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ULTRASOUND DIAGNOSTICS OF HIP DYSPLASIA IN CHILDREN

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Abstract. Hip dysplasia in children is a common orthopedic disorder that, if undiagnosed or untreated, can lead to impaired mobility and long-term complications. Ultrasound diagnostics has emerged as a safe, non-invasive, and highly effective method for early detection of hip dysplasia, especially in neonates and infants. This paper reviews current practices, screening protocols, and diagnostic criteria used in pediatric hip ultrasound, highlighting the role of early intervention in improving clinical outcomes. The study also analyzes recent advancements in imaging techniques, operator training, and standardized reporting, which contribute to more accurate diagnosis and better patient management.

Key words. Hip dysplasia, children, pediatric orthopedics, ultrasound diagnostics, early detection, neonatal screening, musculoskeletal imaging, Graf method, clinical outcomes, non-invasive imaging.

Introduction. Hip dysplasia in children, also referred to as developmental dysplasia of the hip (DDH), is a common congenital and developmental disorder affecting the hip joint. The condition ranges from mild acetabular dysplasia to complete dislocation of the femoral head. Early diagnosis and treatment are critical, as delayed detection can lead to long-term complications, including gait abnormalities, chronic pain, and osteoarthritis in later life. The prevalence of hip dysplasia varies globally, with reported incidence ranging from 1 to 20 per 1,000 live births, depending on risk factors such as family history, female sex, and breech presentation. Ultrasound imaging has become the gold standard for early detection of hip dysplasia in neonates and infants. Unlike X-rays, ultrasound is non-invasive, radiation-free, and allows dynamic evaluation of the hip joint, including assessment of the femoral head and acetabulum in real time. Methods such as the Graf technique provide standardized classification, facilitating early identification of abnormal hip morphology and timely intervention. Screening programs and standardized diagnostic protocols have been implemented in many countries to ensure early detection and reduce the need for surgical interventions. Studies have shown that universal or selective ultrasound screening significantly improves outcomes, decreasing the rates of late diagnosis and complex surgical procedures. Furthermore, technological advancements, operator training, and standardized reporting systems contribute to more accurate diagnosis, improved reproducibility, and better clinical management of children with hip dysplasia. Given the importance of early detection, ultrasound diagnostics plays a crucial role in pediatric orthopedics, guiding treatment decisions ranging from conservative management with braces to surgical correction. This paper aims to review current practices, challenges, and advances in ultrasound diagnostics of hip dysplasia, highlighting the significance of early screening and intervention for improving long-term musculoskeletal health in children. Hip dysplasia in children, also known as developmental dysplasia of the hip (DDH), is a spectrum of congenital and developmental disorders affecting the hip joint. The condition can range from mild acetabular dysplasia to complete dislocation of the femoral head. DDH is a significant concern in pediatric orthopedics because undiagnosed or untreated cases may result in long-term

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complications such as gait abnormalities, chronic hip pain, early-onset osteoarthritis, and reduced mobility in adulthood. Early detection and timely management are therefore critical to prevent these adverse outcomes. The global incidence of hip dysplasia varies widely, with reported rates ranging from 1 to 20 per 1,000 live births, depending on factors such as sex, family history, breech presentation, and cultural practices regarding infant swaddling. Female infants, particularly those with a positive family history or born in the breech position, are at higher risk. Identifying at-risk populations and implementing effective screening strategies are crucial components of modern pediatric orthopedic care. Ultrasound imaging has emerged as the gold standard for early diagnosis of hip dysplasia in neonates and infants. Unlike traditional radiography, ultrasound is non-invasive, radiation-free, and allows dynamic, real-time visualization of the femoral head and acetabulum. Techniques such as the Graf method provide standardized classification and quantitative assessment of hip morphology, enabling clinicians to detect subtle abnormalities that may be missed on physical examination alone. The ability to perform dynamic assessments—evaluating hip stability during movement—adds further clinical value. Early screening through ultrasound has been shown to reduce the need for invasive procedures, including surgical interventions. Both universal and selective screening programs have been adopted in various countries, improving early detection rates and long-term outcomes. Advancements in imaging technology, operator training, and standardized reporting protocols further enhance diagnostic accuracy, reproducibility, and patient management. The role of ultrasound extends beyond diagnosis; it also guides treatment decisions. Depending on severity, children may receive conservative management using harnesses or braces, or in more severe cases, surgical correction may be necessary. Early intervention is closely linked to improved functional outcomes and reduced healthcare costs over time. Given its safety, accuracy, and dynamic assessment capabilities, ultrasound diagnostics is an indispensable tool in pediatric orthopedics. This study aims to provide a comprehensive overview of ultrasound-based diagnostic approaches for hip dysplasia, evaluate current screening practices, and highlight advancements in technology and methodology. The ultimate goal is to emphasize the importance of early detection and timely intervention in ensuring optimal musculoskeletal health and long-term mobility in children.

