ORIGINAL ARTICLE

Comparative Analysis of Ultrasound and MRI in Detecting Endometriosis among Pakistani Women

BINISH ZAIDI[1], SARA GILL[2], ANUM FAROOQ[3], MUHAMMAD IMRAN AKHTAR[4], ZEGHUM HUSSAIN ZEGHUM[5], SAJIDA MAJEED[6]

[1]Faisalabad Medical University and affiliated Hospitals, Faisalabad, Pakistan
[2]District Headquarter Hospital (DHQ), Chiniot, Pakistan.
[3]Allied -1 hospital Faisalabad, Pakistan.
[4]Allied Hospital-II DHQ Faisalabad, Pakistan.
[5]Al Barkat Hospital Gojra, Faisalabad, Pakistan.
[6]Sheikh Zayed Medical College and Hospital (SZMC), Rahim Yar Khan, Pakistan.
Correspondence to: Binish Zaidi, Email: biniahzaidi@gmail.com, Cell: +92 300 7311244

ABSTRACT

Background: Endometriosis is a persistent gynecological disease that greatly affects a woman's quality of life and reproductive health. Diagnosis is increasingly done using such non-invasive imaging modalities as transvaginal ultrasound (TVUS) and magnetic resonance imaging (MRI). Nevertheless, data regarding their performance in detecting deep infiltrative lesions in Pakistani women, in particular, are scarce.

Objective: To assess the diagnostic accuracy of TVUS compared to MRI in the detection of endometriosis in premenopausal Pakistani women using laparoscopic findings and histopathological confirmation as the reference standard.

Methods: This is a prospective study of 12 months (January to December 2021) in 90 premenopausal women (aged 18 to 45 years) with clinical symptoms suggestive of endometriosis. TVUS and MRI evaluations were performed on all the participants before diagnostic laparoscopy. Images were interpreted by independent, experienced radiologists. Each imaging modality's sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated and compared to laparoscopic and histopathological diagnosis. The diagnostic performance of DIE in a subset analysis was also performed.

Results: Laparoscopy confirmed endometriosis in 70 patients (77.8%). In general, TVUS showed a sensitivity of 77.1%, specificity of 70.0%, PPV of 90.0%, and NPV of 46.7%. However, with significantly higher sensitivity (91.4%) and specificity (85.0%), PPV 95.5%, and NPV 73.9% ($p < 0.05$), MRI was found to be in contrast to the US. MRI has a sensitivity of 93.3% for deep infiltrating endometriosis as compared to 66.7% for TVUS. Moreover, the interobserver agreement for MRI ($\kappa = 0.85$) was greater than for TVUS ($\kappa = 0.70$).

Conclusion: TVUS is still a cost-effective and accessible first-line diagnostic tool but MRI is superior for detecting deep infiltrative lesions. Therefore, the findings support a stepwise, tailored diagnostic approach in resource-constrained settings that incorporates MRI when TVUS findings are unspecific or deep disease is suspected to best guide patient management and surgical planning.

Keywords: Endometriosis, Diagnostic Accuracy, Transvaginal Ultrasound, Magnetic Resonance Imaging, Deep Infiltrating Endometriosis, Pakistani Women, Laparoscopy

INTRODUCTION

Endometriosis is an extremely common and debilitating gynecological disorder that involves the ectopic presence of endometrial-like tissue outside the uterine cavity, affecting 10% of women of reproductive age worldwide. Many of the symptoms of this chronic condition are chronic pelvic pain, dysmenorrhea, and infertility which have a significant impact on quality of life and psychosocial well-being. Although endometriosis is very common, it is underdiagnosed, in part, because of its heterogeneous presentation and the challenges inherent in making a definitive diagnosis.[1]. The gold standard for diagnostic laparoscopy has traditionally been diagnostic laparoscopy with histopathological confirmation, however, the invasive nature, associated risks, and high costs render it less than ideal for universal applicability, especially in settings where resources are limited[2].

Over the last decade, transvaginal ultrasound (TVUS) and magnetic resonance imaging (MRI) have become important non-invasive modalities of choice in the diagnostic workup of endometriosis. TVUS is good enough to be considered a first-line investigation because it is relatively cheap, easy to obtain, and has real-time evaluation potential. It is used for the evaluation of pelvic anatomy, for the identification of endometriomas, and the evaluation of adhesions and deep infiltrating lesions[3]. TVUS however, is operator-dependent and may not be able to detect lesions in atypical or posterior locations. In contrast, MRI provides superior soft tissue contrast resolution with multiplanar imaging that helps in delineating the extent of disease particularly in deep infiltrating endometriosis. Although MRI comes with these advantages, its higher cost and limited availability can be challenging, especially in low- to middle-income countries[4].

