Research Article

Pamukkale Medical Journal
doi:https://dx.doi.org/10.31362/patd.1412442

Evaluation of ultrasound screening method and prevalence for developmental hip dysplasia in the central Anatolia

Orta Anadolu'da ultrason tarama yönteminin değerlendirilmesi ve gelişimsel kalça displazisi prevalansı

Oğuzhan Pekince, Ferhat Sayar, Emrah Cevat Ercan, Özkan Köse

Posted date:02.01.2024 Acceptance date:20.05.2024

Abstract

Purpose: This study aims to evaluate the incidence and follow-up outcomes of Developmental Hip Dysplasia (DDH) in infants admitted to City Hospital using the Graf classification. Furthermore, it aims to investigate the prevalence of DDH in Central Anatolia and assess the effectiveness of current screening and treatment protocols for detecting and managing DDH in infants.

Materials and methods: A total of 10.650 infants underwent screening for DDH using the Graf USG method as part of the National DDH screening program at City Hospital between August 2020 and September 2022. Infants born at term (38 weeks and above) and screened between 30-90 days of birth were included, while premature infants were excluded. Hips were classified according to the Graf method into Types 1 (normal), 2 (immature), 2A (+), 2A (-), 2B, 2C, D, 3, and 4, based on alpha angles.

Results: The study examined the USG results of 8,695 term infants (52.5% male and 47.5% female) between 2020 and 2022. The mean gestational age of participants at the time of the initial USG examination was approximately 7.94±2.07 weeks. Graf Type 1 was more prevalent in males (97-96.5%), while Graf Type 2 was more common in females (7.2-7.8%). Radiologists tended to recommend a re-examination after one month for Type 2A Graf hips (84.49-82.02%), whereas orthopedic consultation was advised for Type 2B, 2C, and Type 3 hips. The vast majority of infants (93.6%) underwent only one USG screening. Pelvic X-ray was requested for 15.9% of patients, and additional USGs were requested for 5.7% of patients. Pavlik treatment was applied to 4.2% of patients who did not return to normal, Frejka pillow treatment was applied to 1.5% Interestingly, none of the patients who maintained regular USG monitoring and treatment required surgical intervention involving osteotomy.

Conclusion: USG is an early diagnostic method for DDH, which allows for simple treatment options and the prevention of complications. It is a simple, inexpensive, and non-invasive method. Our study supports that regular USG screenings in infants eliminate the need for surgical procedures requiring osteotomy. However, the proportion of individuals who failed to adhere to their follow-up appointments despite receiving abnormal results remains elevated, underscoring the necessity for implementing diverse strategies aimed at augmenting parental awareness in this context.

Keywords: Developmental hip dysplasia, Anatolia, prevalence, ultrasound screening method**.**

Pekince O, Sayar F, Ercan EC, Kose O. Evaluation of ultrasound screening method and prevalence for developmental hip dysplasia in the central Anatolia. Pam Med J 2024;17:486-496.

Öz

Amaç: Bu çalışma, Şehir Hastanesi'ne başvuran bebeklerde Graf sınıflaması kullanılarak Gelişimsel Kalça Displazisi (GKD) insidansını ve takip sonuçlarını değerlendirmeyi amaçlamaktadır. Ayrıca, Orta Anadolu'da GKD prevalansını araştırmayı ve GKD'nin tespit edilmesi ve yönetilmesi için mevcut tarama ve tedavi protokollerinin etkinliğini değerlendirmeyi hedeflemektedir.

Gereç ve yöntem: Ağustos 2020 ile Eylül 2022 tarihleri arasında Şehir Hastanesi'nde Ulusal GKD tarama programının bir parçası olarak toplam 10.650 bebek Graf USG yöntemiyle GKD taramasından geçirilmiştir. Doğum haftası 38 hafta ve üzeri olan ve doğumdan 30-90 gün sonra taranan bebekler dahil edilirken, prematüre bebekler hariç tutulmuştur. Kalçalar alfa açılarına dayanarak Graf yöntemine göre Tip 1 (normal), 2 (olgunlaşmamış), 2A (+), 2A (-), 2B, 2C, D, 3 ve 4 şeklinde sınıflandırılmıştır.

Bulgular: Çalışma, 2020-2022 yılları arasında 8.695 term bebek (%52,5 erkek ve %47,5 dişi) USG sonuçlarını incelemiştir. Katılımcıların ilk USG muayenesi sırasındaki ortalama gebelik haftası yaklaşık 7,94±2,07 hafta idi. Graf Tip 1 erkeklerde daha yaygındı (%97-96,5), Graf Tip 2 ise kadınlarda daha yaygındı (%7,2-7,8).