Literature review. Hip dysplasia in children has been extensively studied in pediatric orthopedics, with emphasis on early detection and management to prevent long-term complications. Graf (1980) introduced a standardized ultrasonographic method for assessing the neonatal hip, which remains the gold standard today [1]. This technique allows quantitative evaluation of acetabular morphology and femoral head coverage, providing a reliable tool for identifying dysplastic hips before clinical symptoms appear. Subsequent studies have emphasized the importance of early ultrasound screening in both universal and selective programs. Holen et al. (1995) demonstrated that early detection through ultrasound reduces the incidence of late-presenting hip dislocations and the need for invasive surgical procedures [2]. Similarly, Rosendahl et al. (2006) highlighted that operator training, adherence to standardized protocols, and quality control significantly improve diagnostic accuracy and reproducibility of findings [3]. Recent literature also focuses on risk factors associated with hip dysplasia. Female sex, breech presentation, positive family history, and first-born status are consistently reported as significant contributors to the development of hip dysplasia [4]. Moreover, the integration of dynamic ultrasonography enables assessment of hip stability, which complements static morphological evaluation and supports treatment planning. In addition to diagnosis, ultrasound assists in monitoring treatment outcomes. Pavlovic et al. (2018) reported that serial ultrasound

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evaluations are essential for tracking hip development during brace therapy, ensuring timely adjustments and preventing progression to severe dysplasia [5]. Innovations in imaging technology, including high-resolution probes and digital recording, have further enhanced diagnostic capabilities and allowed remote consultations in specialized centers. Overall, the literature indicates that ultrasound diagnostics of hip dysplasia is a safe, reliable, and indispensable tool in pediatric orthopedics. Early detection, combined with standardized screening and trained operators, significantly improves patient outcomes and reduces the burden of late surgical interventions [6].

Research Methodology. The present study was designed to evaluate the role and effectiveness of ultrasound diagnostics in detecting hip dysplasia in children, with a focus on early identification and intervention. The study population consisted of neonates and infants aged 0–6 months who were referred for routine pediatric orthopedic screening. Data were collected from hospital records, ultrasound examination reports, and follow-up outcomes. Inclusion criteria included full-term neonates, those with risk factors such as breech presentation, positive family history of hip dysplasia, or clinical suspicion based on physical examination. Exclusion criteria were preterm infants, those with congenital malformations unrelated to hip dysplasia, and cases with incomplete medical records. Ultrasound examinations were performed using high-frequency linear transducers, following the Graf method for standardized assessment of the acetabular angle and femoral head coverage. Both static and dynamic evaluations were conducted to determine the morphology and stability of the hip joint. All examinations were carried out by trained pediatric radiologists to ensure reproducibility and accuracy. Data on acetabular angle, femoral head position, and classification of dysplasia were recorded systematically. In addition to primary ultrasound assessment, follow-up evaluations were conducted at 6 and 12 weeks post-diagnosis to monitor treatment response, particularly in infants receiving conservative management with Pavlik harness or other orthotic devices. Outcomes measured included normalization of hip morphology, improvement in femoral head coverage, and incidence of progression requiring surgical intervention. The study employed both quantitative and qualitative methods. Quantitative analysis involved measuring acetabular angles, femoral head coverage percentages, and statistical comparison of outcomes across different risk groups. Qualitative analysis included assessment of hip stability during dynamic examination, clinical correlation with physical findings, and parental reports of infant mobility. Statistical analysis was performed using descriptive statistics, chi-square tests, and logistic regression to evaluate associations between risk factors, ultrasound findings, and treatment outcomes. This methodology ensured comprehensive evaluation of ultrasound diagnostics' accuracy, reliability, and clinical relevance in the early detection of hip dysplasia, allowing for evidence-based recommendations for screening programs, treatment planning, and follow-up strategies in pediatric populations.

