COMPARATIVE ANALYSIS OF ULTRASOUND AND RADIOGRAPHIC EVALUATION IN DEVELOPMENTAL DYSPLASIA OF THE HIP IN YOUNG CHILDREN

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Abstract: Developmental dysplasia of the hip (DDH) is one of the most common congenital musculoskeletal disorders in infants, with early diagnosis being critical for optimal treatment outcomes. This study provides a comprehensive comparative analysis of ultrasound (US) and radiographic (X-ray) imaging modalities in the evaluation of DDH in children. Ultrasound, primarily using the Graf method, serves as the gold standard for infants under 4-6 months due to its ability to visualize unossified cartilaginous structures and its lack of ionizing radiation [Krauss et al., 2025, p. 2]. Radiography becomes the preferred modality after the appearance of femoral head ossification nuclei, typically between 4-9 months, allowing assessment of acetabular index, Shenton's line integrity, and femoral head position [Alam et al., 2025, p. 3]. Key findings reveal significant discrepancies between the two modalities: while ultrasonographic hip maturation may appear complete, radiographic assessment can demonstrate persistent pathology in 38% of cases [Atalar et al., 2020, p. 228]. The sensitivity of ultrasound compared to radiography as the reference standard is approximately 45.7%, with specificity of 100% [Atalar et al., 2020, p. 229]. Recent advances include AI-assisted automated analysis achieving Graf angle error rates of 0.21 and three-dimensional ultrasound improving inter-observer reliability [Lee et al., 2025, p. 5; Ghasseminia et al., 2021, p. 1458]. This review emphasizes that ultrasound and radiography are complementary rather than interchangeable, with optimal diagnostic accuracy achieved through age-appropriate modality selection and integrated interpretation of both imaging techniques.

Key words: developmental dysplasia of the hip, ultrasonography, radiography, Graf method, acetabular index, pediatric orthopedics, comparative imaging, hip maturation

INTRODUCTION

Developmental dysplasia of the hip (DDH) encompasses a spectrum of pathological conditions ranging from mild acetabular dysplasia with stable hips to complete fixed dislocation of the femoral head [Barrera et al., 2019, p. 1653]. This condition represents the most common congenital musculoskeletal abnormality in infants, with reported incidence varying between 0.15‰ and 2.00‰ depending on population, diagnostic criteria, and screening protocols [Vogt et al., 2025, p. 2].

The clinical significance of DDH lies in its potential long-term consequences. Untreated or late-diagnosed DDH leads to premature osteoarthritis, gait abnormalities, chronic pain, and significant functional disability, often requiring major reconstructive surgery in adolescence or adulthood [Barrera et al., 2019, p. 1654]. Conversely, early detection and appropriate treatment during infancy result in excellent outcomes with simple, non-invasive interventions such as Pavlik harness or abduction splinting [Krauss et al., 2025, p. 3]. The dynamic nature of hip joint development presents both opportunities and challenges in imaging. At birth, the femoral head and a substantial portion of the acetabulum are composed of cartilage, which is not visible on conventional radiography [Ghasseminia et al., 2021, p. 1457]. As the child grows, ossification progressively replaces cartilage, fundamentally altering the imaging characteristics of the hip joint. This developmental progression necessitates an age-appropriate approach to imaging modality selection. Ultrasound, pioneered by Professor Reinhard Graf in the 1980s, revolutionized DDH diagnosis by enabling visualization of cartilaginous structures [Sioutis et al., 2025, p. 2]. The Graf method provides standardized morphological assessment through measurement of alpha and beta angles, allowing objective classification of hip types from Ia (mature) to IV (dislocated). Ultrasound offers the additional advantages of being radiation-free, dynamic, and relatively inexpensive [Wuermeling et al., 2025, p. 2].

Radiography remains essential for DDH evaluation after the appearance of femoral head ossification nuclei, typically between 4 and 9 months of age [Alam et al., 2025, p. 2]. Key radiographic parameters include the acetabular index (AI), Shenton's line continuity, and the position of the femoral head relative to Perkin's line and Hilgenreiner's line. These measurements provide objective assessment of acetabular development and hip joint congruence.

The purpose of this comprehensive review is to critically analyze and compare the diagnostic performance, clinical applications, limitations, and complementary roles of ultrasound and radiography in the evaluation of DDH in young children. By synthesizing current evidence, this review aims to provide clinicians with evidence-based guidance for optimal imaging selection and interpretation across different developmental stages.