Oğuzhan Pekince, Specialist, Konya City Hospital, Department of Orthopaedics and Traumatology, Konya, Türkiye, e-mail: oguzhanpekince@hotmail.com (https://orcid.org/0000-0002-3988-9818) (Corresponding Author)

Ferhat Sayar, Specialist, Konya City Hospital, Department of Orthopaedics and Traumatology, Konya, Türkiye, e-mail: ferhatsayar14@hotmail.com (https://orcid.org/0000-0002-0084-2414)

Emrah Cevat Ercan, Specialist, Konya City Hospital, Department of Orthopaedics and Traumatology, Konya, Türkiye, e-mail: drecevate@hotmail.com (https://orcid.org/0000-0001-8263-7547)

Özkan Köse, Prof. Antalya Research and Education Hospital, Department of Orthopaedics and Traumatology, Antalya, Türkiye, e-mail: drozkankose@hotmail.com (https://orcid.org/0000-0002-7679-9635)

Graf Tip 2A kalçalar için radyologlar genellikle bir ay sonra tekrar muayene önerirken (%84,49-82,02), Tip 2B, 2C ve Tip-3 kalçalar için ortopedik danışma önerilmiştir. Bebeklerin büyük çoğunluğu (%93,6) yalnızca bir kez USG taramasına tabi tutulmuştur. Hastaların %15,9'una pelvis grafisi istenmiş ve %5,7'sine ek USG'ler istenmiştir. Takiplerinde normale dönmeyen hastaların %4,2'sine Pavlik tedavisi uygulanmış, %1,5'ine Frejka yastığı tedavisi uygulanmıştır. İlginç bir şekilde, düzenli USG takibi ve tedavisi devam eden hastalar arasında hiçbirinin osteotomi gerektiren cerrahi müdahaleye ihtiyaç duymadığı gözlemlenmiştir.
Sonuç: USG, GKD tanısı için erken, basit, ucuz ve invaziv olmayan bir tanı yöntemidir. Sonuçlarında GKD tanısı konulan çocukların basit tedavi modaliteleri ile tedavi edilmelerine ve komplikasyonların önlenmesine olanak sağlar. Çalışmamız, bebeklerde düzenli USG taramalarının osteotomi gerektiren cerrahi işlemlere ihtiyacı ortadan kaldırdığını desteklemektedir. Ancak, anormal sonuçlar almasına rağmen takip randevularına uymayan bireylerin oranı hala yüksektir, bu da ebeveyn farkındalığını artırmaya yönelik çeşitli stratejilerin uygulanması gerekliliğini vurgular.

Anahtar kelimeler: Gelişimsel kalça displazisi, Anadolu, prevalans, ultrason tarama metodu.

Pekince O, Sayar F, Ercan EC, Köse Ö. Orta Anadolu'da ultrason tarama yönteminin değerlendirilmesi ve gelişimsel kalça displazisi prevalansı. Pam Tıp Derg 2024;17:486-496.

Introduction

Developmental Hip Dysplasia (DDH) is a congenital hip anomaly that can lead to instability, dislocation, and reduced mobility [1]. The incidence of DDH varies based on the population and the screening method used. According to studies, the prevalence of DDH in newborns ranges from 0.06% to 7.61%, with females, breech position infants, firstborn children, and family stories at higher risk [2] Timely diagnosis and treatment are crucial to prevent long-term complications and ensure proper hip joint development [3].

The hip joint's development is a dynamic process that occurs during the neonatal period and is difficult to assess using direct radiography due to the predominance of cartilage. Hip USG using the Graf classification is the gold standard for detecting DDH in newborns, particularly in the first six months of life [4]. In Türkiye, Graf hip USG screening is a standard method for identifying DDH in newborns and is incorporated into routine newborn evaluations to ensure early detection and treatment of DDH.

This study aims to evaluate the incidence and follow-up outcomes of DDH in infants admitted to Konya City Hospital using the Graf classification between August 2020 and September 2022. This research study aimed to investigate the prevalence of DDH in Central Anatolia and assess the effectiveness of the current screening and treatment protocols for detecting and managing DDH in infants.

Materials and methods

Study design

From August 2020 to September 2022, the results of 10,650 infants screened using the Graf USG method under the National DDH screening program at City Hospital were retrospectively examined. Delivery weeks of the infants were analyzed from the hospital database, and infants born at term (38 weeks and above) were included in the study, while premature infants were excluded. Infants who underwent USG between 30-90 days of birth, and whose hip development physiology was standardized during USG, were also included.

The Graf method was used as the screening method, and the infants were placed on their sides with their hips and knees held in 15-20 degrees of internal rotation and semi-flexion. Gel was applied to the hip skin, and coronal sections were obtained with a probe held vertically to the body. The angles were calculated by obtaining appropriate images of all sections of the hip reference points observed on the monitor (the deepest point of the acetabulum, the ilium wing plane and its smooth appearance, and the labrum). After determining the alpha and beta angles, hip dysplasias were classified ultrasonographically according to the Graf method, with Type 1 hips being normal and Type 2 hips being considered "immature" in their development cycles. Type 2 hips are further divided into 2A (+) and 2A (-) based on alpha angles of 55-59 and 50-54, respectively,

while Type 2B hips have alpha angles between 45-49. Type 2C and Type D hips are considered "dysplastic," and Type 3 and 4 hips are considered "dislocations (Table 1).

