Exp Biomed Res 2023; 6(4): 323-330 DOI: 10.30714/j-ebr.2023.198

Experimental Biomedical Research *Original article*

Epidemiological investigation and ultrasonographic results of developmental dysplasia of the hip in infants aged 0-6 months

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ABSTRACT

Aim: To determine the prevalence of developmental dysplasia of the hip (DDH), a common condition in our region, and investigate the underlying factors contributing to its occurrence.

Methods: A total of 715 hips from 370 newborns were evaluated using ultrasonography. The patients' gender, alpha, and beta angles, affected hip, and Graf classification types were noted. Risk factors were compared between the groups. Patients diagnosed with DDH were treated with the Pavlik harness.

Results: In the initial evaluation, 61 out of 370 patients (16%) were diagnosed with Graf type 2c, 3, or 4 hips. 48 patients were female, and 13 patients were male. Patients who were female (20.1%) had a statistically significant greater incidence of DDH than patients who were male (9.8%) (p<0.05). In terms of statistical significance, there was no difference between DDH incidence in the right hip and left hip (p>0.05). The application of swaddling was more frequent in the group with diagnosed DDH compared to the normal group (p<0,05). Pavlik treatment was applied to 41 hips. After the treatment, 30 hips converted to type 1 hips. Six hips remained as type 2b, three hips progressed to type 2c, and one hip progressed to type 3.

Conclusions: DDH continues to be a widespread concern. The incidence in our region is higher compared to other areas. Enhancing screening initiatives, pinpointing key risk factors, and bolstering family education are imperative steps towards its prevention.

Keywords: Developmental dysplasia of the hip, newborn, Pavlik harness, ultrasonography.

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Received: 2023-07-25 / Revisions: 2023-08-29
Accepted: 2023-09-15 / Published online: 2023-09-20

Introduction

Developmental dysplasia of the hip (DDH) ranks among the most prevalent musculoskeletal conditions in children. DDH pertains to the abnormal development of tissues surrounding the hip joint. This condition encompasses many abnormalities, from minor acetabular deformities to subluxation or even complete dislocation of the femoral head [1]. If DDH goes undiagnosed and untreated, it can lead to significant impairments such as altered gait patterns, limb shortening, a reduced range of motion in the affected joints, and persistent discomfort [2]. Moreover, it remains the primary reason for total hip replacements in younger individuals and a leading cause of osteoarthritis [3].

The exact causes of DDH remain undetermined. However, several recognized risk factors have been documented, including female gender, certain swaddling techniques, a preference for the left side, breech presentation, a familial history of DDH, and primiparity [4]. Researchers have also investigated other potential risk factors like oligohydramnios, fetal macrosomia, twin pregnancies, joint hyperlaxity, torticollis, clubfoot, metatarsus varus, and variations in pediatric vitamin D levels [5,6]. Genetic elements may play a role in the pathophysiology of DDH, with genes such as PAPPA2, IL-6, COL2A1, HOXD9, GDF-5, and TGFB1 being associated with the condition [7,8].

Newborn DDH diagnosis relies on both clinical and ultrasound examinations. The ultrasonic techniques most employed today were introduced by Graf, Harcke, and Terjesen [9]. A comprehensive physical examination should include the Galeazzi test, the Barlow and Ortolani tests for joint stability, and the identification of limited abduction. Notably, even for experts, the physical signs of DDH can be subtle [10]. It's significant to mention that many hips identified as dysplastic via ultrasonography appear normal upon physical examination [11]. Current DDH ultrasonography screening can adopt either a universal or selective approach. The reported prevalence of DDH fluctuates based on factors such as ethnicity, race, age, diagnostic criteria, and the chosen screening method (be it physical examination, plain radiography, or specific ultrasound techniques) [12]. In this cross-sectional study, we aimed to determine the prevalence of DDH in newborns through hip ultrasonography screening. Additionally, we sought to explore potential associations between DDH diagnosis (based on ultrasound results) and various risk factors. Finally, we assessed the follow-up and treatment outcomes for infants diagnosed with DDH.

Materials and methods

Between February 2021 and February 2022, we conducted a cross-sectional study (Level III) examining the hospital records of 370 newborns undergoing regular clinical follow-up. This investigation adhered to the latest version of the Declaration of Helsinki. The study protocols were approved by Dicle University Faculty of Medicine local ethics committee (date: 07.01.2021, protocol number: 01-2023/46).

Inclusion and exclusion criteria: The inclusion criteria included having a primary diagnosis of DDH according to the 10th revision of the International Classification of Diseases, being between the ages of 14 days and 6 months, being healthy, hospitalized, or having outpatient status, having applied for an ultrasound examination of the bilateral hip joint and stability test. Pathological dislocation, paralytic dislocation, hip dislocation caused by spasm or nervous system abnormalities, and teratoid dislocation were all excluded.