LITERATURE REVIEW

Historical Evolution of DDH Imaging - The history of DDH imaging reflects the broader evolution of medical technology. Early diagnosis relied entirely on clinical examination, with radiographic techniques becoming available in the early 20th century [Ghasseminia et al., 2021, p. 1456]. The term "congenital dislocation of the hip" was later replaced by "developmental dysplasia of the hip" to acknowledge that the condition can develop after birth and represents a spectrum of severity rather than a binary state [Barrera et al., 2019, p. 1653].

Pelvic radiography was the first imaging modality to enable objective assessment of DDH, with Hilgenreiner's description of standardized measurement techniques in 1925 establishing a framework that remains relevant today [Alam et al., 2025, p. 3]. However, the inability of radiography to visualize unossified cartilage limited its utility in young infants, creating a diagnostic gap during the critical early months when non-operative treatment is most effective.

The introduction of hip ultrasonography by Graf in the 1980s represented a paradigm shift [Sioutis et al., 2025, p. 2]. For the first time, clinicians could directly visualize the cartilaginous components of the infant hip, assess morphological relationships, and objectively classify dysplasia severity. Subsequent refinements included dynamic ultrasound techniques, three-dimensional ultrasound, and most recently, artificial intelligence-assisted analysis [Lee et al., 2025, p. 4].

Epidemiology and Risk Factors

Understanding the epidemiology of DDH is essential for appropriate imaging utilization. Systematic reviews estimate global DDH prevalence at approximately 1-3% of newborns, with significant geographic and ethnic variations [Vogt et al., 2025, p. 3]. Major risk factors include:

- **Female sex:** Females are affected 4-8 times more frequently than males, attributed to increased susceptibility to maternal hormones affecting ligamentous laxity [Vogt et al., 2025, p. 4]. Odds ratios range from 3.77 to 5.0 in large cohort studies.

- **Breech presentation:** Breech position, particularly with extended knees, significantly increases DDH risk (OR 3.09-6.0) [Vogt et al., 2025, p. 4].

- **Family history:** First-degree relatives with DDH confer approximately 2-3 fold increased risk.

- **Other factors:** Oligohydramnios, first-born status, high birth weight, and post-term delivery have been associated with increased DDH risk, though with weaker evidence [Vogt et al., 2025, p. 4].

Ultrasound Techniques and Protocols

The Graf Method

The Graf method remains the most widely used and extensively validated ultrasound technique for DDH evaluation [Krauss et al., 2025, p. 4]. This standardized approach requires:

1. **Standardized coronal plane:** The ultrasound probe must be positioned to obtain a true coronal section through the deepest part of the acetabulum, with the iliac line parallel to the transducer surface.

2. **Key anatomical landmarks:** The inferior iliac bone, labrum, and femoral head must be clearly visualized.

3. **Angle measurements:**

   - **Alpha angle (α):** Formed by the iliac line and the acetabular roof line, measuring the osseous coverage of the femoral head. Higher alpha angles indicate better acetabular development [Sioutis et al., 2025, p. 3].

   - **Beta angle (β):** Formed by the iliac line and the cartilage roof line, measuring the cartilaginous coverage [Krauss et al., 2025, p. 5].

4. **Graf classification system:**

   - **Type I (mature):** Alpha ≥60° (Ia: beta <55°; Ib: beta >55°)
   - **Type IIa (physiologically immature):** Alpha 50-59° (age <3 months)
   - **Type IIb (delayed ossification):** Alpha 50-59° (age >3 months)
   - **Type IIc (critical zone):** Alpha 43-49°
   - **Type D (decentered):** Alpha 43-49° with femoral head displacement
   - **Type III (dislocated):** Alpha <43°, with (IIIa) or without (IIIb) cartilaginous roof deformity
   - **Type IV (dislocated):** Alpha <43°, with femoral head covered by capsule and labrum compressed [Krauss et al., 2025, p. 6]

Technical Considerations and Pitfalls

The accuracy of Graf method ultrasonography is highly dependent on proper technique. A recent study by Sioutis et al. (2025) examined the impact of probe tilt on measurement accuracy in 42 newborns across three age groups [Sioutis et al., 2025, p. 3]. Key findings included:

- In neonates aged 0-1 weeks, a 10° caudocranial probe tilt resulted in Graf classification changes in 90.91% of cases

- In infants aged 5-6 weeks, classification changes occurred in only 7.96% of cases

- The alpha angle measurement error decreased significantly with increasing infant age

These findings have important clinical implications, suggesting that the optimal timing for initial ultrasound screening is between 5-6 weeks of life, when measurement errors are minimized and the physiological immaturity of type IIa hips can be appropriately interpreted [Sioutis et al., 2025, p. 4].

