Original Research Article

Assessment of developmental dysplasia of the hip using ultrasonography in infants

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Received: 20 December 2025
Accepted: 16 January 2026

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ABSTRACT

Background: Developmental dysplasia of the hip (DDH) represents a spectrum of anatomical abnormalities that may lead to long-term functional impairment if not diagnosed and treated early. Ultrasonography allows real-time visualization of cartilaginous hip structures and is the preferred imaging modality during early infancy. This study aimed to evaluate ultrasonographic findings of DDH in infants and analyze associated demographic characteristics, risk factors and Graf classification patterns.

Methods: This cross-sectional study was conducted at the Department of Radiology and Imaging, Bangladesh Shishu Hospital and Institute, Dhaka, Bangladesh, from July 2024 to June 2025. Thirty infants aged six months or younger underwent bilateral hip ultrasonography using the standardized Graf technique. Demographic variables, perinatal risk factors and sonographic parameters were recorded systematically. Data were analyzed using SPSS version 25.0.

Results: Female infants constituted 63.3% of the study population. Normal hips (Graf type I) were identified in 46.7% of infants, while 23.3% demonstrated physiologic immaturity (type IIa). Moderate to severe dysplasia (types IIb-IV) was observed in 26.7% of cases. Reduced α-angle, shallow acetabulum and increased β-angle were the most frequent abnormal findings. The proportion of normal hips increased with advancing age, indicating progressive acetabular maturation.

Conclusions: Ultrasonography is an effective, reliable modality for early detection of DDH, particularly among high-risk infants. Early identification facilitates timely intervention and may reduce the burden of late-presenting disease.

Keywords: Developmental dysplasia of the hip, Pediatric radiology, Ultrasonography

INTRODUCTION

Developmental dysplasia of the hip (DDH) encompasses a spectrum of abnormalities ranging from mild acetabular dysplasia to complete dislocation of the femoral head from the acetabulum. It represents one of the most common musculoskeletal disorders in infancy and early childhood, with reported incidence varying widely depending on population characteristics and screening strategies.[1,2] Early identification of DDH is crucial, as delayed diagnosis may result in long-term morbidity, including gait abnormalities, chronic pain, early osteoarthritis and the need for complex surgical interventions later in life.[3,4]

Clinical screening methods, such as the Ortolani and Barlow maneuvers, have traditionally been used for early detection; however, their sensitivity is limited, particularly in mild or clinically silent cases.[5] Ultrasonography has emerged as the imaging modality of choice for evaluating the immature hip joint, owing to its ability to visualize cartilaginous structures not visible on radiographs during early infancy.[6] The Graf method, which is based on standardized coronal imaging and quantitative angle measurements, remains the most widely accepted and validated sonographic technique for DDH assessment.[7]

Several risk factors have been consistently associated with

DDH, including female sex, breech presentation, positive family history, first-born status and oligohydramnios.[8,9] Despite the presence of known risk factors, a significant proportion of affected infants may remain asymptomatic, underscoring the importance of imaging-based screening strategies.[10] Selective versus universal ultrasound screening remains a subject of debate, particularly in resource-limited settings where cost-effectiveness and feasibility must be carefully balanced.[11]

In developing countries, delayed presentation of DDH remains common, often due to limited access to early diagnostic services and a lack of standardized screening protocols.[12] Ultrasonography offers a non-invasive, radiation-free and relatively affordable solution for early diagnosis when performed by trained personnel.[13] Recent studies have highlighted the role of early ultrasound screening in reducing late-detected DDH and improving treatment outcomes.[14,15]

Although several international studies have examined the utility of ultrasonography in DDH detection, local data from Bangladesh remain limited. Differences in population demographics, healthcare access and referral patterns necessitate region-specific evidence to inform clinical practice. Moreover, there is a paucity of institutional data correlating demographic risk factors with ultrasonographic findings using standardized classification systems. This study was therefore designed to assess developmental dysplasia of the hip in infants using ultrasonography at a tertiary pediatric hospital in Bangladesh. By evaluating demographic characteristics, risk factors and Graf classification patterns, this research aims to contribute locally relevant evidence to support early diagnosis and optimize screening strategies for DDH.

METHODS

This cross-sectional study was conducted in the Department of Radiology and Imaging, Bangladesh Shishu Hospital & Institute, Dhaka, Bangladesh, over one year from July 2024 to June 2025. The study population consisted of infants referred for hip ultrasonography due to clinical suspicion or presence of recognized risk factors for developmental dysplasia of the hip. A total of 30 infants were included in the final analysis.

Inclusion criteria

Infants aged ≤6 months, infants referred for hip ultrasonography, presence of one or more risk factors for DDH (e.g., breech presentation, family history, first-born status), and clinically suspected hip instability.

Exclusion criteria

Infants with neuromuscular disorders, infants with congenital musculoskeletal anomalies unrelated to DDH, and previous treatment for DDH.

