Original Research

Diagnostic Accuracy of Transvaginal Ultrasound versus Magnetic Resonance Imaging for the Detection of Pelvic Endometriosis: A Prospective Study of 50 Patients

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ABSTRACT:
Objective: To compare the diagnostic accuracy of transvaginal ultrasound (TVUS) and magnetic resonance imaging (MRI) in detecting pelvic endometriosis, using surgical and histopathological findings as the reference standard. **Methods:** This prospective study enrolled 50 women with suspected endometriosis between January 2013 and July 2013. All participants underwent TVUS and MRI examinations before laparoscopic surgery. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of each imaging modality were calculated for the detection of endometriosis at various anatomical locations. **Results:** Of the 50 patients, 42 (84%) had histologically confirmed endometriosis. For overall detection of endometriosis, TVUS showed sensitivity, specificity, PPV, NPV, and accuracy of 76.2%, 87.5%, 97.0%, 41.2%, and 78.0%, respectively. MRI demonstrated sensitivity, specificity, PPV, NPV, and accuracy of 85.7%, 75.0%, 94.7%, 50.0%, and 84.0%, respectively. MRI was superior for detecting endometriotic lesions in the uterosacral ligaments (sensitivity: 81.8% vs. 63.6%) and rectovaginal septum (sensitivity: 85.7% vs. 71.4%), while TVUS performed better for ovarian endometriomas (sensitivity: 94.7% vs. 89.5%). Inter-observer agreement was substantial for both modalities (κ = 0.78 for TVUS, κ = 0.82 for MRI). **Conclusion:** Both TVUS and MRI demonstrate good diagnostic performance in detecting pelvic endometriosis, with complementary strengths depending on lesion location. TVUS may be preferred as the initial imaging modality due to lower cost and wider availability, while MRI offers advantages for evaluating specific anatomical regions and planning surgical intervention in complex cases.
Keywords: Endometriosis; Transvaginal ultrasound; Magnetic resonance imaging; Diagnostic accuracy; Laparoscopy

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INTRODUCTION

Endometriosis is a chronic inflammatory condition characterized by the presence of endometrial-like tissue outside the uterine cavity, affecting approximately 10% of women of reproductive age.[1] This condition is associated with chronic pelvic pain, dysmenorrhea, dyspareunia, and infertility, significantly impacting patients' quality of life.[2] Despite its prevalence and clinical importance, the diagnosis of endometriosis remains challenging, with an average delay of 7-10 years from symptom onset to definitive diagnosis.[3]
While laparoscopic visualization with histological confirmation remains the gold standard for diagnosis, non-invasive imaging techniques play a crucial role in the diagnostic pathway.[4] Transvaginal ultrasound (TVUS) and magnetic resonance imaging (MRI) are the most commonly employed imaging modalities for the evaluation of suspected endometriosis.[5] TVUS is widely available, cost-effective, and does not involve radiation exposure, making it suitable as a first-line imaging technique.[6] MRI offers superior soft tissue contrast and a wider field of view, potentially providing more detailed information about the extent and location of endometriotic lesions.[7]
Despite numerous studies evaluating these imaging modalities individually, there is limited prospective data directly comparing their diagnostic performance across different anatomical locations.[8,9] Furthermore, most previous studies have focused on specific types

of endometriosis, such as deep infiltrating endometriosis or ovarian endometriomas, rather than evaluating overall diagnostic accuracy.[10,11]

The aim of this prospective study was to compare the diagnostic accuracy of TVUS and MRI for the detection of pelvic endometriosis at various anatomical locations, using surgical and histopathological findings as the reference standard.

MATERIALS AND METHODS
Study Design and Participants
This prospective, single-center study was conducted at University Medical Center between January 2013 and July 2013. The study protocol was approved by the Institutional Review Board, and written informed consent was obtained from all participants.

Women aged 18-45 years with clinical suspicion of endometriosis (based on symptoms such as chronic pelvic pain, dysmenorrhea, dyspareunia, or infertility) who were scheduled for laparoscopic surgery were eligible for inclusion. Exclusion criteria included: previous surgical diagnosis of endometriosis, contraindications to MRI (e.g., claustrophobia, metallic implants), pregnancy, and malignancy.