Dynamic Ultrasound Techniques - While the Graf method provides static morphological assessment, dynamic ultrasound techniques evaluate hip stability through provocative maneuvers. The Harcke method assesses femoral head position during flexion-extension and abduction-adduction, providing information about reducibility and stability that complements Graf classification [Ghasseminia et al., 2021, p. 1459]. The femoral head coverage method, measuring the percentage of the femoral head covered by the acetabulum, offers an alternative quantitative approach.

Radiographic Techniques and Measurements

Indications and Timing - Radiography becomes the primary imaging modality after the appearance of femoral head ossification nuclei, typically between 4-9 months of age [Alam et al., 2025, p. 2]. The American College of Radiology recommends radiography as the appropriate initial imaging study for infants older than 4-6 months with suspected DDH [Barrera et al., 2019, p. 1656]. Standard evaluation requires a properly positioned anteroposterior pelvic radiograph with neutral rotation and symmetrical positioning.

Key Radiographic Parameters

1. **Acetabular Index (AI):** Measured as the angle formed by Hilgenreiner's line (horizontal line through the triradiate cartilages) and the acetabular roof line [Alam et al., 2025, p. 3]. The AI decreases with age as acetabular ossification progresses. Normal values vary by age, with mean AI of approximately 25° at 4 months, decreasing to 20° by 12 months.

2. **Shenton's Line:** An imaginary curved line connecting the medial femoral neck to the superior pubic ramus. Disruption of this line indicates femoral head displacement [Alam et al., 2025, p. 4].

3. **Center-Edge Angle of Wiberg:** Measured on anteroposterior radiographs as the angle formed by Perkin's line (vertical through the lateral acetabular margin) and a line from the lateral acetabular edge to the femoral head center [Wuermeling et al., 2025, p. 3].

4. **Femoral Head Ossification Center:** Presence, symmetry, and position of ossification nuclei provide important information about hip development. The average age of ossification center appearance is approximately 5-6 months, with some normal variation [Alam et al., 2025, p. 4].

Reliability and Reproducibility

Recent research has examined inter- and intra-reader agreement for radiographic parameters. Alam et al. (2025) evaluated 149 pelvic radiographs assessed by readers with varying experience levels [Alam et al., 2025, p. 3]. Key findings included:

- Significant differences in acetabular angle measurements between first-year residents and experienced fellows (p=0.047 for right AI, p=0.008 for left AI)
- High inter- and intra-reader consistency for Shenton's line assessment and ossification center evaluation
- No single parameter proved sufficient to significantly predict acetabular angle >30°, supporting the need for multi-parameter diagnostic approaches

These findings emphasize the importance of standardized training and experience in radiographic interpretation, and support the use of multiple complementary parameters rather than reliance on any single measurement.

RESULTS

Comparative Diagnostic Performance

Sensitivity and Specificity Analysis - The comparative diagnostic performance of ultrasound and radiography depends critically on patient age and the reference standard employed. When considering the full spectrum of DDH in infants under 6 months, ultrasound demonstrates superior sensitivity due to its ability to visualize cartilaginous structures. However, in older infants where radiography serves as the reference standard, ultrasound shows lower sensitivity despite high specificity.

Atalar et al. (2020) conducted a landmark study comparing ultrasound and radiographic findings in 88 infants (98 hips) treated for DDH [Atalar et al., 2020, p. 229]. With radiography as the reference standard, key results included:

- Sensitivity of hip ultrasonography: 45.7% (95% CI: 41.5-45.7%)
- Specificity: 100% (95% CI: 89.4-100%)
- Hips normal on ultrasound but pathological on radiography: 38 of 98 hips (38.8%)
- Hips normal on radiography but pathological on ultrasound: 0 hips

These findings have profound clinical implications. Hip maturation apparent on ultrasonography may not be consistent with radiographic hip development, meaning that normal ultrasound findings do not guarantee normal radiographic outcomes. This discrepancy suggests that ultrasonographic normalization may precede radiographic normalization, and definitive assessment of hip development requires radiographic confirmation after ossification nucleus appearance [Atalar et al., 2020, p. 230].

