] low body weight (defined as less than 2,500 g according to WHO),[28] and malformation or deformity in infants. The infants were clinically examined by the same pediatrician on the first day of the life to detect DDH by using Piston test, Ortolani and Barlow maneuvers, asymmetric folding, and abduction restriction. None of them were found to have subluxation or dislocation by clinical examination.

Two experienced radiologists performed US examinations by using a linear probe (7.5 MHz Toshiba Aplio 300, Japan). Two serial measurements were performed at the 1st and 5th weeks for all the babies. The relationship between femur head and acetabulum was assessed according to the Graf's scanning and measurement method.[17–19] The transducer was placed on the anatomic coronal plane, and the view was obtained in the physiological neutral position (15°–20° flexion) or the 90° flexed position of the hip. The rounded structures of the hip joint were defined by the transducer's forward and backward motions from the base position. The top edge of the transducer was rotated from 10° to 15° in an oblique coronal plane to view the ilium in the straight position. The calcified nucleus of femur head, the chondro-osseous junction, the lower limb of ilium, acetabular edge, bony and cartilaginous acetabular roofs, acetabular rim and labrum, hip joint capsule, and synovial fold were identified as the anatomical landmarks.

In all the infants, a sonogram containing the iliac line, a triradiate cartilage, and an apparent acetabular labrum was printed out as a standard plane.[13–16] These frozen sonograms were used to bilaterally measure the α and β angles as the indicators of bony and cartilage acetabular roofs, respectively. The α angle was defined as the angle between the acetabular roof and the vertical cortex of the ilium in the coronal plane. An α angle less than 60° reflecting a shallow acetabulum was considered as abnormal. The β angle was defined by a line drawn through the vertical ilium and the cartilaginous acetabular labrum. A β angle greater than 55° was accepted as abnormal.[2] The acetabular rim was classified as angular (sharp), round/blunt, and flat, whereas the bony acetabular roof was classified as good, incomplete, and poor.

Statistical Analysis

This study had cross-sectional and interventional components. We performed statistical analysis by using Statistical Package for the Social Sciences (SPSS) version 22.0 (IBM SPSS Corp.; Armonk, NY, USA). We used Chi-square and Fisher's exact tests to compare the categorical variables. Moreover, we used the McNemar test to determine the change in the frequency or percentage of categorical variables between the 1st and 5th weeks of evaluation. We employed Wilcoxon signed-rank test to compare the Graf's α and β angles between the 1st and 5th weeks' measurements. We evaluated the agreement between the two radiologists by using κstatistics. $P < .05$ was considered as significant in each test.

RESULTS

We included 27 [18 girls (6.7%) and nine (33.3%) boys] infants in the study. In two series of measurements, the femoral head diameter, acetabular labrum development, and positions were normal in all the infants (Table 1). There was an incomplete bone roof in the 1st and 5th weeks for the right and left hips of

Main Points

- In this study, we compared 1st-week and 5th-week US findings in order to find developmental hip dysplasia in infants.
- After the clinical examination, all the infants underwent US.
- Two experienced radiologists assessed the Graf's scanning and measurements of alpha and beta angles, femur head, ossification, acetabulum, rim, labrum, joint capsule, and type of hip both in 1st and 5th weeks.
- In the 1st week, 18.5% of infants showed blind acetabular rim and physiologically immaturity, while 3.9% and 5.6% for 5th week, respectively. Most of the hips recovered spontaneously at the 5th week.
- Additionally, alpha and beta angles were improved.

Table 1. Gender, Femur Head Diameters, and Acetabular Labrums at the 1st and 5th Weeks

Features	Subgroups	Frequency	%			
Gender	Girls	27	66.7			
	Boys	9	33.3			
		1st Week		5th Week		
Femur Head Diameter		Frequency	%	Frequency	%	P
Right	Normal	27	100.0	27	100.0	1.000
Left	Normal	27	100.0	27	100.0	1.000
		1st Week		5th Week		
Acetabular Labrum		Frequency	%	Frequency	%	
Right	Normal	27	100.0	27	100.0	1.000
Left	Normal	27	100.0	27	100.0	1.000

