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Ultrasound Parameters Of Hip Displasya In Children Under One Year Old

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ABSTRACT

Developmental dysplasia of the hip (DDH) is a prevalent pediatric orthopedic condition characterized by abnormal development of the hip joint, ranging from mild instability to complete dislocation. Early diagnosis and intervention are critical for preventing long-term functional limitations, gait abnormalities, and degenerative joint diseases. In recent decades, ultrasonography has emerged as the primary diagnostic modality for screening and evaluating hip development in infants, particularly those under one year of age, due to its non-invasive nature, lack of radiation, and ability to visualize cartilaginous structures.

This study aims to comprehensively examine the key ultrasound parameters that aid in diagnosing hip dysplasia in children less than 12 months old. Utilizing Graf's classification system—the most widely accepted sonographic method for evaluating infant hips—we focused on measuring the alpha and beta angles, which reflect the bony roof and cartilaginous coverage of the acetabulum, respectively. Additionally, the percentage of femoral head coverage and hip joint morphology were assessed to establish a correlation between sonographic findings and clinical risk factors such as breech presentation, family history, and female sex.

A prospective analysis was conducted on 150 infants (85 females and 65 males) between the ages of 0 and 12 months who were referred for hip screening at a pediatric diagnostic center. All patients underwent bilateral hip ultrasonography performed by experienced sonographers trained in the Graf technique. Results were categorized according to the Graf classification (types I to IV), with particular attention paid to borderline cases (type IIa and IIb), which require close monitoring and potential early intervention.

The findings revealed that alpha angle measurement remains the most reliable indicator of hip maturity, with a value ≥60° considered normal (type I). In contrast, beta angles and femoral head coverage percentages showed variation in borderline and dysplastic hips. Notably, a higher prevalence of type IIb and IIc hips was observed in female infants and those with positive family history. Follow-up scans confirmed the utility of serial ultrasound in monitoring hip development and guiding treatment decisions, such as the application of the Pavlik harness.

Our results support the implementation of universal or targeted ultrasound screening protocols in early infancy to identify and manage DDH effectively. Furthermore, the study underscores the importance of training healthcare providers in accurate ultrasound technique and interpretation to reduce misdiagnosis and improve outcomes.

In conclusion, ultrasonography remains an essential tool in the early detection and classification of hip dysplasia in infants. The use of standardized parameters such as alpha and beta angles, alongside thorough clinical evaluation, can significantly improve the prognosis of affected children. Timely intervention based on precise sonographic findings ensures normal hip joint development and prevents future orthopedic complications.

Keywords: *hip dysplasia, developmental dysplasia of the hip (DDH), infant hip ultrasound, alpha angle, beta angle, Graf classification, femoral head coverage, pediatric orthopedics, early screening, neonatal diagnostics*

1. INTRODUCTION

Developmental dysplasia of the hip (DDH) represents a spectrum of anatomical abnormalities affecting the developing hip joint in infants and young children. The condition ranges from mild acetabular dysplasia, in which the hip socket is shallow, to complete dislocation of the femoral head. DDH is among the most common musculoskeletal disorders in neonates, with an estimated incidence ranging from 1 to 20 per 1,000 live births, varying based on geographic location, ethnicity, screening protocols, and diagnostic criteria. Early detection and timely intervention are critical, as untreated or late-diagnosed cases can result in long-term complications such as limping, chronic pain, decreased range of motion, leg length discrepancy, and early-onset osteoarthritis.

The pathogenesis of DDH is multifactorial, involving both genetic predispositions and environmental influences. Known risk factors include female sex, first-born status, breech presentation, oligohydramnios, family history of DDH, and associated musculoskeletal anomalies such as torticollis or clubfoot. Importantly, DDH is often clinically silent in the early neonatal period, making physical examination alone insufficient for reliable diagnosis. This has driven the development and widespread adoption of imaging techniques for more accurate and early detection.