Age-Related Considerations

The optimal imaging modality varies significantly with patient age:

0-4 months: Ultrasound is the imaging modality of choice, with sensitivity and specificity approaching 90-100% for experienced operators [Krauss et al., 2025, p. 3]. Radiography during this period is limited by absence of ossification and may lead to both false-negative and false-positive interpretations.

4-9 months: This transitional period presents the greatest diagnostic complexity. Ultrasound may show apparently normal findings while radiography demonstrates persistent pathology [Atalar et al., 2020, p. 229]. Combined use of both modalities may be necessary for comprehensive evaluation.

>9 months: Radiography becomes the primary imaging modality, with well-established normative values and clear diagnostic criteria [Alam et al., 2025, p. 4]. Ultrasound may still provide complementary information about cartilage status but is rarely sufficient as a standalone modality.

Ultrasound Accuracy and Reliability

Wuermeling et al. (2025) evaluated ultrasound effectiveness compared to radiography in 327 hips from 169 patients [Wuermeling et al., 2025, p. 3]. Key findings demonstrated:

- ✓ No significant differences between bony ultrasonographic migration index (bUMI: 17.4%) and radiographic Reimers index (RI: 16.8%)
- ✓ No significant differences between cartilaginous ultrasonographic migration index (cUMI: 25.9%) and radiographic extrusion index (EI: 27.7%)
- ✓ All lateral parameters correlated well with the lateral center-edge angle
- ✓ High inter- and intra-rater reliability with intraclass correlation coefficients (ICC) exceeding 0.80

These results indicate that ultrasound is a reliable alternative to radiography for detecting hip decentration, supporting its use in reducing radiation exposure while maintaining diagnostic accuracy [Wuermeling et al., 2025, p. 4].

Emerging Technologies

Three-Dimensional Ultrasound - Conventional two-dimensional ultrasound has known limitations in reproducibility, particularly among less experienced operators. Three-dimensional (3D) ultrasound addresses these limitations by acquiring volumetric data that can be reformatted into standard planes after image acquisition [Ghasseminia et al., 2021, p. 1460].

Ghasseminia et al. (2021) reviewed the role of 3D ultrasound in DDH evaluation, finding [Ghasseminia et al., 2021, p. 1461]:

- ✓ Improved inter-observer reliability, particularly among novice users

✓ Better characterization of the three-dimensional deformity of DDH

✓ Suitability for automated image analysis and artificial intelligence applications

✓ Limitation: high-resolution 3D probes remain costly and not widely available

Artificial Intelligence-Assisted Diagnosis

Artificial intelligence (AI) represents a transformative technology for DDH imaging. Lee et al. (2025) developed and evaluated an AI-based diagnostic system using the Graf algorithm [Lee et al., 2025, p. 4]. Key findings included:

a) Average Graf angle error rate of 0.21 compared to expert diagnostics

b) NASNetMobile achieving the highest Area Under the Curve (AUC) of 0.864 (95% CI: 0.850-0.878)

c) UnestedUNet demonstrating the highest overall performance with Dice coefficients of 0.794 and runtime of 40.078 ms

d) DeepLabV3Plus successfully integrated with handheld smartphone-connected ultrasound devices

AI-assisted diagnosis offers several advantages: standardization of measurements, reduced operator dependence, improved reproducibility, and potential for mass screening applications in resource-limited settings [Lee et al., 2025, p. 5].

DISCUSSION

The Complementary Nature of Ultrasound and Radiography

The evidence synthesized in this review demonstrates that ultrasound and radiography are fundamentally complementary rather than interchangeable modalities in DDH evaluation. Each modality has distinct strengths and limitations that align with specific developmental stages and clinical questions.