Table 2. Bone Roofs at the 1st and 5th Weeks

		1st Week		5h Week		
Bone Roof		Frequency	%	Frequency	%	P
Right	Complete	26	96.3	26	96.3	1.000
	Incomplete	1	3.9	1	3.9	
Left	Complete	26	96.3	26	96.3	1.000
	Incomplete	1	3.9	1	3.9	
Total	Complete	52	96.3	52	96.3	1.000
	Incomplete	2	3.9	2	3.9	

one (3.9%) infant (Table 2). With regard to the cartilaginous roof, none of the babies had displaced hips. However, both hips were noted as short and wide in one (3.9%) baby at the 1st week, and in another baby (3.9%), it was noted at the 5th week. The shape of cartilaginous roof was similar between the 1st and 5th week of evaluations of the left and right hip joints (Table 3). The shape of the acetabular rim was blunt/round in the right hips of four (14.8%) infants at the 1st week and in the right hips of one (3.9%) infant at the 5th week. Similarly, the blunt/round structure was shown in the left hips of six (22.2%) infants at the 1st week and one (3.9%) infant at the 5th week. There was no difference between the 1st and 5th weeks' separate measurements of the right and left hips ($P > .05$, for each). A further analysis was performed considering the total number of hips on both the sides ($n = 54$). The blunt/round shape of acetabular rim defined in the 10 hips at the 1st week was improved to an angular shape in the eight hips at the 5th week ($P = .008$, Table 4).

In our series, no hip was classified as Graf's type IIb or higher. Moreover, four (14.8%) right hips and six (22.2%) left hips (total of 10 hips) were classified as Graf's type IIa (physiologically immature) at the 1st week. In total, seven hips spontaneously returned to the normal position during the following 4 weeks. However, two (7.4%) right and one (3.7%) left hip joints were still classified as type IIa at the 5th week of evaluation. Graf type of hips was reported as similar in all the infants by the measurements at the 1st and 5th weeks ($n = 54$, $P > .05$, for each) (Table 5). The boys and the girls had the same hip types at the 1st and 5th weeks ($P > .05$, for each). The Graaf's α and β angles were significantly different between the calculations of 1st and 5th weeks ($P < .01$, for each, Table 6). There was no interobserver variability between the two radiologists with respect to Graf's classification ($\kappa > .81$).

DISCUSSION

The results of this study show that the bilateral femur head diameter, acetabular labrum development, and position were in the normal limits, consistent with the normal measurements occurring at the age of infants in the 1st and 5th weeks. There were no suboptimal results for any of the infants with respect

Table 3. Cartilaginous Roofs at the 1st and 5th Weeks

		1st Week		5th Week		
	Cartilaginous Roof	**Frequency**	**%**	**Frequency**	**%**	***P***
Right	Covers the femoral head (long, narrow)	26	96.3	26	96.3	1.000
	Short, wide	1	3.9	1	3.9	
Left	Covers the femoral head (long, narrow)	26	96.3	26	96.3	1.000
	Short, wide	1	3.9	1	3.9	
Total	Covers the femoral head (long, narrow)	52	96.3	52	96.3	1.000
	Short, wide	2	3.9	2	3.9	

Table 4. Acetabular Rims at the 1st and 5th Weeks

		1st Week		5th Week		
	Acetabular Rim	**Frequency**	**%**	**Frequency**	**%**	***P***
Right	Angular	23	88.5	26	96.3	.250
	Blind/round	4	11.5	1	3.9	
Left	Angular	21	77.8	26	96.3	.063
	Blind/round	6	22.2	1	3.9	
Total	Angular	44	81.5	52	96.3	.008
	Blind/round	10	18.5	2	3.9	

Table 5. Type of Hips at the 1st and 5th Weeks

		1st Week		5th Week		
	Type of Hip	**Frequency**	**%**	**Frequency**	**%**	***P***
Right	Type I mature	23	85.2	25	92.6	.687
	Type IIa physiologically immature	4	14.8	2	7.4	
Left	Type I mature	21	77.8	26	96.3	.063
	Type IIa Physiologically immature	6	22.2	1	3.9	
Total	Type I mature	44	81.5	51	94.4	.065
	Type IIa physiologically immature	10	18.5	3	5.6	

to bone and cartilaginous roofs. However, researchers had previously reported immature developments for femur head diameter and acetabular labrum.[22,23,29–31] In our study, the Graf's α and β angles showed statistically significant improvement between the 1st and 5th weeks. However, there was no unilateral improvement in the acetabular rim between the 1st and 5th weeks' measurements. We attributed this result to the small number of the patients. Hence, we repeated the analysis over the number of bilateral total hips. This analysis revealed that the blunt/round acetabular rim shape, which was defined in the 10 hips at the 1st week, became angular in eight hips at the 5th week. Only two hips remained abnormal at the 5th week. Palliative care and follow-up were planned for these infants. The bone roof of one baby was bilaterally incomplete at the 1st and 5th weeks. It was suggested that this baby should be monitored with palliative care and periodic checkups.

