Section: Radiodiagnosis

Original Research Article

CORRELATION OF THREE-DIMENSIONAL ULTRASONOGRAPHY WITH MAGNETIC RESONANCE IMAGING IN THE DIAGNOSIS OF MÜLLERIAN DUCT ANOMALIES: A PROSPECTIVE STUDY

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ABSTRACT

Background: Müllerian duct anomalies (MDAs) are congenital malformations of the female reproductive tract arising from abnormal development, fusion, or resorption of the Müllerian ducts during embryogenesis. They are associated with infertility, recurrent pregnancy loss, dysmenorrhea, primary amenorrhea, and adverse obstetric outcomes. Three-dimensional ultrasonography (3D USG) has emerged as a valuable non-invasive diagnostic tool, while magnetic resonance imaging (MRI) is considered highly reliable for detailed anatomical evaluation. The aim is to correlate 3D ultrasonography with MRI in the diagnosis of Müllerian duct anomalies. **Materials and Methods:** This prospective study was conducted on 56 female patients clinically suspected of having uterine malformations at a tertiary care center. All participants underwent both 3D transvaginal ultrasonography and pelvic MRI. Findings from both modalities were classified using the American Society for Reproductive Medicine (ASRM) system and compared for concordance, diagnostic distribution, and associated anomalies. **Result:** The mean age of participants was 27.91 ± 7.35 years. Infertility (44.6%) and recurrent abortion (35.7%) were the most common referral indications. Septate uterus was the most frequently diagnosed anomaly on both 3D USG (35.7%) and MRI (37.5%), followed by arcuate uterus. Associated renal or skeletal anomalies were detected in 7.1% of cases on MRI. Overall concordance between 3D USG and MRI was 89.3% (Cohen's $\kappa = 0.86$, $p < 0.001$), indicating almost perfect agreement. **Conclusion:** Three-dimensional ultrasonography demonstrates strong correlation with MRI in the evaluation of Müllerian duct anomalies. Given its accessibility, lower cost, non-invasive nature, and high diagnostic accuracy, 3D USG can be considered an effective first-line imaging modality, while MRI remains valuable in complex or inconclusive cases.

INTRODUCTION

Müllerian duct anomalies (MDAs) constitute a diverse group of congenital malformations of the female reproductive tract arising from aberrations in the development, fusion, or resorption of the paired Müllerian ducts during embryogenesis. These anomalies involve varying degrees of structural alteration in the uterus, cervix, fallopian tubes, and upper vagina, with a clinical spectrum ranging from asymptomatic anatomical variants to significant reproductive and gynaecological dysfunction.[1].

The reported prevalence of MDAs ranges from 1% to 10% in the general population, rising to 2–8% among infertile women and as high as 13–16% in those with recurrent pregnancy loss. Septate uterus is consistently the most common subtype, followed by bicornuate, didelphys, and unicornuate uteri.[2]. Clinical presentations vary widely and include primary amenorrhea, dysmenorrhea, infertility, recurrent pregnancy loss, and adverse obstetric outcomes such as preterm labour and malpresentation.

Historically, evaluation relied on hysterosalpingography, two-dimensional ultrasonography, hysteroscopy, and laparoscopy, each limited by an inability to simultaneously assess the internal cavity and external uterine contour, or by procedural invasiveness.[3,4]. Three-dimensional ultrasonography has substantially improved non-invasive evaluation by permitting multiplanar reconstruction, particularly of the coronal plane, enabling accurate differentiation between septate and bicornuate uteri through measurement of intercornual

distance, intercornual angle, and fundal indentation depth. MRI complements this by offering superior soft-tissue contrast, operator-independence, and simultaneous assessment of associated renal or skeletal anomalies, making it particularly useful in complex or ambiguous presentations.[5,6].

Given the differing strengths of these two modalities, the present study was designed to correlate 3D USG findings with MRI in a cohort of women with clinically suspected Müllerian duct anomalies, using the ASRM classification system as the diagnostic framework.

Aim and Objectives:

To correlate 3D USG with MRI in the diagnosis of Müllerian duct anomalies.

1. To diagnose and classify Müllerian duct anomalies using 3D USG and MRI.
2. To determine the accuracy of 3D USG and MRI in the diagnosis of Müllerian duct anomalies.