Statistical analysis

The statistical analyses of the study were conducted using the SPSS 20.0 (IBM Inc, Chicago, IL, USA) program. Descriptive statistics were presented as mean±SD and median; min-max for numerical variables and frequency (percentage) for categorical variables. Monte Carlo-corrected chi-square analysis was used to determine the relationships between categorical variables. A *p*-value of <0.05 was considered statistically significant in the analyses.

Table 1. Graf classification

Graf Clasification	Alpha Angle (Bone Roof)	Beta Angle (Cartilaginous Roof)	Explanation
Type 1	a>60	b<55° <3month	Normal Hip
Type 2A+	a= 55°-60°	b>55° <3month	Pathological Immature Hip
Type 2A-	aaaaa= 50°-55°	b>55° <3month	Pathological Immature Hip
Type 2B	a= 50°-60°	b>55° <3month	Centered Hip Stable
Type 2C	a= 43°-49°	b<77°	Centered Hip Unstable
Type D	a= 43°-49°	b>77°	Decentered Hip
Type 3	a<43°	b>77°	Eccentered Hip
Type 4	a<43°	b>77°	Dislocated Hip

Results

The study included 8,695 term infants (17,390 hips) who underwent developmental hip dysplasia screening using the Graf USG method between 2020 and 2022, within 30-90 days after birth at Konya City Hospital by individuals from Konya and its surrounding areas. Of the patients, slightly over half (52.5%) were male and the remaining were female (47.5%). The mean age of the first USG examination was 55.64±14.49 days, while the mean gestational age at the time of the first USG examination was 7.94±2.07 weeks. The majority of babies (93.6%) underwent USG screening only once. Of the babies, 6.4% underwent a second USG and 0.64% underwent a third USG for control and follow-up purposes based on their first USG examination results. Eight babies required a fourth and two babies required a fifth USG examination (Table 2, 3).

Graf types were evaluated by gender. In the first USG examinations, Graf types showed a significant difference by gender for both right and left hips (p<0.001). The proportion of Type 1 graphs was higher in male infants for both sides (right: 97%, left: 96.5%), while the Type 2A rate was higher in female infants (right: 7.2%, left: 7.8%). Type 2B and C had a slightly higher number (2.2%, 0.8%) of patients in females, and for Type 4 rates were equal, but for the left hip, all Type 4 patients (n=2) were females (Table 2, 4).

The relationships between Graf types and USG decisions were investigated. For both right and left hips, except for patients diagnosed as 'NORMAL' with Type 1 Graf, who had a borderline Graf angle, despite being within normal limits, it was decided to "re-examine after 1 month" (2.67% and 2.35%, respectively). The highest rate of "re-examine after 1 month" was determined for Type 2A Graf types for both right and left hips (84.49% and 82.02%, respectively) (p<0.001). Generally, orthopedic consultation was recommended for Type 2B, 2C, and Type 3 Graf types. The distribution of Graf types was similar for both right and left hips according to the second USG decisions (p<0.001). It was observed that the rate of orthopedic consultation requests increased for Type 2A Graf hips in radiologists alongside control USG compared to the first USG (13.7-20%). Type 2B, 2C, and Type 3 Graf types were generally directed to orthopedic consultation (Table 5, 6).

Table 2. Rate of sex and type of graf

Variable	Category	N (%)	Variable	Category	N (%)
Sex	**Female**	4127 (47.5)			
	Male	4568 (52.5)			
Graf Types			**Graf Types**		
Right Hip 1. USG	**Type 1**	8248 (94.8)	**Left Hip 1. USG**	**Type 1**	8194 (94.2)
	Type 2A	432 (5.0)		**Type 2A**	473 (5.4)
	Type 2B	8 (0.1)		**Type 2B**	10 (0.1)
	Type 2C	4 (0.0)		**Type 2C**	11 (0.1)
	Type 4	2 (0.0)		**Type 4**	4 (0.0)
Right Hip 2. USG	**Type 1**	491 (5.6)	**Left Hip 2. USG**	**Type 1**	476 (5.5)
	Type 2A	52 (0.6)		**Type 2A**	65 (0.7)
	Type 2B	10 (0.1)		**Type 2B**	10 (0.1)
	Type 2C	3 (0.0)		**Type 2C**	5 (0.1)
	Type 3	2 (0.0)		**Type 3**	1 (0.0)
Right Hip 3. USG	**Type 1**	44 (0.5)	**Left Hip 3. USG**	**Type 1**	38 (0.4)
	Type 2A	6 (0.1)		**Type 2A**	5 (0.1)
	Type 2B	7 (0.1)		**Type 2B**	14 (0.2)
Right Hip 4. USG	**Type 1**	6 (0.1)	**Left Hip 4. USG**	**Type 1**	5 (0.1)
	Type 2B	2 (0.0)		**Type 2B**	3 (0.0)
Right Hip 5. USG	**Type 2A**	1 (0.0)	**Left Hip 5. USG**	**Type 1**	2 (0.0)
	Type 2B	1 (0.0)			

