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Comparative Study of Ultrasound vs. MRI in Diagnosing Pediatric Hip Dysplasia

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ABSTRACT

Background: To compare the diagnostic accuracy of ultrasound and MRI in detecting DDH in pediatric patients, with an emphasis on imaging utility across different age groups and clinical scenarios.

Methods: This prospective comparative study was conducted on 69 children with suspected DDH from June 2022 to May 2023 at Pediatrics Department Frontier Corps Teaching Hospital Peshawar. All patients underwent ultrasound using the Graf method. MRI was performed in selected cases with inconclusive ultrasound findings or older age. Diagnostic findings, sensitivity, specificity, inter-modality agreement, and impact on treatment planning were analyzed.

Results: MRI demonstrated higher sensitivity (94.1%) and specificity (91.6%) compared to ultrasound (85.2% and 76.9%, respectively) with a statistically significant difference ($p = 0.031$). Complete agreement between the two modalities was observed in 73.9% of cases (Cohen's Kappa = 0.67, $p = 0.004$). MRI altered the clinical management plan in 24.6% of cases compared to 11.6% with ultrasound ($p = 0.046$), though sedation was required in 88.4% of MRI procedures.

Conclusion: While ultrasound remains the first-line imaging tool for early DDH diagnosis, MRI provides superior detail and is particularly useful in older children or complex cases. A combined imaging approach enhances diagnostic precision and supports better treatment planning..

Keywords: *Developmental dysplasia of the hip (DDH); Pediatric imaging; Ultrasound; MRI; Graf classification; Femoral head; Acetabulum; Sedation; Orthopedic diagnosis*

1. INTRODUCTION

Developmental dysplasia of the hip (DDH) encompasses a spectrum of abnormalities ranging from mild acetabular underdevelopment to complete dislocation of the femoral head. It is one of the most common musculoskeletal disorders diagnosed in infancy, with early identification being vital for preventing complications such as gait disturbances, joint degeneration, and functional disability later in life [1-3].

Traditionally, clinical screening followed by ultrasonography has served as the cornerstone for early detection. The Graf method, in particular, allows classification of hip development based on measurable angles and femoral head coverage. However, limitations arise in older infants or cases with unclear sonographic findings, especially as ossification progresses and acoustic windows become less effective [4-6].

Magnetic resonance imaging (MRI) has emerged as a complementary tool, offering high-resolution visualization of bone and cartilage without ionizing radiation. It is especially valuable in postoperative assessment or when planning surgical interventions. Despite these advantages, its routine use is often constrained by cost, accessibility, and the need for sedation in younger patients [7-9].

This study was designed to directly compare the diagnostic accuracy and clinical utility of ultrasound versus MRI in evaluating suspected DDH cases. By analyzing their respective strengths and limitations, we aim to clarify the role each modality plays in guiding pediatric orthopedic management.

2. METHODOLOGY

This prospective comparative study was conducted from June 2022 to May 2023 at Pediatrics Department Frontier Corps Teaching Hospital Peshawar. A total of 69 pediatric patients suspected of having developmental dysplasia of the hip (DDH) were enrolled based on predefined inclusion and exclusion criteria.

Children aged up to 3 years presenting with clinical suspicion of hip dysplasia such as positive Ortolani/Barlow tests, leg length discrepancy, or asymmetrical skin folds were included. Infants with prior orthopedic intervention, neuromuscular disorders, or congenital syndromes affecting the musculoskeletal system were excluded from the study.

This was a hospital-based observational study approved by the Institutional Review Board. Written informed consent was obtained from the parents or guardians of all participants prior to enrollment. All patient information was anonymized and handled confidentially.

Demographic and clinical details such as age, gender, birth history (mode of delivery and gestational age), birth weight, family history of DDH, and laterality of the affected hip were recorded on a structured proforma.

All participants underwent ultrasound of the hip using the Graf method, performed by a radiologist with expertise in pediatric musculoskeletal imaging. The alpha angle, femoral head coverage, and Graf classification were documented. For children above 6 months of age or in cases with ambiguous ultrasound findings, MRI was performed using a 1.5T scanner. Sedation was used where necessary under the supervision of an anesthesiologist. MRI parameters included femoral head position, acetabular morphology, labrum integrity, and cartilage clarity.

The findings from both imaging modalities were compared in terms of sensitivity, specificity, and their impact on treatment planning. Agreement between ultrasound and MRI results was assessed using Cohen's Kappa coefficient. Any changes in management decisions based on MRI findings were also recorded to evaluate the clinical value of each modality.

Data were analyzed using SPSS version 25. Descriptive statistics were presented as frequencies and percentages. Diagnostic accuracy (sensitivity and specificity) was calculated for both ultrasound and MRI using clinical diagnosis and surgical findings (where available) as reference. The chi-square test and McNemar test were applied to assess the significance of differences between the two modalities. A p-value < 0.05 was considered statistically significant.