MATERIALS AND METHODS

Study Design and Setting: This prospective observational study was conducted in the Department of Radiodiagnosis, National Institute of Medical Sciences & Research (NIMS University), Jaipur, Rajasthan, over a period of 18 months, following approval from the Institutional Scientific and Ethics Committee (Ref. No. NIMSUR/IEC/2024/1022).

Study Population: Women of any age group referred for evaluation of suspected uterine malformation presenting with delayed menarche, infertility, or recurrent abortion, and willing to provide written informed consent, were included. Patients with MRI-incompatible implants (pacemakers, cochlear implants, ferromagnetic devices) were excluded.

Sample Size: Using a 95% confidence interval, an estimated MDA prevalence, and a 6% margin of error, the calculated minimum sample size was 55.46, rounded to 56. Patients were enrolled by convenient sampling.

Imaging Protocol: All participants underwent 3D transvaginal ultrasonography with acquisition of coronal, sagittal, and transverse planes to assess uterine cavity morphology, fundal contour, endometrial thickness, and associated anomalies, followed by pelvic MRI using high-resolution T2-weighted multiplanar sequences to evaluate internal and external uterine anatomy and associated pelvic structures. Demographic and clinical data were collected using a semi-structured proforma. Findings from both modalities were classified according to the ASRM system and compared for diagnostic concordance.

Statistical Analysis: Data were expressed as frequencies, proportions, percentages, and mean ± standard deviation. Diagnostic agreement between 3D USG and MRI was assessed using Cohen's kappa statistic. All analyses were performed using SPSS and Microsoft Excel; $p < 0.05$ was considered statistically significant.

RESULTS

A total of 56 women with clinically suspected Müllerian duct anomalies were evaluated. The mean age of participants was 27.91 ± 7.35 years, indicating that the majority belonged to the reproductive age group.

Referral Indications: Infertility was the most common referral reason, observed in 25 patients (44.6%), followed by recurrent abortion in 20 patients (35.7%). Incidental detection on prior imaging accounted for 5 cases (8.9%), while primary amenorrhea and dysmenorrhea/abnormal uterine bleeding were each reported in 3 patients (5.4%).

Referral Reason	n (%)
Infertility	25 (44.6)
Recurrent abortion	20 (35.7)
Incidental finding on imaging	5 (8.9)
Primary amenorrhea	3 (5.4)
Dysmenorrhea / Abnormal uterine bleeding	3 (5.4)

Distribution of Uterine Anomalies: Abnormal uterine morphology was identified on MRI in all 56 patients (100%). On 3D USG, septate uterus was the most frequently diagnosed anomaly (35.7%), followed by arcuate uterus (26.8%), bicornuate uterus (17.9%), unicornuate uterus (12.5%), and uterus didelphys (7.1%). On MRI, septate uterus was again the most common finding (37.5%), followed by arcuate uterus (30.4%), with unicornuate and bicornuate uterus each accounting for 12.5%, and uterus didelphys the least common (7.1%).

Uterine Anomaly	3D USG n (%)	MRI n (%)
Septate uterus	20 (35.7)	21 (37.5)
Arcuate uterus	15 (26.8)	17 (30.4)
Bicornuate uterus	10 (17.9)	7 (12.5)
Unicornuate uterus	7 (12.5)	7 (12.5)
Uterus didelphys	4 (7.1)	4 (7.1)

Final Diagnosis and Associated Anomalies: Based on combined imaging findings, the final diagnostic distribution mirrored MRI findings: septate uterus (37.5%), arcuate uterus (30.4%), unicornuate and bicornuate uterus (12.5% each), and uterus didelphys (7.1%). Associated renal or skeletal anomalies were

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detected on MRI in 4 patients (7.1%), most frequently unilateral renal agenesis, while the remaining 52 patients (92.9%) showed no extra-uterine anomalies.

Diagnostic Concordance and Accuracy: Concordant findings between 3D USG and MRI were observed in 50 of 56 patients (89.3%), while discordance was noted in 6 patients (10.7%), predominantly involving differentiation between septate and bicornuate uterus or arcuate uterus. The overall diagnostic accuracy of 3D USG relative to MRI was 89.3%, with a Cohen's kappa value of 0.86, indicating almost perfect agreement ($p < 0.001$).