The age, sex, α and β angles, swaddling habits, hip type of newborns during the ultrasound, and the occurrence of dislocated hips on the right or left side were investigated. In a clinical examination, the Ortolani and Barlow tests, hip abduction limits, asymmetries, femoral length discrepancies, and related abnormalities were identified. The ultrasonographic evaluations were performed utilizing the static hip ultrasound technique defined by Graf using a Siemens Sonoline SI-250 (Siemens Sonoline SI-250 and G-20, Berlin and Munich, Germany) ultrasound device outfitted with a 7.5 MHz high-frequency linear probe on both hips in the position of the lateral decubitus on a specially made table. In the visual below, an ultrasound image is being displayed (Figure 1). Each ultrasonography was assessed using the Graf classification system (Table 1).

Hips categorized as Graf type I (mature) were excluded from further follow-up. Hips classified as type IIc, D, III, and IV were deemed pathologic and were treated using the Pavlik

Table 1. Graf classification of developmental dysplasia of the hip.

Classification	Description	α angle	β angle
Type I	Normal, mature hips	≥ 60	≤ 55
Type IIa	Physiological immature infants <3 months	50–59	55–77
Type IIb	Physiological delay in ossification infants >3 months	50–59	55–77
Type IIc	Abnormal, slightly dislocated hip (critical range)	43–49	≤77
Type D	On point of dislocation (decentric)	43–49	>77
Type III	Dislocated with/without structural alteration	<43	>77
Type IV	Dislocated inferomedially	<43	>77

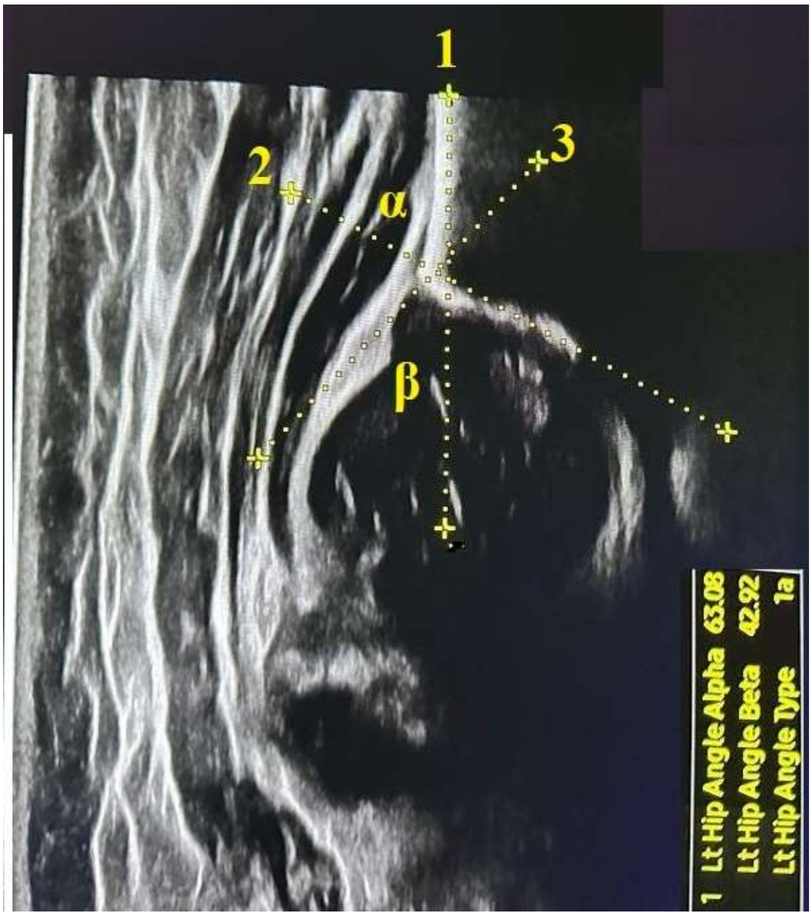

Figure 1. 1. Baseline; 2: Bony roof line; 3: Cartilaginous roof line. α: Angle between the baseline and bony roof line β: Angle between the baseline and cartilaginous roof line.

harness. For type IIa hips, a follow-up ultrasound examination was conducted at 4 weeks. If type IIa hips progressed to type IIb during follow-up, they were also managed with the Pavlik harness. We documented the distribution of DDH by age group and recorded the outcomes of the Pavlik harness therapy.

The Pavlik harness serves as a dynamic abduction orthosis, designed to flex and gently abduct the hip [13]. With informed consent from families, orthopedists employed the Pavlik harness, a trusted treatment option, for infants diagnosed with type IIb DDH or more severe variations [14]. As the hips matured to type I, patients wearing the harness were monitored with ultrasound assessments every four weeks to gauge the progress of treatment. Additionally, six months after commencing Pavlik harness therapy, bilateral anteroposterior and frog-leg radiographic images were obtained.