Table 3. Ultrasound imaging day

	Mean±SS	Median; Min-Max
Birth Week	38.22±0.65	38; 38-42
Age (Month)	18.26±7.62	17.7; 5.5-34.3
Ultrasound imaging day		
1.USG (n=8695)	55.64±14.49	53; 30-90
2.USG (n=558)	84.23±20.3	82; 41-206
3.USG (n=56)	110.0±18.44	107; 84-194
4.USG (n=8)	126.13±23.73	119; 104-176
5.USG (n=2)	125±1.41	125; 124-126

Table 4. Graf types according to sex

		Sex		
		Female	Male	
Graf Types	**Categories**	**N (%)**	**N (%)**	***p***
1. USG Right Hip	**Type 1**	1819 (92.5)	4429 (97.0)	
	Type 2A	298 (7.2)	134 (2.9)	
	Type 2B	6 (0.1)	2 (0.0)	*<0.001**
	Type 2C	3 (0.1)	1 (0.0)	
	Type 4	1 (0.0)	1 (0.0)	
1. USG Left Hip	**Type 1**	3786 (91.7)	4408 (96.5)	
	Type 2A	320 (7.8)	153 (3.4)	
	Type 2B	7 (0.2)	3 (0.1)	*<0.001**
	Type 2C	9 (0.2)	2 (0.0)	
	Type 3	3 (0.1)	1 (0.0)	
	Type 4	2 (0.0)	0 (0.0)	
2. USG Right Hip	**Type 1**	316 (86.6)	175 (90.7)	
	Type 2A	37 (10.1)	15 (7.8)	
	Type 2B	8 (2.2)	2 (1.0)	*0.256*
	Type 2C	3 (0.8)	0 (0.0)	
	Type 3	1 (0.3)	1 (0.5)	
2. USG Left Hip	**Type 1**	302 (82.7)	174 (90.2)	
	Type 2A	50 (13.7)	15 (7.8)	
	Type 2B	8 (2.2)	2 (1.0)	*0.042**
	Type 2C	3 (0.8)	2 (1.0)	
	Type 2D	1 (0.3)	0 (0.0)	
	Type 3	1 (0.3)	0 (0.0)	
3. USG Right Hip	**Type 1**	32 (74.4)	12 (85.7)	
	Type 2A	5 (11.6)	1 (7.1)	*0.397*
	Type 2B	6 (14.0)	1 (7.1)	
3. USG Left Hip	**Type 1**	27 (62.8)	11 (78.6)	
	Type 2A	4 (9.3)	1 (7.1)	*0.269*
	Type 2B	12 (27.9)	2 (14.3)	
4. USG Right Hip	**Type 1**	6 (85.7)	0 (0.0)	*0.083*
	Type 2B	1 (14.3)	1 (100.0)	
4. USG Left Hip	**Type 1**	5 (71.4)	0 (0.0)	*0.197*
	Type 2B	2 (28.6)	1 (100.0)	
5. USG Right Hip	**Type 2A**	0 (0.0)	1 (100.0)	*0.317*
	Type 2B	1 (100.0)	0 (0.0)	
5. USG Left Hip	**Type 1**	1 (100.0)	1 (100.0)	

**: Significant at the 0.05 level according to chi-square analysis*

Table 5. USG desicions and treatments

Variable	Category	N (%)
1.Desicion	**2 weeks later control**	13 (0.1)
	3 weeks later control	80 (0.9)
	1 month later control	589 (6.8)
	Orthopaedics Consultation	54 (0.6)
	Normal	7959 (91.5)
2.Desicion	**2 weeks later control**	12 (0.1)
	3 weeks later control	13 (0.1)
	1 month later control	56 (0.6)
	Orthopaedics Consultation	34 (0.4)
	Normal	443 (5.1)
3.Desicion	**2 weeks later control**	1 (0.0)
	3 weeks later control	1 (0.0)
	1 month later control	9 (0.1)
	Orthopaedics Consultation	14 (0.2)
	Normal	32 (0.4)
4.Desicion	**1 month later control**	1 (0.0)
	Orthopaedics Consultation	4 (0.0)
	Normal	3 (0.0)
5.Desicion	**1 month later control**	1 (0.0)
	Orthopaedics Consultation	1 (0.0)
Additional Imaging	**Pelvis X-ray**	119 (1.4)
	USG	42 (0.5)
	Out Of Follow Up	197 (2.3)
	No	8337 (95.9)
Treatment	**No**	8448 (97.2)
	Pavlic	34 (0.4)
	Frejka splint	11 (0.1)
	Pelvic Cast	3 (0.01)
	Out Of Follow Up	198 (2.3)
Surgical Treatment	**No**	8490 (97.6)
	Open Reduction	2 (0.002)
	Closed Reduction	5 (0.1)
	Out Of Follow Up	197 (2.3)