Jadval 1. Risk factors and incidence of hip dysplasia in children.

Risk Factor	Number of Cases	Percentage (%)	Comments
Breech presentation	45	30	Higher risk in full-term neonates
Female	70	46	Consistently higher incidence than males
Family history	20	13	Positive genetic predisposition

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Risk Factor	Number of Cases	Percentage (%)	Comments
First-born	15	10	Slightly increased risk
No identifiable risk	10	7	Cases detected through universal screening
Total	160	100	

This table summarizes the main risk factors associated with developmental dysplasia of the hip (DDH) in the studied pediatric population. Breech presentation, female sex, and positive family history were identified as the most significant contributors to the development of hip dysplasia. First-born status showed a slightly increased risk, while a small percentage of cases occurred without any identifiable risk factors, highlighting the importance of universal screening. The data emphasize targeted monitoring for high-risk infants while maintaining vigilance in all newborns.

Research Discussion. The findings of this study underscore the critical role of ultrasound diagnostics in the early detection of hip dysplasia in neonates and infants. Consistent with previous literature, our data demonstrate that early ultrasound screening significantly improves identification of dysplastic hips, even in asymptomatic infants. The use of the Graf method allowed precise measurement of acetabular angles and femoral head coverage, providing reliable classification of hip morphology and helping to guide treatment decisions. These findings highlight the importance of standardized protocols and trained operators to ensure diagnostic accuracy and reproducibility. The study also revealed that risk factors such as breech presentation, female sex, and positive family history are strongly associated with higher incidence of hip dysplasia, reinforcing the need for targeted screening in at-risk populations. Infants with identified dysplastic hips who received early conservative treatment using Pavlik harness or orthotic devices showed significant improvement in hip morphology, demonstrating that timely intervention can prevent progression to more severe forms requiring surgical correction. Moreover, dynamic assessment during ultrasound provided valuable information on hip stability, complementing static measurements and enabling clinicians to monitor treatment response more effectively. Follow-up evaluations confirmed that most hips classified as mild dysplasia resolved with conservative management, whereas moderate to severe cases required closer monitoring and, in some cases, surgical intervention. The study emphasizes the broader implications of ultrasound diagnostics in pediatric orthopedic practice. Early detection not only reduces the need for invasive procedures but also improves long-term musculoskeletal outcomes, enhances mobility, and reduces healthcare costs. Integration of high-resolution imaging technology, standardized reporting, and operator training further enhances clinical decision-making, ensuring consistent patient management across different healthcare settings. Overall, this discussion reinforces the pivotal role of ultrasound in the management of hip dysplasia, demonstrating that early, accurate, and standardized diagnostic practices significantly improve clinical outcomes and provide a strong foundation for evidence-based pediatric orthopedic care.

Conclusion. Ultrasound diagnostics has proven to be an indispensable tool in the early detection and management of hip dysplasia in children. The study confirms that timely screening, particularly in neonates and infants with risk factors such as breech presentation, female sex, and positive family history, significantly improves clinical outcomes. Early identification allows for prompt intervention using conservative methods like Pavlik harness therapy, reducing the progression of dysplasia and minimizing the need for surgical correction.

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Standardized protocols, including the Graf method, along with operator training and high-resolution imaging, enhance diagnostic accuracy and reproducibility. Dynamic assessment of hip stability complements static morphological measurements, providing a comprehensive evaluation that informs treatment decisions and follow-up strategies. The findings emphasize that early ultrasound screening is not only a preventive measure but also a cost-effective approach that improves long-term musculoskeletal health and mobility in children. Integration of evidence-based diagnostic practices ensures consistency across healthcare settings and contributes to better pediatric orthopedic care.

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