Table 6. Graaf's Alpha and Beta Angle Calculations at the 1st and 5th Weeks

Graaf's Angles		1st Week		5th Week		
		Mean ± SD	Median; Range	Mean ± SD	Median; Range	*P*
Alpha	Right (n = 27)	59.9 ± 1.6	60; 57–64	61.3 ± 2.3	60; 58–67	.007
	Left (n = 27)	59.4 ± 2.7	60; 50–64	60.9 ± 3.0	60; 53–68	.008
	Total (n = 54)	59.7 ± 2.2	60; 50–64	61.1 ± 2.6	60; 53–68	.000
Beta	Right (n = 27)	46.1 ± 6.2	46; 35–67	42.7 ± 4.8	42; 34–55	.001
	Left (n = 27)	46.8 ± 5.5	48; 37–63	42.4 ± 4.7	43; 32–53	.000
	Total (n = 54)	46.4 ± 5.8	47; 35–67	42.6 ± 4.7	42; 32–55	.000

We have previously emphasized that US is a sensitive method that is used in the screening programs for the diagnosis of DDH in many countries. However, despite its advantages, it is still not recommended as a universal screening strategy worldwide because of its disadvantages such as high cost–benefit ratio, observer-related nature, and overdiagnosis.[31] The overdiagnosis of DDH is a more common problem when US is used in especially the first 6 weeks of the life.[23] Additionally, the previous data suggest that overdiagnosis in the first 6 weeks may be due to the different interobserver evaluations. Hence, some researchers noted that an early screening of the US would impose unnecessary monitoring and, hence, anxiety in the family. It also would increase the burden of radiology, orthopedic, and neonatal clinics.[23]

It should be noted that it is difficult to screen the children after the neonatal period in some countries. We planned a universal screening study focusing on the efficacy of early US measurements in detecting the hip problems. We implemented US measurements in two different, but early weeks of life. In our study, all the infants were examined by a pediatrician, and none of them had signs of subluxation or dislocation. However, US measurements have provided suboptimal findings for some infants. We conclude that early US screening can diagnose subtle hip disorders. When we compared the US measurements performed between the two different weeks, the statistical analysis showed that two series of US findings were almost similar. Some findings that were detected in the 1st week and accepted as immaturity improved in the 5th week. Therefore, we interpreted that infants with optimal hip findings according to the US measurements of 1st week can be removed from follow-up. Additionally, infants with suboptimal findings can be followed-up by physical examination and repeated US scans. In our study, there were no differences between the two radiologists.

There are some limitations of our study. First, we believe that our small patient population did not allow us to take some results that were previously obtained in the larger patient series. For example, none of the babies in our study had displaced cartilage roof. Additionally, the shape of the cartilage roof was short and wide in only two infants. In the literature, more serious and high-grade DDH cases have been reported in many babies.[22,23,29–31] On the contrary, most of the studies showed that the girls were more affected than the boys, and the left hip was more dysplastic than the right one,[2–8] whereas our study did not reveal any difference. Second, none of our infants had been classified as Graf IIb or higher. Third, the follow-up period of our study was relatively short.

CONCLUSION

We believe that an early UG screening along with normal physical examination can diagnose hip disorders in the babies. When we compare the US measurements of two separate weeks, we observed that most of the abnormal findings detected at the 1st week can be recovered spontaneously at the 5th week. Infants with normal US measurements at the 1st week may be excluded from the follow-up, and infants with suboptimal findings may be monitored by physical examination and repeated US scans. We state that early UG screening is useful.

Ethics Committee Approval: Ethics committee approval was received from the ethics committee of Erciyes University, Faculty of Medicine, Kayseri Turkey "Clinic Investigations Of Ethics Committee" (date of February 9, 2018; decision 2018/73).

Informed Consent: Written informed consent was obtained from children's legal guardians who participated in this study.

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