Data collection procedure

Ultrasonographic evaluation of the hip joints was performed using high-resolution real-time ultrasound equipment with a linear transducer suitable for infant musculoskeletal imaging. All examinations were conducted according to the standardized Graf technique, ensuring proper positioning of the infant in the lateral decubitus position. Both hips were assessed systematically, regardless of unilateral or bilateral clinical suspicion. Anatomical landmarks, including the iliac wing, bony acetabular roof, cartilaginous acetabular rim and femoral head, were carefully visualized. Alpha (α) and beta (β) angles were measured to classify hip morphology according to Graf criteria.

Clinical and demographic data, including age, sex, birth presentation, laterality and risk factors, were recorded using a structured data collection form. To maintain consistency and reliability, all scans were performed by experienced radiologists trained in pediatric musculoskeletal ultrasonography. Images were stored digitally for review and quality assurance. Ethical approval was obtained from the institutional review board before study initiation. Written informed consent was obtained from parents or legal guardians and confidentiality of patient data was strictly maintained throughout the study.

Statistical analysis

Data were analyzed using SPSS version 25.0. Descriptive statistics were used to summarize demographic variables and ultrasonographic findings, presented as frequencies and percentages. Age-wise distribution of Graf classification types was tabulated to identify patterns across different age groups.

RESULTS

Most infants were aged between >1 and 3 months (40.0%), followed by those aged ≤1 month (33.3%). Female infants constituted nearly two-thirds of the cohort (63.3%). Cephalic presentation was the predominant birth presentation (70.0%), while breech presentation accounted for 30.0%. Among identified risk factors, first-born status was the most frequent (40.0%), followed by a positive family history of DDH (23.3%) and oligohydramnios (16.7%). Unilateral hip involvement was more common (63.3%) than bilateral involvement (36.7%).

Table 2 describes the ultrasonographic classification of hip joints based on the Graf system. Normal hips (Type I) were observed in 46.7% of infants. Physiologic immaturity (Type IIa) was identified in 23.3% of cases. Moderate dysplasia (Types IIb/IIc) was present in 20.0% of infants, while severe dysplasia (Types III/IV) was detected in 6.7% of the study population.

Table 3 outlines specific ultrasonographic abnormalities observed during hip assessment. Reduced α-angle (<60°)

was noted in 36.7% of infants and increased β-angle (>77°) was present in 30.0%. A shallow acetabulum was observed in 33.3% of cases. Femoral head subluxation was identified in 20.0%, while complete dislocation was seen in 6.7%. Normal ultrasonographic findings were recorded in 46.7% of infants.

Table 1: Baseline characteristics of the study population (n=30).

Characteristic		Frequency (N)	Percentage (%)
Age group in month	≤1	10	33.3
	>1-3	12	40.0
	>3-6	8	26.7
Sex	Male	11	36.7
	Female	19	63.3
Birth presentation	Cephalic	21	70.0
	Breech	9	30.0
Risk factors	Family history	7	23.3
	Oligohydra-mnios	5	16.7
	First-born child	12	40.0
Laterality	Unilateral	19	63.3
	Bilateral	11	36.7

Table 2: Ultrasonographic assessment of hip joints using Graf classification (n=30).

Graf type	Description	Frequency (N)	Percentage (%)
I	Normal	14	46.7
IIa	Physiologic immaturity	7	23.3
IIb/IIc	Moderate dysplasia	6	20.0
III/IV	Severe dysplasia	2	6.7

Table 3: Distribution of ultrasonographic findings in infants with DDH (n=30).

Finding	Frequency (N)	Percentage (%)
Reduced α-angle (<60°)	11	36.7
Increased β-angle (>77°)	9	30.0
Shallow acetabulum	10	33.3
Femoral head subluxation	6	20.0
Femoral head dislocation	2	6.7
Normal findings	14	46.7

Figure 1 illustrates the age-wise distribution of Graf classification types among infants. Normal hips (Type I) increased with age, while physiologically immature and dysplastic hips (Types IIa/IIb and IIc/IV) were more frequent in younger infants and declined progressively across older age groups.
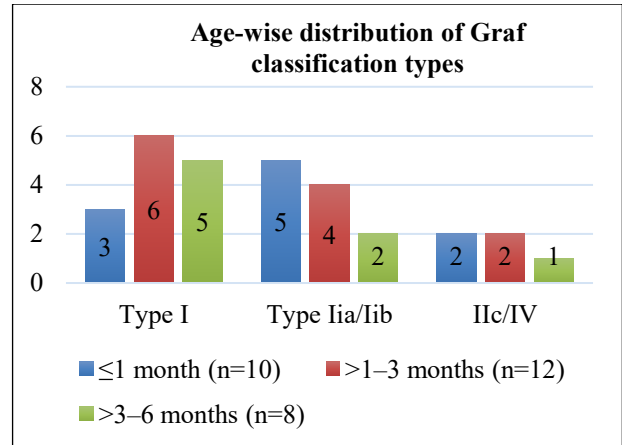

Figure 1: Age-wise distribution of Graf classification types in infants with developmental dysplasia of the hip.