Statistical analysis: The Pearson chi-square test was used to analyze the relationships between the Graf classification and sex, hip side, and history of swaddling. IBM Corp., Armonk, New York, produced SPSS version 22.0 for use in all statistical analyses. At $p<0.05$, the findings were deemed statistically significant.

Results

A total of 715 hips from 370 patients were subjected to examination. Among these patients, 238 were female, and 132 were male. During the initial evaluation, 61 out of 370 patients (16%) were diagnosed with Graf type 2c, 3, or 4 hips.
In the non-DDH group, out of 309 patients, 190 were female (61.5%), and 119 were male (38.5%). Out of the 61 patients with DDH, 48 (78.5%) were female, and 13 (21.5%) were male. The incidence of DDH was found to be statistically significantly higher in female (20,1%) patients compared to males (9,8%) ($p<0,05$). In the right hip joint, 19 cases of DDH were detected, accounting for 31% of the cases. In the left hip joint, 27 cases of DDH were identified, making up 44% of the cases. DDH was observed in 15 patients (24.5%) with bilateral hip joint involvement. There was no statistically significant difference between the occurrence of DDH in the right or left hip ($p>0.05$). Out of the 370 infants examined in this study, 172 (46.4%) hailed from families that practiced the traditional method of swaddling. Of the 61 infants diagnosed with DDH, 40 (65.5%) were from families who employed swaddling. In contrast, among the 309 infants without DDH, 132 (42.7%) came from families practicing this method. A statistically significant difference was observed between the two groups ($p<0.05$) (Table 2).

Of the 715 hips examined, the classifications were: 405 hips (56.6%) as Graf type 1; 147 hips (20.5%) as type 2a; 87 hips (12.1%) as type 2b; 53 hips (7.4%) as type 2c; 16 hips (2.2%) as type 3; and 7 hips (0.9%) as type 4.
Initial screening of infants aged 0-1 month revealed no pathological signs in 82 hips. In the 1-2 month age group, 15% (43 out of 270) of hips showed signs of DDH. For infants aged 2-3 months, DDH was identified in 8% (12 out of 144) of the hips. In the 3-4 month bracket, 6.5% (6 out of 92) hips exhibited DDH. Lastly, in the 4-6 month age group, 11.8% (15 out of 127) of hips were diagnosed with DDH (Table 3).

Table 2. Demographic characteristics and risk factors of patients.

Parameters	**Mature or type IIa + IIb (N,%)**	**Pathologic (N, %)**	***p*-value**
Gender			
Male	119 (38.5)	13 (21.5)	**<0.05**
Female	190 (61.5)	48 (78.5)	
Hip side			
Right		19 (31)	>0.05
Left		27 (44)	
Bilateral		15 (24.5)	
Swaddling			
Yes	132 (42.7)	40 (65.5)	**<0.05**
No	177 (57.3)	21 (34.5)	
Total	309 (84)	61 (16)	

Table 3. Distribution of normal and pathological hips according to graph classification and age range.

Variables	Normal + type IIb (N, %)	Pathologic (N, %)
Graf I	405 (56.6)	
Graf IIa	147 (20.5)	
Graf IIb	87 (12.1)	
Graf IIc		53 (7.4)
Graf III		16 (2.2)
Graf IV		7 (0.9)
Age		
0-1 month	82	-
1-2 month	227	43 (15)
2-3 month	132	12 (8)
3-4 month	86	6 (6.5)
4-6 month	112	15 (11.8)
Total	639 (89.4)	76 (10.6)

Table 4. Results of Pavlik harness treatment.

Pavlik treatment	Number of hips	Follow-up results
Applied to Graf IIb or higher	41	30 converted to type I hips
		6 remained as type IIb hips
		3 progressed to type IIc hips
		1 progressed to type III hip

Pavlik treatment was applied to 41 hips with a Graf classification of 2b or higher. The average duration of the treatment was 13 weeks. After the treatment, 30 hips converted to type 1 hips. Six hips remained as type 2b, three hips progressed to type 2c, and one hip progressed to type 3 (Table 4).

Discussion

Reported incidence rates of DDH vary significantly worldwide, with values ranging from 1.5% to 20.0% [15]. For instance, in a study by Xu et al., DDH was identified in 1.7% out of 19,833 infants [16], while Güler et al. documented an incidence of 9.9% (14). In contrast, our study observed a 16% incidence rate, which surpasses the typical rates cited in existing literature. This elevated incidence could be due to the high prevalence of consanguineous marriages and the widespread practice of swaddling in our country. Furthermore, being the largest hospital in the region, the influx of infants diagnosed with DDH from other centers could also influence the heightened incidence noted in our research.