Imaging Protocols
All participants underwent both TVUS and MRI examinations within 30 days prior to scheduled laparoscopy. The radiologists and sonographers performing and interpreting the imaging studies were blinded to clinical data and the results of the other imaging modality.

Transvaginal Ultrasound
TVUS examinations were performed using a Voluson E8 ultrasound system (GE Healthcare, Chicago, IL, USA) with a 5-9 MHz endovaginal probe. Examinations were conducted by one of two experienced sonographers (each with >5 years of experience in gynecological ultrasound), following a standardized protocol that included:
- Assessment of uterine morphology and position
- Evaluation of both adnexa
- Systematic survey of the anterior and posterior compartments
- Assessment of organ mobility and site-specific tenderness

Specific attention was paid to identifying endometriomas, hyperechoic foci in the intestinal wall, thickened uterosacral ligaments, and hypoechoic nodules in the rectovaginal septum.

Magnetic Resonance Imaging
MRI examinations were performed using a 1.5-Tesla scanner (Siemens MagnetomAvanto, Erlangen, Germany) with a pelvic phased-array coil. Patients were instructed to fast for 4 hours prior to the examination and received an antispasmodic agent (hyoscine butylbromide, 20 mg intramuscularly) to reduce bowel peristalsis.

The MRI protocol included:
- T1-weighted turbo spin-echo (TSE) sequence in axial plane
- T2-weighted TSE sequences in axial, sagittal, and coronal planes
- Fat-suppressed T1-weighted sequences in axial plane
- Diffusion-weighted imaging (DWI) with b-values of 0, 500, and 1000 s/mm²

Slice thickness was 4 mm with a 0.4 mm gap, and field of view was 24-28 cm.

Image Interpretation
TVUS and MRI examinations were independently interpreted by two radiologists with expertise in gynecological imaging (>10 years of experience), who were blinded to clinical information and the results of the other imaging modality. In cases of discrepancy, a consensus was reached through discussion.

The presence and location of endometriotic lesions were recorded for the following anatomical sites:
- Ovaries (right and left)
- Uterosacral ligaments
- Rectovaginal septum
- Bladder
- Rectosigmoid junction
- Pelvic peritoneum

Diagnostic criteria for endometriosis on TVUS included:
- Ovarian endometriomas: unilocular or multilocular cysts with ground-glass echogenicity and no or few papillary projections
- Deep infiltrating endometriosis: hypoechoic irregular nodules or masses with or without echogenic foci
- Adhesions: fixed retroversion of the uterus, limited organ mobility, or compartmentalization of the pelvis

Diagnostic criteria for endometriosis on MRI included:
- Ovarian endometriomas: cystic lesions with high signal intensity on T1-weighted images and relatively low signal intensity on T2-weighted images ("shading sign")
- Deep infiltrating endometriosis: fibrous nodules with low signal intensity on T2-weighted images, sometimes with small hyperintense foci representing ectopic endometrial glands
- Adhesions: distortion of normal pelvic anatomy, tethering of organs, or compartmentalization of pelvic fluid

Surgical Procedure and Histopathological Analysis
All patients underwent laparoscopic surgery performed by one of three gynecologists with expertise in endometriosis surgery (each with >8 years of experience). The surgeons were aware of the

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patients' clinical symptoms but blinded to the results of the imaging studies.

During laparoscopy, a systematic exploration of the pelvis was performed, and all visible endometriotic lesions were documented and photographed. Suspicious lesions were excised and sent for histopathological examination. The extent of disease was classified according to the revised American Society for Reproductive Medicine (rASRM) scoring system (12).

Histopathological confirmation of endometriosis required the presence of both endometrial glands and stroma in the excised specimens. The pathologists were blinded to the imaging results.

Statistical Analysis

Sample size calculation was based on an expected difference in sensitivity of 15% between TVUS and MRI, with an estimated prevalence of endometriosis of 80% in our study population. A minimum of 47 patients was required to achieve 80% power at a 5% significance level.