DISCUSSION

This study underscores the diagnostic value of ultrasonography in the early identification of developmental dysplasia of the hip (DDH) during infancy, demonstrating patterns that are consistent with both regional and international literature. The predominance of female infants in the present cohort reflects a well-documented epidemiological trend. Harsanyi et al reported that female infants exhibit a significantly higher susceptibility to DDH, likely due to increased ligamentous laxity mediated by maternal relaxin exposure.[16] Similar sex-based disparities have been consistently observed in ultrasound-based screening studies across diverse populations, reinforcing the biological basis of this association.[1,17]

Age-related variation in ultrasonographic findings was a notable feature of this study. A higher frequency of physiologically immature hips (Graf type IIa) was observed among infants younger than three months, with a progressive shift toward normal hip morphology in older age groups. Graf et al emphasized that acetabular maturation continues dynamically during the early postnatal period and transient immaturity should be interpreted cautiously to avoid unnecessary intervention.[7] Longitudinal sonographic analyses by Liu et al further demonstrated that many type IIa hips normalize spontaneously with growth, supporting conservative monitoring in selected cases.[18] The current findings align with this developmental trajectory and highlight the importance of age-adjusted interpretation of the Graf classification.

The proportion of moderate and severe dysplasia observed in this study is comparable to results reported in hospital-based cohorts employing selective screening strategies. Amer et al. identified a similar distribution of Graf types among infants referred due to risk factors or clinical suspicion while Okasha et al reported that dysplastic hips

were more frequently detected in tertiary care settings than in population-based screening programs.[19,20] These findings suggest that referral-based ultrasound assessment may enrich the detection of clinically relevant DDH cases.

Risk factor analysis revealed a notable association between DDH and breech presentation, first-born status and positive family history. Tirta et al., in a recent meta-analysis, confirmed breech presentation as one of the strongest predictors of DDH, independent of gestational age and sex.[8] Xingguang et al similarly demonstrated that first-born infants face increased risk due to uterine constraint, particularly during late gestation.[21] The convergence of these findings with the present results reinforces the continued relevance of risk-based screening approaches, especially in healthcare systems with limited resources.

Morphological abnormalities such as reduced α-angle, increased β-angle and shallow acetabulum constituted the most frequent ultrasonographic findings in dysplastic hips. Fan et al demonstrated that reduced femoral head coverage and abnormal angular measurements are sensitive markers for early acetabular insufficiency.[22] Duarte et al, through a systematic review, further confirmed the diagnostic accuracy of Graf-based angle measurements when standardized acquisition protocols are followed.[23] The relatively low frequency of femoral head dislocation in the present study suggests that early referral and imaging may contribute to detection prior to progression to advanced instability.

The reliability and reproducibility of the Graf method have been well established when examinations are performed by trained operators. Mostofi et al reported high interobserver agreement for both two-dimensional and three-dimensional ultrasound measurements, emphasizing the importance of operator expertise.[24] Orak et al similarly demonstrated that diagnostic accuracy improves significantly with experience, underscoring the need for structured training programs in pediatric hip ultrasonography.[25] The consistency of findings in this study supports the applicability of the Graf method in routine clinical practice within tertiary pediatric centers.

From a broader clinical perspective, early ultrasonographic detection of DDH has significant implications for treatment outcomes and healthcare resource utilization. Biedermann et al showed that universal or targeted early ultrasound screening substantially reduces late-presenting DDH and the need for surgical intervention.[15] Harper et al further highlighted the cost-effectiveness of early detection, particularly by minimizing long-term disability and complex orthopedic procedures.[26] The present study contributes institution-specific evidence supporting the integration of structured ultrasound assessment into early infant care pathways.

Overall, these findings reaffirm ultrasonography as an indispensable tool for early DDH diagnosis. When combined with risk factor assessment and standardized classification systems, ultrasound facilitates timely identification, appropriate monitoring and early intervention, ultimately improving long-term musculoskeletal outcomes.

CONCLUSION

Ultrasonography using the Graf method is an effective and reliable tool for the early detection of developmental dysplasia of hip DDH in infants. The study demonstrated a predominance of physiological immaturity and mild dysplasia in early infancy, with risk factors such as female sex and breech presentation remaining strongly associated. Early imaging facilitates timely intervention and may reduce the long-term morbidity associated with delayed diagnosis.

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Cite this article as: Hossain MM, Monowara M. Assessment of developmental dysplasia of the hip using ultrasonography in infants. Int J Res Med Sci 2026;14:460-4.