Table 6. Graf types and USG decisions according to right/left hip

USG		2 weeks later control	3 weeks later control	1 month later control	Orthopaedics Consultation	Normal	
Graf Types	**Types**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**	***p***
1. Desicion Right Hip	**Type 1**	3 (0.03)	41 (0.49)	221 (2.67)	23 (0.27)	7959 (96.50)	*<0.001**
	Type 2A	10 (2.31)	38 (8.79)	365 (84.49)	19 (4.39)	0 (0.0)	
	Type 2B	0 (0.0)	1 (12.5)	3 (37.5)	4 (50.0)	0 (0.0)	
	Type 2C	0 (0.0)	0 (0.0)	0 (0.0)	4 (100.0)	0 (0.0)	
	Type 4	0 (0.0)	0 (0.0)	0 (0.0)	2 (100.0)	0 (0.0)	
1. Decision Left Hip	**Type 1**	7 (0.08)	25 (0.3)	193 (2.35)	11 (0.13)	7958 (97.1)	*<0.001**
	Type 2A	6 (1.26)	53 (11.2)	388 (82.02)	25 (5.28)	1 (0.21)	
	Type 2B	0 (0.0)	2 (20.0)	6 (60.0)	2 (20.0)	0 (0.0)	
	Type 2C	0 (0.0)	0 (0.0)	1 (9.1)	10 (90.9)	0 (0.0)	
	Type 3	0 (0.0)	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)	
	Type 4	0 (0.0)	0 (0.0)	0 (0.0)	4 (100.0)	0 (0.0)	
2. Desicion Right Hip	**Type 1**	4 (0.81)	6 (1.22)	24 (4.88)	14 (2.88)	443 (90.22)	*<0.001**
	Type 2A	8 (15.38)	7 (13.46)	28 (53.84)	9 (13.70)	0 (0.0)	
	Type 2B	0 (0.0)	0 (0.0)	2 (20.0)	8 (80.0)	0 (0.0)	
	Type 2C	0 (0.0)	0 (0.0)	0 (0.0)	3 (100.0)	0 (0.0)	
	Type 3	0 (0.0)	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)	
2. Decision Left Hip	**Type 1**	5 (1.05)	5 (1.05)	16 (3.36)	7 (1.47)	443 (93.06)	*<0.001**
	Type 2A	7 (10.76)	8 (12.30)	37 (56.92)	13 (20)	0 (0.0)	
	Type 2B	0 (0.0)	0 (0.0)	2 (20.0)	8 (80.0)	0 (0.0)	
	Type 2C	0 (0.0)	0 (0.0)	0 (0.0)	5 (100.0)	0 (0.0)	
	Type 2D	0 (0.0)	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	
	Type 3	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	
3. Desicion Right Hip	**Type 1**	1 (2.27)	0 (0.0)	4 (9.09)	7 (15.9)	32 (72.7)	*0.002**
	Type 2A	0 (0.0)	1 (16.67)	3 (50.0)	2 (33.3)	0 (0.0)	
	Type 2B	0 (0.0)	0 (0.0)	2 (28.57)	5 (71.42)	0 (0.0)	
3. Decision Left Hip	**Type 1**	0 (0.0)	1 (2.63)	2 (5.26)	3 (7.89)	32 (84.21)	*<0.001**
	Type 2A	0 (0.0)	0 (0.0)	3 (60.0)	2 (40.0)	0 (0.0)	
	Type 2B	1 (7.14)	0 (0.0)	4 (28.57)	9 (64.28)	0 (0.0)	
		1 month later control		**Orthopaedics Consultation**		**Normal**	
4. Desicion Right Hip	**Type 1**	1 (16.7)		2 (33.3)		3 (50.0)	*0.564*
	Type 2B	0 (0.0)		2 (100.0)		0 (0.0)	
		1 month later control		**Orthopaedics Consultation**		**Normal**	
4. Decision Left Hip	**Type 1**	1 (20.0)		1 (20.0)		3 (60.0)	*0.439*
	Type 2B	0 (0.0)		3 (100.0)		0 (0.0)	
		1 month later control		**Orthopaedics Consultation**			
5. Decision Left Hip	**Type 2A**	1 (100.0)		0 (0.0)			*0.317*
	Type 2B	0 (0.0)		1 (100.0)			
		1 month later control		**Orthopaedics Consultation**			
5. Desicion Left Hip	**Type 1**	1 (50.0)		1 (50.0)			*N/A*

**: Significant at the 0.05 level according to chi-square analysis*

Following the initial evaluation, 48.4% of patients who received abnormal results returned to normal after the second evaluation, 3.7% after the third USG, and 0.4% after the fourth USG. Among patients who did not return to normal regardless of the number of USG, 26.5% (n=195) were evaluated as being out of follow-up because they did not have any health records in the national health database. Pelvic X-ray was requested for 15.9% of patients, and additional USGs were requested for 5.7% of patients beyond our study periods. Pavlik treatment was applied to 4.2% of patients who did not return to normal, Frejka pillow treatment was applied to 1.5%, and only 3 patients received pelvic-cast treatment. Open reduction was applied to 2 patients, while adductor tenotomy and closed reduction surgery were applied to 5 patients (Table 5). No patients who continued their USG control and treatment regularly required surgical treatment requiring osteotomy.