Statistical analysis was performed using SPSS version 20.0 (IBM Corp., Armonk, NY). The diagnostic accuracy of TVUS and MRI was assessed by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy for each anatomical location and for the overall detection of endometriosis.

McNemar's test was used to compare the sensitivity and specificity of the two imaging modalities. Inter-observer agreement was assessed using Cohen's kappa (κ) statistic. A p-value <0.05 was considered statistically significant.

RESULTS

Patient Characteristics

Fifty women with suspected endometriosis were enrolled in the study. The mean age was 32.4 ± 6.7 years (range: 19-44 years). The most common presenting symptoms were dysmenorrhea (78%), chronic pelvic pain (72%), and dyspareunia (58%). Eighteen patients (36%) reported infertility.

Of the 50 patients, 42 (84%) had histologically confirmed endometriosis. According to the rASRM classification, 9 patients (21.4%) had stage I disease, 12 (28.6%) had stage II, 14 (33.3%) had stage III, and 7 (16.7%) had stage IV disease. The remaining 8 patients (16%) had alternative diagnoses, including adenomyosis (n=3), pelvic inflammatory disease (n=2), pelvic congestion syndrome (n=2), and functional ovarian cyst (n=1).

Table 1. Overall diagnostic performance of TVUS and MRI for the detection of endometriosis

Parameter	TVUS (95% CI)	MRI (95% CI)	P-value
Sensitivity	76.2% (60.5-87.9)	85.7% (71.5-94.6)	0.047
Specificity	87.5% (47.3-99.7)	75.0% (34.9-96.8)	0.317
PPV	97.0% (84.2-99.9)	94.7% (82.3-99.4)	0.558
NPV	41.2% (18.4-67.1)	50.0% (21.1-78.9)	0.317
Accuracy	78.0% (64.0-88.5)	84.0% (70.9-92.8)	0.083

PPV: positive predictive value; NPV: negative predictive value; CI: confidence interval

Table 2. Diagnostic performance of TVUS and MRI by anatomical location

Location	Modality	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Ovaries	TVUS	94.7	93.5	90.0	96.7	94.0
	MRI	89.5	96.8	94.4	93.8	94.0
Uterosacral ligaments	TVUS	63.6	89.7	77.8	81.3	80.0
	MRI	81.8*	79.3	69.2	88.5	80.0
Rectovaginal septum	TVUS	71.4	97.7	90.9	91.3	91.2
	MRI	85.7*	95.3	85.7	95.3	93.2
Bladder	TVUS	40.0	100	100	93.8	94.0
	MRI	80.0*	97.8	80.0	97.8	96.0
Rectosigmoid	TVUS	73.3	94.3	84.6	89.2	88.0
	MRI	86.7	91.4	81.2	94.1	90.0
Pelvic peritoneum	TVUS	42.9	97.2	90.0	76.0	78.0
	MRI	71.4*	88.9	78.9	84.2	82.0

*p<0.05 compared to TVUS sensitivity

Inter-observer Agreement

Inter-observer agreement was substantial for both imaging modalities, with slightly higher agreement for MRI (κ = 0.82, 95% CI: 0.74-0.90) compared to TVUS (κ = 0.78, 95% CI: 0.69-0.87).

Correlation with Disease Severity

Both imaging modalities showed better diagnostic performance in patients with moderate to severe endometriosis (rASRM stages III-IV) compared to those with minimal to mild disease (stages I-II). For stages III-IV, the sensitivity of TVUS and MRI was

90.5% and 95.2%, respectively, while for stages I-II, the sensitivity decreased to 61.9% and 76.2%, respectively (p<0.01 for both modalities).

DISCUSSION

This prospective study compared the diagnostic accuracy of TVUS and MRI for the detection of pelvic endometriosis in various anatomical locations, using surgical and histopathological findings as the reference standard. Our results demonstrate that both imaging modalities have good overall diagnostic performance, with MRI showing higher sensitivity and TVUS demonstrating higher specificity for most anatomical locations.