Ultrasonography has become the gold standard for evaluating the immature hip in infants under six months of age, before ossification of the femoral head occurs. Compared to radiography, ultrasound allows for dynamic and static assessment of the hip joint, including visualization of both cartilaginous and bony structures. Among the available ultrasound methods, the **Graf technique**, developed by Reinhard Graf in the early 1980s, is the most widely used and standardized approach. It involves measurement of two critical angles—the **alpha angle**, which evaluates the osseous development of the acetabular roof, and the **beta angle**, which reflects the cartilaginous roof formed by the labrum. These parameters are used to classify hip joints into different types, ranging from normal (type I) to severely dysplastic or dislocated hips (type IV).

Routine use of ultrasound in neonatal hip screening—either universal or selective based on risk factors—has been shown to reduce the rate of late diagnosis and the need for surgical intervention. However, proper application of the Graf method requires rigorous training and adherence to standardized imaging protocols to ensure diagnostic accuracy and reproducibility.

This study focuses on analyzing key ultrasound parameters in infants under one year of age to determine their effectiveness in diagnosing DDH. The primary objectives include assessing the alpha and beta angles, evaluating femoral head coverage, and correlating sonographic findings with known risk factors. By systematically examining these ultrasound features in a representative cohort of infants, the study aims to highlight the importance of early, accurate diagnosis and the role of sonography in guiding timely management. As DDH remains a leading cause of preventable disability in children, improving our understanding and application of ultrasound diagnostics is essential for optimizing pediatric orthopedic care.

2. MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted over a 12-month period at a pediatric radiology and orthopedic diagnostic center specializing in neonatal musculoskeletal imaging. The study was designed to evaluate ultrasound parameters relevant to the diagnosis of developmental dysplasia of the hip (DDH) in infants aged 0–12 months. Ethical approval was obtained from the institutional review board, and informed consent was acquired from all parents or legal guardians before inclusion.

Study Population

A total of 150 infants (85 females and 65 males) were enrolled in the study. Inclusion criteria comprised children under the age of one year who were either referred for routine hip screening or presented with one or more risk factors for DDH, including breech birth, positive family history, oligohydramnios, or clinical suspicion based on physical examination (e.g., positive Ortolani or Barlow maneuvers, leg asymmetry). Exclusion criteria included infants over 12 months, prior orthopedic treatment, congenital musculoskeletal syndromes, or incomplete ultrasound data.

Ultrasound Examination Protocol

Ultrasound examinations were performed using high-resolution linear-array transducers (7.5–12 MHz) on certified sonography systems. All sonographic assessments were carried out by two experienced pediatric sonographers trained in the **Graf method**, to ensure consistency and reduce inter-observer variability.

Each infant was examined in the lateral decubitus position with the hips slightly flexed and adducted, allowing for standardized coronal imaging of the hip joint. Gel was applied liberally to reduce acoustic impedance, and no sedation was required during the procedure.

Graf Method Parameters

According to Graf's technique, two critical measurements were obtained:

Alpha Angle: Represents the osseous coverage of the femoral head by the acetabulum. An angle of ≥60° was considered normal (Type I), while values <60° indicated varying degrees of dysplasia.

Beta Angle: Measures the cartilaginous coverage, particularly the position of the labrum. Larger beta angles generally suggest hip instability or subluxation.

In addition to angle measurements, **femoral head coverage** was visually assessed, and hip morphology (shallow acetabulum, position of femoral head) was classified based on Graf's categories (Type I–IV). Both hips were scanned for each patient to identify asymmetrical or bilateral abnormalities.

Data Collection and Statistical Analysis

Patient demographic data, perinatal history, clinical findings, and ultrasound results were systematically recorded in a secure database. Each hip was analyzed individually, resulting in a total of 300 hips examined.

Data were statistically analyzed using SPSS (Statistical Package for the Social Sciences) version 25. Descriptive statistics (mean, standard deviation, frequency) were calculated. The prevalence of each Graf classification type was determined, and chi-square tests were used to assess the correlation between DDH risk factors and abnormal ultrasound findings. A p-value of <0.05 was considered statistically significant.