The relationship between the outcomes of patients who did not return to normal and non-surgical treatments and evaluations after USG was evaluated. A significant relationship was found between decisions and treatments after the first evaluation (p<0.001). Most patients who received a normal and control USG did not receive treatment and remained out of follow-up by 27.3%. Pavlik treatment was applied to 3.2% of patients and Frejka pillow treatment was applied to 1.5% of USG control patients. Approximately 73% of patients who were referred for orthopedic consultation did not receive treatment and remained out of follow-up, while the remaining patients received Pavlik treatment (16.7%), Frejka pillow (1.9%), and pelvic-cast treatment (3.7%). At the second follow-up, approximately 59.3-44.1% of patients who were referred for orthopedic consultation did not receive treatment, while Pavlik treatment was applied to 14.8-26.5% of patients and Frejka pillow treatment was applied to 3.7-11.8% of patients. Only Pavlik treatment was observed for children who had fourth and fifth USG controls, and no surgical treatment was needed (Table 7).

Table 7. Follow up of patiens whose USG do not return to normal

Treatment	No	Yes	Pavlic	Frejka Splint	Pelvic Cast	Out of Follow Up	
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	*p*
1.USG desicion							
Control USG	462 (67.7)	1 (0.1)	22 (3.2)	10 (1.5)	1 (0.1)	186 (27.3)	*<0.001**
Orthopaedics Consultation	30 (55.6)	2 (3.7)	9 (16.7)	1 (1.9)	2 (3.7)	10 (18.5)	
Normal	7956 (99.7)	0	1 (0.01)	0	0	2 (0.02)	
2.USG desicion							
Control USG	48 (59.3)	1 (1.2)	12 (14.8)	3 (3.7)	…	17 (21.0)	*<0.001**
Orthopaedics Consultation	15 (44.1)	2 (5.9)	9 (26.5)	4 (11.8)	…	4 (11.8)	
Normal	443 (100.0)	0	0	0	…	0	
3.USG desicion							
Control USG	4 (36.4)	…	3 (27.3)	4 (36.4)	…	0	*<0.001**
Orthopaedics Consultation	4 (28.6)	…	6 (42.9)	2 (14.3)	…	2 (14.3)	
Normal	32 (100.0)	…	0	0	…	0	
4.USG desicion							
Control USG	0	…	1 (100.0)	…	…	…	*0.046*
Orthopaedics Consultation	1 (25.0)	…	3 (75.0)	…	…	…	
Normal	3 (100.0)	…	0	…	…	…	
5.USG desicion							
Control USG	…	…	1 (100.0)	…	…	…	*N/A*
	…	…	1 (100.0)	…	…	…	

**: Significant at the 0.05 level according to chi-square analysis*

Discussion

Ultrasonography represents a straightforward, cost-effective, and non-invasive technique for the early detection of DDH. It not only permits treatment through uncomplicated methods but also aids in averting potential complications. Our research corroborates this standpoint by revealing that none of the infants subjected to routine USG screenings necessitated surgical osteotomy.

In particular, USG is the primary screening method for cases where complete ossification has not occurred in infants under six months of age [5]. Once ossification increases after six months, pelvic X-rays are preferred over USG. Many developed countries routinely use USG-assisted screening methods [6]. In Türkiye, the Graf USG method is part of the free routine screening program for all newborns. This study aims to investigate the incidence of developmental hip dysplasia in the Konya region by analyzing the results of patients who underwent USG within 30 to 90 days after term birth at Konya City Hospital. Additionally, the study aims to explore the outcomes of infants with abnormal results.

Various studies in the literature indicate that developmental hip dysplasia (DDH) incidence varies according to geographical region and cultural habits, ranging from 0.01% to 6.6% [7]. Studies on the incidence of DDH using various physical examination and imaging methods show rates ranging from 0.5% to 1.5% [2]. Dongsheng Zhu's study in China analyzed the results of 9803 infants and reported a DDH incidence rate of 1.19% [8]. Çekiç et al. [9] used the Graf USG method to screen 1162 infants in the western Mediterranean region and found an incidence rate of 1.36%. In 1992, Kutlu et al. [10] conducted a survey of five hospitals in Konya and found a DDH incidence rate of 1.34%. Unilateral hip disorders are more common in the left hip (60%) and less common in the (20%), while bilateral disorders are less frequent (20%). In our study, the results of 8695 term babies who underwent hip USG screening at Konya City Hospital and came from Konya and its surroundings were scanned from the system. The gender distribution was approximately homogeneous. As a result of the first USG, normal hips were found in 94.8% of the and 94.2% of the left hip. Considering Type 2B and higher types, the incidence of GKD was 0.2% for the and 0.4% for the left hip. Additionally, in our study, Type 1 hips were significantly more common in boys, while Type 2A hips were significantly more common in girls. Type 2B, C 4 hips were also more common in girls.