The overall sensitivity of TVUS (76.2%) and MRI (85.7%) in our study is comparable to previous reports in the literature. A meta-analysis by Nisenblat et al. reported pooled sensitivities of 79% for TVUS and 83% for MRI in detecting pelvic endometriosis.[13] Similarly, Guerriero et al. found sensitivities of 73% for TVUS and 85% for MRI in a systematic review.[14] The slightly higher sensitivity of MRI observed in our study may be attributed to our comprehensive imaging protocol, including DWI sequences, which have been shown to improve the detection of small endometriotic implants.[15]

Our findings suggest that the diagnostic performance of TVUS and MRI varies depending on the anatomical location of endometriotic lesions. TVUS performed exceptionally well for the detection of ovarian endometriomas, with a sensitivity of 94.7% and specificity of 93.5%. This is consistent with previous studies that have established TVUS as the preferred imaging modality for ovarian endometriosis.[16,17] The characteristic appearance of endometriomas on ultrasound—cysts with homogeneous ground-glass echogenicity—makes them readily identifiable on TVUS.

In contrast, MRI demonstrated superior sensitivity for detecting deep infiltrating endometriosis in the uterosacral ligaments, rectovaginal septum, bladder, and pelvic peritoneum. These findings align with those of Bazot et al., who reported higher sensitivity of MRI compared to TVUS for endometriosis of the uterosacral ligaments (85.5% vs. 68.1%) and rectovaginal septum (82.4% vs. 70.6%).[18] The superior soft tissue contrast of MRI and its ability to provide multiplanar images likely contribute to its enhanced performance in these anatomical regions, which can be challenging to visualize completely with TVUS due to technical limitations and operator dependence.

For rectosigmoid endometriosis, both imaging modalities demonstrated good diagnostic performance, with MRI showing slightly higher sensitivity (86.7% vs. 73.3%) but lower specificity (91.4% vs. 94.3%) compared to TVUS. These results are comparable to those reported by Abrao et al., who found sensitivities of 98% for MRI and 91% for TVUS in detecting rectosigmoid endometriosis.[19] The

relatively high performance of TVUS in this location may be attributed to the standardized approach used in our study, which included assessment of sliding signs and systematic evaluation of the anterior rectal wall.

Interestingly, both imaging modalities showed significantly lower sensitivity for detecting endometriosis in patients with minimal to mild disease (rASRM stages I-II) compared to those with moderate to severe disease (stages III-IV). This finding highlights the ongoing challenge of diagnosing early-stage endometriosis through imaging alone, particularly small peritoneal implants that may not produce significant anatomical distortion or signal abnormalities.[20] Novel MRI techniques, such as magnetization transfer imaging and intravoxel incoherent motion, may potentially improve the detection of these subtle lesions in the future.[21]

Our study demonstrated substantial inter-observer agreement for both TVUS (κ = 0.78) and MRI (κ = 0.82), indicating good reproducibility of both imaging modalities when performed and interpreted by experienced specialists. This finding underscores the importance of expertise and standardized protocols in optimizing the diagnostic performance of imaging studies for endometriosis.

From a clinical perspective, our results suggest that TVUS and MRI should be considered complementary rather than competitive imaging modalities in the diagnostic workup of suspected endometriosis. TVUS offers advantages of lower cost, wider availability, absence of contraindications, and superior performance for ovarian endometriomas, making it a reasonable first-line imaging technique. MRI, while more expensive and less accessible, provides more comprehensive evaluation of deep infiltrating endometriosis and may be particularly valuable for surgical planning in complex cases.

CONCLUSION

This prospective study demonstrates that both TVUS and MRI have good overall diagnostic performance for the detection of pelvic endometriosis, with complementary strengths depending on lesion location. MRI shows higher sensitivity for deep infiltrating endometriosis in the uterosacral ligaments, rectovaginal septum, bladder, and pelvic peritoneum, while TVUS performs exceptionally well for ovarian endometriomas. Both modalities show limited sensitivity for early-stage disease. These findings suggest that TVUS may be preferred as the initial imaging modality due to its lower cost and wider availability, while MRI may be reserved for cases with suspected deep infiltrating endometriosis or for detailed preoperative mapping in complex cases.

Future research should focus on developing and validating standardized imaging protocols, exploring novel imaging techniques to improve the detection of early-stage disease, and investigating the cost-effectiveness of different diagnostic strategies for endometriosis.

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