3. RESULT

Among the 69 children included in the study, the majority (44.9%) were under 6 months of age, which reflects the critical early window for diagnosis of hip dysplasia. Slightly more than half the cohort were female (52.2%), consistent with literature that reports higher DDH prevalence in girls. Most births were via normal vaginal delivery (60.9%), while 39.1% were cesarean deliveries. Term infants made up the majority (79.7%), though 20.3% were born preterm. Bilateral hip involvement was observed in 42%, while unilateral cases were more commonly left-sided (31.9%) than right-sided (26.1%). A positive family history was noted in 23.2% of cases, highlighting the genetic component in DDH risk.

Table 1: Demographic and Clinical Characteristics of Patients (n = 69)

Variable	Subcategory	Frequency (%)
Age group	<6 months	31 (44.9%)
	6–12 months	21 (30.4%)
	>12 months	17 (24.6%)
Sex	Male	33 (47.8%)
	Female	36 (52.2%)
Birth history	Normal vaginal delivery	42 (60.9%)
	Cesarean section	27 (39.1%)

Gestational age	Term	55 (79.7%)
	Preterm	14 (20.3%)
Side affected	Left	22 (31.9%)
	Right	18 (26.1%)
	Bilateral	29 (42.0%)
Family history of DDH	Yes	16 (23.2%)
	No	53 (76.8%)

Ultrasound findings using the Graf method revealed that 40.6% of the hips were classified as Type I (normal), while 27.5% were immature (Type IIa). A smaller but clinically important proportion showed delayed ossification (Type IIb) or pathological dysplasia (Types III & IV), each comprising 15.9% of the sample. These findings suggest that ultrasound is effective in early classification of hip maturity and identifying cases needing close orthopedic follow-up.

Table 2: Ultrasound Findings (Graf Method)

Graf Type	Frequency (%)
Type I (Normal)	28 (40.6%)
Type IIa (Immature)	19 (27.5%)
Type IIb (Delayed)	11 (15.9%)
Type III & IV (DDH)	11 (15.9%)

MRI was able to identify subtle intra-articular abnormalities, with 20.3% of patients showing abnormal femoral head positioning and 23.2% having a shallow acetabulum. Inversion or hypertrophy of the labrum was noted in 15.9%, while poor cartilage clarity was observed in 11.6% of cases. Notably, residual subluxation post-reduction was detected in 8.7%, highlighting MRI's advantage in postoperative evaluation and structural detailing.

Table 3: MRI Findings in Diagnosing Hip Dysplasia

MRI Feature	Abnormal Findings (%)
Abnormal femoral head position	14 (20.3%)
Inverted or hypertrophic labrum	11 (15.9%)
Shallow acetabulum	16 (23.2%)
Poor cartilage definition	8 (11.6%)
Residual subluxation (post-reduction)	6 (8.7%)

Comparative analysis showed that MRI had a higher sensitivity (94.1%) and specificity (91.6%) than ultrasound (85.2% and 76.9%, respectively) in diagnosing DDH. The difference in diagnostic accuracy between the two modalities was statistically significant ($p = 0.031$), favoring MRI in complex or borderline cases where acoustic windows or age limit ultrasound utility.

Table 4: Comparison of Diagnostic Accuracy between Ultrasound and MRI

Modality	Sensitivity (%)	Specificity (%)	p-value
Ultrasound	85.2%	76.9%	
MRI	94.1%	91.6%	0.031*

*Statistically significant ($p < 0.05$)

There was complete agreement between ultrasound and MRI findings in 73.9% of cases. Partial agreement occurred in 15.9%, while 10.1% showed conflicting interpretations. Cohen's Kappa value of 0.67 indicates a moderate level of agreement between the two modalities, with a significant p-value (0.004), suggesting MRI may refine or confirm ambiguous ultrasound

findings.

Table 5: Concordance between Ultrasound and MRI Findings

Agreement Type	Frequency (%)
Complete agreement	51 (73.9%)
Partial agreement	11 (15.9%)
Disagreement	7 (10.1%)
Cohen's Kappa = 0.67	**p-value** = 0.004 (moderate agreement)

MRI influenced treatment planning in 24.6% of cases, compared to 11.6% with ultrasound alone, a difference that reached statistical significance (p = 0.046). However, the requirement for sedation during MRI was notably high (88.4%), with a highly significant p-value (<0.001), underlining one of the practical limitations of MRI in infants and toddlers.