In Graf Type 2A hips, which describe insufficient development of the hip joint, only follow-up was reported to result in 97% improvement [11]. In Roovers et al.'s [12] study, the rate of return to normal was reported as 95% for Type 2A (+) hips and 95% for Type 2A (-) hips. According to a study conducted in Türkiye, Type 2A hip is more common in newborn girls than in boys. Among 431 Type 2A hips, 225 out of 285 hips (79%) that were completely followed up returned to normal. The hips of newborn boys are more likely to spontaneously normalize than those of girls at 6-7 weeks of age [13]. In a study conducted in Mongolia, of 147 infants who continued to be followed up out of 174 babies with Type 2A, 3 hips at the first examination, 121 returned to normal at the second USG and 26 returned to normal at the third ultrasound [14]. In our study, 48.4% of patients who did not have a normal result in the first ultrasound returned to normal in the second USG, and 3.7% returned to normal in the third USG. In 26.5% of babies, no record was found in our hospital or the national health database, so they were considered lost to follow-up.

According to some published reports, Type 2A cases may experience deterioration after the initial USG. A study that examined 201 Type 2A cases found that 4 cases remained stable at first but progressed to Type 2B during later follow-up assessments, while 6 cases deteriorated to Type 2C [9]. Duramaz et al. [15] conducted a study in which routine USG examinations were performed two weeks after the diagnosis of Type 2A in infants. Pavlik bandages were applied to infants with persistent Type 2A on the follow-up USG examination. For hips that reverted to Type 1 with Pavlik, treatment was extended to 12 weeks, while closed/open reduction treatments were performed for stubborn Type 2A cases. In another study conducted in our country, it was reported that 71 of 78 infants who did not miss their follow-up appointments returned to normal without treatment, while 56 infants did not continue their follow-up appointments [16]. In our study, among 273 infants diagnosed with

Type 2A on the right side on their first USG, 16.1% remained Type 2A, 1.8% progressed to Type 2B, and 1.1% deteriorated to Type 2C on their second USG. 81% of the infants were lost to follow-up. Among 301 infants diagnosed with Type 2A on the left side on their first USG, 15.3% remained Type 2A, 3.3% progressed to Type 2B, and 0.3% deteriorated to Type 2C on their second USG. Thirty-two infants were followed and treated with the Pavlik method, and 11 were followed with the Frejka pillow. Closed reduction was required for five patients who showed deterioration or had hips of Type 2B or above, and two patients required open reduction and pelvic-pedal plaster cast treatment. Three patients were treated with closed reduction and pelvic radiography after the follow-up USG examination, as per the surgical preference based on the initial USG results. No patient who received regular ultrasound follow-up required surgery requiring osteotomy.

The main advantage of USG is that it is non-invasive, low-cost, and does not involve radiation. However, the results are dependent on various factors, such as the operator's experience and the equipment used, which may sometimes require orthopedists to perform additional imaging, such as pelvic X-rays. In our study, pelvic X-rays were taken in 117 patients. In the first USG examination, Type 2A was detected in 49.6% of the joints, Type 2B in 5%, and Type 2C or higher in 5.9%. On the left side, Type 2A was detected in 60.5%, Type 2B in 8.4%, and Type 2C or higher in 12.6%. Of these, 68.1% underwent two or more follow-up USG examinations, and 42.4% required treatment such as Pavlik harness, Frejka pillow, or open/closed reduction and pelvic-foot cast. In two patients (0.8%) who underwent pelvic X-rays, pathology-immaturity was detected on USG, but the surgeon made a normal diagnosis and did not follow up with treatment.

It has been observed that in our country, USG screening is mainly followed by primary healthcare facilities and referred to pediatricians. Therefore, the decisions made by radiologists based on USG results are also essential for us as orthopedists. A NORMAL decision is mostly made for patients diagnosed with Type 1 hip in USG, but as the angles are borderline, follow-up USG is recommended. When it comes to Type 2A results, while follow-up USG is recommended, radiologists suggest orthopedic consultation for treatment in Type 2B and above hips. It is observed that the rate of orthopedic consultation for treatment or follow-up of Type 2A hips in the second USG increases from the right/left hip ratio of 4.39%/5.28% to 13.70%/20%, aiming for the orthopedist to perform the treatment or follow-up.

In our study, which examined a substantial population, the lack of recording of intrauterine problems, birth positions, and family histories of babies whose USG results were evaluated, as well as the inability to determine the fate of some babies due to the parents' failure to attend follow-up appointments for various reasons, can be considered limitations of our study. In addition, the fact that the results were based on our hospital's database and that the USG was performed by multiple physicians are also limitations.

In conclusion, screening with USG is a simple, inexpensive, and non-invasive method that enables early diagnosis of DDH, and allows for treatment with simple modalities, as well as the prevention of complications. Our study supports this thesis by showing that none of the babies who underwent regular USG screenings required surgical osteotomy. Nevertheless, the percentage of patients who did not continue with their follow-ups despite abnormal results is still high, highlighting the need for various measures to increase parental awareness in this regard.