DDH is predominantly observed in females, and there has been a long-standing suspicion of a hormonal/endocrine relationship. Consistent with previous research findings, the incidence of DDH in female infants (20.1%) was higher than in male infants (9.8%) in this study [17,18]. This trend could be linked to endocrine factors causing the relaxation of the hip joint capsule and its surrounding ligaments in female infants [19]. In cases where DDH is unilateral, the left hip is often more affected. Loder et al.'s study revealed a predilection for DDH on the left side (64%) and a proclivity for it to be unilateral (63.4%) [20]. However, in our study, there was no noticeable difference in DDH frequency between the right and left hips.

While hip radiographs of newborns in cribs demonstrate that their hips are not in true adduction—allowing for abduction up to 15-20°—swaddling keeps the hip extended and adducted. Some studies, including one by Walker et al. on 427 infants, suggest that swaddling does not increase the risk of DDH development [21]. Nevertheless, the majority of research underscores a strong link between swaddling and DDH [22]. Notably, a sonographic study from Turkey identified swaddling as the most significant risk factor for DDH, with a prevalence of 21.2% in children with DDH Graf IIb. This rate surpassed other factors such as breech birth (9.0%), family history (6.6%), and gender (6.2%) [11]. In our research, 65.5% (40 out of 61) of the infants diagnosed with DDH were swaddled, whereas only 42.7% (132 out of 309) of the infants without DDH were swaddled. This indicates a significantly higher swaddling rate among the DDH-diagnosed group.

In regions where swaddling is uncommon, such as South China, Africa (Bantu), Thailand, North Korea, and Sri Lanka, DDH is notably rare [23]. This pattern has led many to theorize that the lack of swaddling plays a key role in this reduced incidence. In contrast, swaddling remains a prevalent practice in our country. Targeted educational efforts can be instrumental in curbing this tradition. For instance, in Qatar, a concerted community awareness campaign spotlighting the adverse effects of swaddling and advocating against its use led to a significant decrease in reported ultrasonographic dysplasia in high-risk children for DDH: rates plummeted from 20% to 6%. It's crucial to note, however, that while swaddling may exacerbate the conditions of a dysplastic hip, it isn't the sole cause of hip dysplasia [24].

In Xu et al.'s study of 19,833 infants, the highest incidence of DDH was observed in infants aged 1 to 2 months, with the rate of DDH decreasing as the infants developed [16]. In contrast, our study showed the highest prevalence of DDH-positive hips between 1-2 months at 15%. This rate subsequently dropped to 8% for the 2-3 month age bracket and further to 6.5% for the 3-4 month age range. Interestingly, we noticed an uptick to 11% between 4-6 months. This rise could be explained by the referral of hips showing no improvement from external centers to our hospital for further evaluation. Another potential factor is the higher percentage of the rural population in our region. Infants not presented for initial follow-up in their early months were brought in as they aged, which might have contributed to the increased identification of pathological hips in this older age group [25, 26].

In a study by Ömeroğlu et al., 130 infants diagnosed with DDH received Pavlik harness treatment, of which 92 patients (71%) showed successful outcomes. Notably, their study identified a negative correlation between the degree of hip dislocation at initial presentation and treatment success rate [27]. Another study reported an even higher success rate of 81% and pinpointed similar factors for treatment failures [28]. In our investigation, we observed a 73% success rate with Pavlik harness treatment. This rate may hinge on both the initial Graf classification of the hip and the family's adherence to the treatment regimen.

One of the primary limitations of our study is its retrospective design and the relatively small sample size that represents a single center. The retrospective nature might have resulted in the omission of infants not screened at the study center, and there could be biases introduced due to inter-observer variability. As a result, the generalizability of our findings is constrained. Furthermore, the range of examined risk factors was not comprehensive. However, our results do enrich the current literature on DDH. They underscore the high incidence rate in our area and emphasize the potential risk posed by swaddling. Additionally, assessing DDH hips across different age groups can provide insights for optimizing ultrasound usage in both screening and subsequent follow-up.

Conclusions

An early diagnosis and immediate intervention are crucial in deflecting the long-term morbidities associated with DDH. While there have been significant advancements in healthcare technology, the elevated incidence highlighted in our study underscores the potential need for renewed screening efforts for DDH. Furthermore, post-delivery, it's imperative to educate families about risk factors, notably swaddling, and emphasize the importance of adhering to follow-up appointments before they are discharged from the hospital.

Funding: *The authors received no financial support for the research, authorship, and/or publication of this article.*

Conflict of interest: *The authors declare that they have no conflict of interest.*

Ethical statement: *The study protocols were approved by Dicle University Faculty of Medicine local ethics committee (date: 07.01.2021, protocol number: 01-2023/46).*

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