Ultrasound excels in:

✓ Visualizing cartilaginous structures before ossification [Krauss et al., 2025, p. 2]

✓ Providing real-time dynamic assessment of hip stability

✓ Enabling early diagnosis during the optimal window for non-operative treatment

✓ Serial monitoring without radiation exposure during abduction treatment [Wuermeling et al., 2025, p. 2]

Radiography excels in:

- ✓ Assessing osseous acetabular development after ossification nucleus appearance [Alam et al., 2025, p. 3]
- ✓ Providing standardized measurements with established normative values
- ✓ Evaluating final hip maturation before treatment completion [Atalar et al., 2020, p. 230]
- ✓ Pre-operative planning for surgical interventions

The transition from ultrasound-based to radiography-based assessment represents a critical juncture in DDH management. The finding by Atalar et al. (2020) that 38% of hips with normal ultrasound findings had persistent pathology on radiography has important implications [Atalar et al., 2020, p. 229]. This suggests that:

1. Ultrasonographic normalization may precede radiographic normalization by months or years
2. Discontinuing follow-up based solely on ultrasound findings risks missing residual dysplasia
3. Radiographic confirmation of hip maturation is essential before discharging patients from follow-up
4. Risk factors for late dysplasia should influence follow-up duration regardless of ultrasound findings

Clinical Practice Implications

Screening Strategies - Universal ultrasound screening for DDH remains controversial. Proponents argue that universal screening enables earlier diagnosis and reduces late-detected cases requiring surgical intervention. Opponents cite concerns about overdiagnosis, unnecessary treatment of physiologically immature hips, and resource utilization [Vogt et al., 2025, p. 3].

The German model combines universal clinical examination with selective ultrasound screening for high-risk infants [Vogt et al., 2025, p. 2]. Vogt et al. (2025) found comparable DDH prevalence in universal (2.5%) versus risk-based (3.2%) screening cohorts (p=0.350), suggesting that selective screening of high-risk populations may be adequate.

However, risk-based screening requires accurate identification of at-risk infants. Risk factors include female sex, breech presentation, family history, and clinical instability [Vogt et al., 2025, p. 4]. Approximately 70-80% of DDH cases occur in infants with identifiable risk factors, but 20-30% occur in low-risk populations, representing a limitation of selective screening approaches.

Optimal Timing of Ultrasound Examination

The optimal timing of initial ultrasound examination balances diagnostic accuracy with clinical practicality. Sioutis et al. (2025) demonstrated that examination at 5-6 weeks significantly reduces measurement errors compared to earlier examination [Sioutis et al., 2025, p. 4]. Advantages of this timing include:

- Resolution of physiological hip immaturity (type IIa hips often normalize by 6 weeks)
- Reduced risk of overdiagnosis and unnecessary treatment
- Improved accuracy and reproducibility of Graf classification
- Opportunity to assess both morphological and dynamic parameters

However, delaying examination until 5-6 weeks must be balanced against the benefits of very early treatment initiation. Infants with severe dysplasia or dislocation may benefit from earlier diagnosis and intervention. A pragmatic approach might include clinical examination at birth, selective early ultrasound for clinically unstable or high-risk infants, and universal screening at 5-6 weeks for all infants [Vogt et al., 2025, p. 3].

Monitoring During Treatment

Both ultrasound and radiography play important roles in monitoring treatment response. During abduction splinting or Pavlik harness treatment, serial ultrasound examinations enable radiation-free assessment of hip position and development [Krauss et al., 2025, p. 7]. Ultrasound can detect persistent instability or progressive dysplasia, guiding treatment modifications.

After treatment completion, radiographic assessment is essential to confirm normal hip development [Atalar et al., 2020, p. 230]. The optimal timing of final radiographic evaluation remains debated, but should occur after ossification nucleus appearance and before walking age (typically 6-12 months). Later radiographic follow-up (12-24 months) may be appropriate for children with initial severe dysplasia or residual risk factors.

Future Directions

Artificial Intelligence Integration

The integration of AI into DDH imaging holds tremendous promise. AI systems can standardize image acquisition, automate measurement calculations, and provide diagnostic support [Lee et al., 2025, p. 4]. Potential applications include:

- **Point-of-care ultrasound:** AI-enabled handheld devices could enable accurate DDH screening in primary care settings, reducing the need for specialist referrals
- **Quality assurance:** Automated assessment of image quality and proper technique could reduce operator-dependent variability

- **Decision support:** Integration of imaging findings with clinical risk factors could generate personalized diagnostic and management recommendations

- **Population screening:** Cost-effective AI systems could enable widespread screening programs in resource-limited settings

Current AI systems demonstrate promising accuracy, with Graf angle error rates of 0.21 compared to expert diagnostics [Lee et al., 2025, p. 5]. However, prospective validation studies are needed before clinical implementation.