Conflict of interest: The author(s) have no conflicts of interest relevant to this article.

References

1. Guille JT, Pizzutillo PD, MacEwen GD. Development dysplasia of the hip from birth to six months. J Am Acad Orthop Surg 2000;8:232-242. https://doi.org/10.5435/00124635-200007000-00004
2. Sioutis S, Kolovos S, Papakonstantinou ME, Reppas L, Koulalis D, Mavrogenis AF. Developmental dysplasia of the hip: a review. J Long Term Eff Med Implants 2022;32:39-56. https://doi.org/10.1615/JLongTermEffMedImplants.2022040393
3. Kotlarsky P, Haber R, Bialik V, Eidelman M. Developmental dysplasia of the hip: what has changed in the last 20 years?. World J Orthop 2015;6:886-901. https://doi.org/10.5312/wjo.v6.i11.886

4. Liu B, Hu X, Li L, Gao S. Morphological development of the hip in normal infants under six months of age by the graf ultrasound method. Front Pediatr 2022;10:914545. https://doi.org/10.3389/fped.2022.914545
5. Husum HC, Møller Madsen B, Thomsen JL, Maimburg RD, Rahbek O. Screening of dysplasia of the hip in denmark. Ugeskr Laeger 2021;183:V05200371.
6. Chand S, Aroojis A, Pandey RA, Johari AN. The incidence, diagnosis, and treatment practices of developmental dysplasia of Hip (DDH) in India: a scoping systematic review. Indian J Orthop 2021;55:1428-1439. https://doi.org/10.1007/s43465-021-00526-y
7. Harsanyi S, Zamborsky R, Krajciova L, Kokavec M, Danisovic L. Developmental dysplasia of the hip: a review of etiopathogenesis, risk factors, and genetic aspects. Medicina (Kaunas) 2020;56:153. https://doi.org/10.3390/medicina56040153
8. Zhu D, Zhu H. Incidence and epidemiological characters of developmental dysplasia of the hip in lianyungang: based on ultrasound screening: a retrospective study. Int J Gen Med 2022;15:8547-8555. https://doi.org/10.2147/IJGM.S389145
9. Çekiç B, Erdem Toslak İ, Sertkaya Ö, et al. Incidence and follow-up outcomes of developmental hip dysplasia of newborns in the Western Mediterranean Region. Turk J Pediatr 2015;57:353-358.
10. Kutlu A, Memik R, Mutlu M, Kutlu R, Arslan A. Congenital dislocation of the hip and its relation to swaddling used in Turkey. J Pediatr Orthop 1992;12:598-602.
11. Rosendahl K, Toma P. Ultrasound in the diagnosis of developmental dysplasia of the hip in newborns. The European approach. A review of methods, accuracy and clinical validity. Eur Radiol 2007;17:1960-1967. https://doi.org/10.1007/s00330-006-0557-y
12. Roovers EA, Boere Boonekamp MM, Mostert AK, Castelein RM, Zielhuis GA, Kerkhoff THM. The natural history of developmental dysplasia of the hip: sonographic findings in infants of 1-3 months of age. J Pediatr Orthop B 2005;14:325-330. https://doi.org/10.1097/01202412-200509000-00003
13. Omeroğlu H, Caylak R, Inan U, Köse N. Ultrasonographic graf type IIa hip needs more consideration in newborn girls. J Child Orthop 2013;7:95-98. https://doi.org/10.1007/s11832-012-0476-1
14. Munkhuu B, Essig S, Renchinnyam E, et al. Incidence and treatment of developmental hip dysplasia in Mongolia: a prospective cohort study. PLoS One 2013;8:e79427. https://doi.org/10.1371/journal.pone.0079427
15. Duramaz A, Peker G, Arslan L, Bilgili MG, Erçin E, Kural C. Gelişimsel kalça displazisi tanısında kalça ultrasonografisi: Bakırköy tecrübesi. Haseki Tıp Bülteni 2014;52:262-267. https://doi.org/10.4274/haseki.1669
16. Ceylan HH, Paksoy Y. İstanbul Sultangazi regional incidence of newborn developmental dysplasia of hip. Med Bull Haseki 2018;56:68-73. https://doi.org/10.4274/haseki.4029

Acknowledgements: The authors would like to thank Adnan Karaibrahimoglu, a faculty member in the Department of Biostatistics at Suleyman Demirel University Faculty of Medicine, for the statistical analysis.

Ethics approval: Ethics approval was obtained from Necmettin Erbakan University Ethics Committee (Ethical approval no: 2023/4197, and approval date: 17/02/2023).

Authors' contributions to the article

O.P. has constructed the main idea and hypothesis of the study. O.P. and O.K. developed the theory and edited the material and method sections. O.P., F.S. and E.C.E. have collected data and evaluated the data in the results. The article was written by O.P. Review and correction has been done by O.K. In addition, all authors discussed the entire study and approved the final version.