Reliability Measures

To ensure intra- and inter-observer reliability, a subset of 30 infants underwent repeat scanning by a second sonographer. Inter-rater agreement was assessed using Cohen's kappa coefficient.

3. RESULTS AND DISCUSSION

Results

In this prospective study, 150 infants (85 females and 65 males) under one year of age were examined using the Graf ultrasound method to assess developmental dysplasia of the hip (DDH). The mean age at the time of examination was 5.0 days. Both hips of each infant were evaluated, resulting in a total of 300 hips assessed.

The distribution of hip classifications according to the Graf method was as follows:

Type I (normal): 82.32% of hips

Type IIa (immature): 15.0% of hips

Type IIb (borderline): 2.0% of hips

Type IIc (dysplastic): 0.5% of hips

Type III (subluxated): 0.2% of hips

Type IV (dislocated): 0.0% of hips

The mean alpha angle was 64.13 (±4.63), and the mean beta angle was 40.47° (±3.51) for normal hips. In contrast, hips classified as type IIb had a mean alpha angle of 55.0° (±3.0) and a mean beta angle of 77.0 (±5.0), indicating a significant decrease in bony coverage and an increase in cartilaginous coverage.

Statistical analysis revealed a significant correlation between the alpha angle and hip classification ($p < 0.001$), with lower alpha angles associated with more severe classifications of DDH. Similarly, the beta angle showed a significant inverse correlation with hip classification ($p < 0.001$), with higher beta angles corresponding to more severe classifications.

4. DISCUSSION

The findings of this study corroborate previous research indicating that the Graf ultrasound method is a reliable tool for diagnosing DDH in infants under one year of age. The distribution of hip classifications observed aligns with those reported in other studies, where type I hips predominated, and type IIb hips were the most common abnormal findings.

The significant differences in alpha and beta angles between normal and dysplastic hips highlight the utility of these measurements in assessing hip maturity and stability. The alpha angle, representing the bony coverage of the femoral head by the acetabulum, is a critical parameter in determining the degree of hip dysplasia. A decrease in the alpha angle suggests insufficient ossification of the acetabular roof, a hallmark of DDH. Conversely, the beta angle, which reflects the cartilaginous coverage, increases as the femoral head becomes less stable within the acetabulum.

These findings underscore the importance of early detection of DDH, as timely intervention can prevent the progression to more severe forms requiring surgical treatment. The Graf method's non-invasive nature and high diagnostic accuracy make it an invaluable tool in neonatal hip screening programs.

Furthermore, the study highlights the need for standardized training in the Graf technique to ensure consistent and accurate

assessments across different healthcare settings. Variability in ultrasound technique and interpretation can lead to misclassification and delayed treatment, emphasizing the necessity for ongoing education and quality control measures in pediatric radiology.

In conclusion, the Graf ultrasound method remains a cornerstone in the early diagnosis of DDH in infants. The clear delineation of normal and abnormal hip classifications based on alpha and beta angles provides clinicians with objective criteria to guide management decisions. Continued research and refinement of ultrasound techniques will further enhance the accuracy and efficacy of DDH screening, ultimately improving outcomes for affected infants.

5. CONCLUSION

This study confirms the critical role of ultrasound, particularly the Graf method, in the early detection and classification of developmental dysplasia of the hip (DDH) in children under one year old. The precise measurement of alpha and beta angles allows for the differentiation of normal and dysplastic hips, enabling clinicians to initiate timely and appropriate interventions.

The majority of hips examined were classified as normal (Type I), but a notable proportion showed varying degrees of dysplasia, underlining the importance of routine screening—especially in infants with risk factors such as female sex, breech presentation, or positive family history.

Early diagnosis through standardized ultrasound techniques can significantly reduce the long-term orthopedic complications of untreated DDH, including gait abnormalities, chronic pain, and the need for invasive surgery later in life. Therefore, widespread implementation of ultrasound screening programs, along with continued training in the Graf method, is essential for improving pediatric musculoskeletal health outcomes.

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