Advanced Imaging Techniques

Magnetic resonance imaging (MRI) provides detailed assessment of both osseous and cartilaginous structures without radiation exposure [Barrera et al., 2019, p. 1659]. MRI is particularly valuable in complex cases, including:

- Pre-operative assessment before open reduction

- Evaluation after closed reduction in spica cast

- Assessment of residual dysplasia in older children

- Detection of soft-tissue obstacles to concentric reduction (pulvinar, inverted labrum, ligamentum teres hypertrophy)

Walbron et al. (2019) used MRI to characterize two types of residual DDH [Walbron et al., 2019, p. 420]:

- **Harmonious dysplasia:** Both osseous and cartilaginous acetabular defects present

- **Divergent dysplasia:** Osseous defect with sufficient cartilaginous coverage

Divergent dysplasia showed spontaneous improvement in one-third of cases, suggesting that MRI findings could guide surgical timing and patient selection [Walbron et al., 2019, p. 422]. MRI may identify children likely to improve without surgery, avoiding unnecessary interventions.

CONCLUSION

This comprehensive review demonstrates that ultrasound and radiography serve complementary roles in the evaluation of developmental dysplasia of the hip in young children, with optimal diagnostic accuracy achieved through age-appropriate modality selection and integrated interpretation.

Ultrasound, primarily using the standardized Graf method, remains the imaging modality of choice for infants under 4-6 months of age. Its ability to visualize unossified cartilage, provide dynamic assessment of hip stability, and enable radiation-free monitoring makes it indispensable for early diagnosis and treatment guidance [Krauss et al., 2025, p. 8]. The optimal timing for initial ultrasound screening appears to be 5-6 weeks of life, when measurement errors are minimized and physiological immaturity can be appropriately distinguished from true pathology [Sioutis et al., 2025, p. 4].

Radiography becomes the preferred modality after the appearance of femoral head ossification nuclei, typically between 4-9 months of age. Standardized measurements including the acetabular index and Shenton's line assessment provide objective evaluation of acetabular development and hip joint congruence [Alam et al., 2025, p. 5]. The reliability of radiographic interpretation improves with reader experience and multi-parameter assessment.

Critically, ultrasonographic hip maturation may not be consistent with radiographic hip development [Atalar et al., 2020, p. 230]. Normal ultrasound findings do not guarantee normal radiographic outcomes, and definitive assessment of hip maturation requires radiographic confirmation after ossification nucleus appearance. This has important implications for clinical follow-up protocols and discharge criteria.

Emerging technologies including three-dimensional ultrasound, artificial intelligence-assisted analysis, and advanced MRI techniques promise to further improve diagnostic accuracy, reduce operator dependence, and enable personalized treatment approaches [Ghasseminia et al., 2021, p. 1462; Lee et al., 2025, p. 5; Walbron et al., 2019, p. 422].

Clinical Recommendations

Based on this evidence synthesis, the following clinical recommendations are proposed:

1. **Screening:** Risk-based ultrasound screening at 5-6 weeks for infants with risk factors (female sex, breech presentation, family history, clinical instability) [Vogt et al., 2025, p. 4].

2. **Initial diagnosis:** Ultrasound evaluation using the standardized Graf method by trained operators [Krauss et al., 2025, p. 4].

3. **Treatment monitoring:** Serial ultrasound examinations during abduction treatment to assess response without radiation exposure [Wuermeling et al., 2025, p. 4].

4. **Transition to radiography:** Obtain pelvic radiograph after femoral head ossification nucleus appearance (typically 6-9 months) to confirm normal development [Atalar et al., 2020, p. 230].

5. **Final assessment:** Radiographic evaluation before treatment completion to document hip maturation [Alam et al., 2025, p. 5].

6. **Complex cases:** Consider MRI for residual dysplasia, pre-operative planning, or assessment of soft-tissue barriers to reduction [Walbron et al., 2019, p. 421].

By understanding the strengths, limitations, and appropriate applications of both ultrasound and radiography, clinicians can optimize DDH diagnosis, guide treatment decisions, and improve long-term outcomes for children with this common developmental condition.

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