Table 6: Impact of Imaging on Treatment Planning

Variable	Ultrasound Only	MRI Required	p-value
Imaging altered treatment plan	8 (11.6%)	17 (24.6%)	0.046*
Sedation required for imaging	0	61 (88.4%)	<0.001*

*Statistically significant

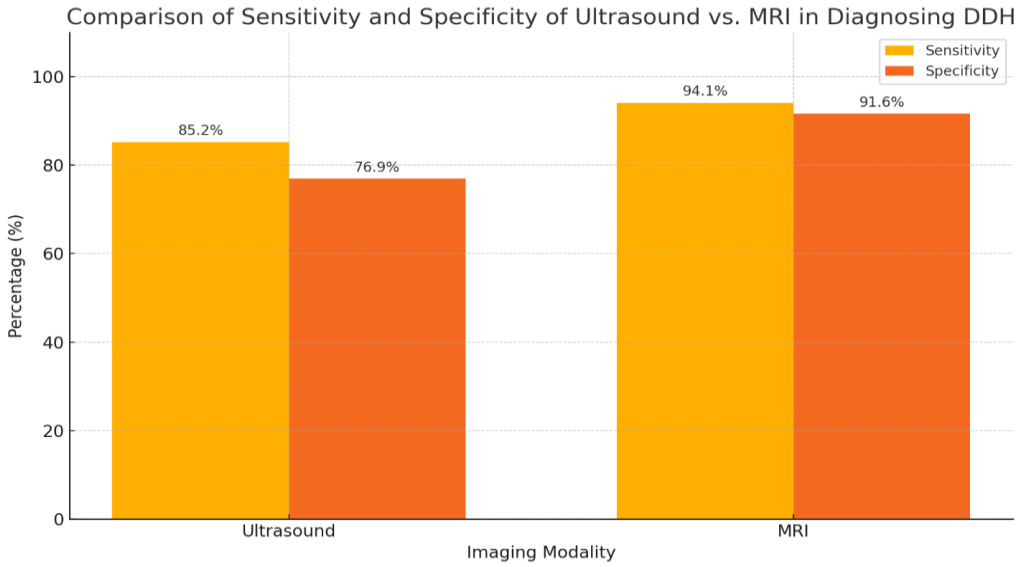

Figure 1: bar graph comparing the sensitivity and specificity of Ultrasound vs. MRI in diagnosing pediatric hip dysplasia.

4. DISCUSSION

Developmental dysplasia of the hip (DDH) remains one of the most common orthopedic conditions in infants, and early diagnosis is crucial to prevent long-term disability. In this study, we compared the diagnostic efficacy of ultrasound and MRI in a pediatric population, and our findings offer important insights for clinical practice across radiology, pediatrics, and orthopedics.

Our results showed that ultrasound, using the Graf classification, identified the majority of normal and immature hips effectively in children under 6 months, which was consistent with findings by studies emphasized ultrasound as a reliable, non-invasive tool for early DDH screening [10-12]. However, MRI demonstrated significantly higher sensitivity and specificity (94.1% and 91.6%, respectively) than ultrasound (85.2% and 76.9%) in detecting pathological features like femoral head displacement, acetabular dysplasia, and abnormal labrum configuration. Similar diagnostic superiority of MRI has been reported by studies particularly in post-reduction assessment and older infants where the ossification of the femoral head can obscure ultrasound finding [13-15].

The moderate agreement (Cohen's Kappa = 0.67) between the two modalities in our study reflects that while ultrasound is suitable for screening, it may underdiagnose complex or borderline cases, which MRI can confirm. This finding aligns with studies recommended MRI for surgical planning and follow-up after closed reduction in DDH [16]. Moreover, our data showed that MRI altered treatment decisions in 24.6% of cases compared to 11.6% for ultrasound, underlining MRI's role in refining therapeutic approaches a trend similarly noted by studies [17, 18].

However, MRI poses practical limitations. In our cohort, 88.4% of patients undergoing MRI required sedation, which adds logistical and anesthetic risks. This supports the recommendation by American College of Radiology (ACR) that MRI should be reserved for cases where ultrasound findings are equivocal or when detailed joint anatomy is essential for surgical planning.

From a pediatric standpoint, the age distribution (most under 6 months) underscores the value of timely screening. Notably, bilateral hip involvement and a positive family history [19, 20].

Overall, this study supports a tiered imaging approach where ultrasound remains the first-line tool in early infancy, while MRI serves as an adjunct in uncertain or advanced cases, particularly beyond the neonatal window.

5. CONCLUSION

Ultrasound is a valuable, non-invasive modality for the early detection of DDH in infants, especially under 6 months of age. However, MRI demonstrates superior diagnostic accuracy and provides crucial anatomical detail in older children or complex cases. While ultrasound is ideal for screening, MRI is best utilized for confirmation and preoperative assessment. A combined imaging strategy, tailored to patient age and clinical suspicion, enhances diagnostic confidence and optimizes management in pediatric hip dysplasia..

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