Parameter	Value
Overall Accuracy	89.3%
Cohen's Kappa (κ)	0.86
Strength of Agreement	Almost Perfect Agreement
p-value	< 0.001

DISCUSSION

The present study evaluated the diagnostic correlation between 3D USG and MRI in 56 women with clinically suspected Müllerian duct anomalies. The mean age of 27.91 ± 7.35 years is consistent with prior reports by Grimbizis et al. and Chan et al., who observed that congenital uterine anomalies are most frequently detected in the second and third decades of life, coinciding with evaluation during infertility work-up.[7,8].

Infertility (44.6%) and recurrent abortion (35.7%) were the leading indications for imaging, corroborating findings by Saravelos et al. and Chan et al., who identified these as the predominant presentations among women with Müllerian anomalies [8,9]. Septate uterus emerged as the most common anomaly on both modalities, a finding consistent with previous literature identifying it as the most prevalent congenital uterine malformation, particularly in populations undergoing infertility or recurrent pregnancy loss evaluation.[7,8]. This predominance likely reflects both its strong association with adverse reproductive outcomes and its amenability to hysteroscopic correction, which increases the probability of clinical detection and referral.

The overall concordance of 89.3% between 3D USG and MRI observed in this study aligns closely with previously reported agreement rates of 80–97%.[10,11]. Graupera et al. reported 93% accuracy for 3D USG against 96% for MRI with excellent interobserver correlation, while Bermejo et al. demonstrated sensitivity and specificity above 90% for 3D USG in identifying major MDA subtypes.[12,13]. Similarly, a systematic review by Mehtab et al. reported 3D USG sensitivity ranging from 91–98% and specificity from 93–99% across 22 pooled studies.[14]. The near-perfect kappa value (0.86) obtained in the present study reinforces these findings and supports the reliability of 3D USG as an initial diagnostic tool.

Discordant cases in the present study (10.7%) predominantly involved differentiation between septate and bicornuate uterus, a distinction of substantial clinical importance since management differs markedly between the two — septate uterus is typically managed surgically via hysteroscopic metroplasty, whereas bicornuate uterus is generally managed conservatively. Similar diagnostic overlap has been reported by Salim et al., who noted that discrepancies most often arise in cases with subtle or borderline fundal contour abnormalities, where MRI's superior external-contour delineation provides confirmatory value.[15].

Associated renal or skeletal anomalies were identified in 7.1% of patients in this cohort, consistent with the published range of 5–20%, reflecting the shared embryological origin of the Müllerian and mesonephric systems.[6,16]. This underscores the value of MRI in providing a comprehensive extra-uterine assessment, particularly in unicornuate uterus and uterus didelphys, which are more frequently associated with renal anomalies.

Taken together, these findings support a sequential diagnostic strategy in which 3D USG serves as the accessible, cost-effective, radiation-free first-line investigation, with MRI reserved for complex, discordant, or inconclusive cases and for evaluation of associated congenital anomalies, consistent with recommendations in recent reviews.[1,17].

Strengths and Limitations: Strengths of this study include direct within-patient comparison of two imaging modalities using a standardized ASRM classification and a clinically representative population. Limitations include the single-centre design, relatively small sample size, absence of surgical or hysteroscopic correlation, potential inter-observer variability, and lack of long-term reproductive outcome data.

CONCLUSION

Three-dimensional ultrasonography demonstrates strong diagnostic correlation with MRI in the evaluation of Müllerian duct anomalies, with an overall concordance of 89.3% and almost perfect agreement ($\kappa = 0.86$). Given its non-invasive nature, accessibility, cost-effectiveness, and absence of ionizing radiation, 3D USG can be recommended as an effective first-line imaging modality for MDAs, while MRI should be reserved for complex, discordant, or inconclusive cases and for comprehensive assessment of associated renal or skeletal anomalies. A structured, stepwise imaging approach combining these complementary modalities can optimize diagnostic accuracy, guide appropriate

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surgical planning, and improve reproductive counselling and outcomes.

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