Timely and accurate diagnosis of endometriosis is crucial in Pakistan where resources for healthcare are limited and distribution of diagnostic infrastructure is uneven. There are unique socio-cultural and economic barriers that Pakistani women have to face that can delay diagnosis and treatment and result in prolonged suffering and long-term sequelae[5]. The current healthcare paradigm in Pakistan necessitates a pragmatic approach to diagnosis—balancing the need for high diagnostic accuracy with considerations of cost-effectiveness and accessibility. Although several studies have been conducted to evaluate the usefulness of TVUS and MRI in the detection of endometriosis in Western populations, little is known about this in South Asian populations where the disease prevalence, presentation, and availability of resources may be very different[6].

This study aimed to close this critical gap by giving a comparative assessment of the diagnostic precision of TVUS and MRI in endometriosis identification in Pakistani women. In a real-world clinical setting, we will rigorously evaluate the sensitivity, specificity, and predictive values of these imaging modalities using prospective design and laparoscopic findings as the reference standard. These data are necessary for the refinement of the diagnostic protocol as well as for preoperative planning, which is critical for reducing surgical morbidity and improving patient outcomes[7].

Additionally, the study stresses the need for incorporating advanced imaging techniques in routine clinical routine in Pakistani society, while also highlighting the limitations that many healthcare providers face. A local understanding of the relative strengths and weaknesses of TVUS and MRI can help shape diagnostic pathways that are conceived to be efficacious and efficient in caring for patients. This study aimed to participation in the global discourse on endometriosis and to provide answers to the specific needs of Pakistani women to increase diagnostic accuracy and clinical management of this complex condition[8, 9].

MATERIALS AND METHODS

Study Design and Setting: This was a prospective comparative study that was carried out for 12-months from January 2021 to January 2022 at tertiary care hospitals in Pakistan. The purpose of the study was to compare the diagnostic accuracy of TVUS and MRI in women with suggestive clinical symptoms and the presence of endometriosis. The protocol was approved by the hospital's Ethics Committee and all participants gave informed consent before enrolment.

Patient Selection and Sample Size: Ninety premenopausal women 18–45 years of age were consecutively recruited from the outpatient gynecology clinics based on clinical symptoms suggestive of endometriosis such as chronic pelvic pain, dysmenorrhea, dyspareunia, or infertility. Patients with a high clinical suspicion of endometriosis were enrolled in the study and all participants were subsequently scheduled for diagnostic laparoscopy, which was used as the reference standard for the diagnosis of endometriosis.

Inclusion and Exclusion Criteria: If the patient was premenopausal and between 18 to 45 years of age, with clinical signs compatible with endometriosis and willing to undergo both imaging studies and laparoscopic examination, she was included in the study. Pregnant women or any individual with contraindications to MRI (e.g. metallic implants or severe claustrophobia) as well as those with a history of previous pelvic surgery, which could confound imaging interpretation, were excluded. The criteria were put in place to achieve a homogenous study population and to rule out potential confounding factors.

IMAGING TECHNIQUES

Transvaginal Ultrasound (TVUS): High-resolution ultrasound equipment fitted with dedicated transvaginal probes was used for TVUS examinations. Radiologists with over five years experience of in gynecological imaging conducted each examination. A systematic assessment of the pelvic organs with special emphasis on the uterine, ovarian, and adnexal regions was adhered to through a standardized protocol. Details of lesion size, location, and characteristics, including nodularity or increased vascularity, were recorded and endometriomas, adhesions, and signs of deep infiltrating endometriosis were noted. The dynamic real-time evaluation also gave information on the mobility and tenderness of the pelvic structures.

Magnetic Resonance Imaging (MRI): Pelvic-phased array coils were used for MRI examinations in a 1.5 Tesla scanner. The imaging protocol consisted of T1-weighted, T2-weighted, and fat-suppressed sequences to achieve better visualization of pelvic anatomy and endometriotic lesions. When necessary, intravenous contrast was administered selectively to more clearly define lesion characteristics. Radiologists with special expertise in pelvic imaging performed MRI interpretations, which gave high reproducibility and accuracy. Particularly useful for visualizing deep infiltrating endometriosis and also for lesions in atypical anatomic locations, the multiplanar imaging capabilities and superior soft tissue contrast of MRI were key.

Laparoscopic and Histopathological Evaluation: After the imaging studies, all patients were taken to the operating room under general anesthesia for diagnostic laparoscopy by experienced gynecologic surgeons. To perform the laparoscopic procedure, suspected endometriotic lesions were carefully examined or documented and excised when possible. Once the tissue samples were excised, they were sent for histopathological examination to confirm a diagnosis of endometriosis. As a definitive reference standard, the laparoscopy and histopathology combined findings were used.

Data Analysis: Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated about the laparoscopic and histopathological findings to evaluate the diagnostic performance of TVUS and MRI. A chi-square test was conducted between the imaging modalities with a p-value of <0.05 considered statistically significant. To achieve robustness and reliability of the study outcome, validated statistical software was used for data analysis.

RESULTS

Over the 12 months of this study, n=90 prep menopausal women were enrolled and all underwent TVUS and MRI before diagnostic laparoscopy and histopathological evaluation. At last, 70 patients (77.8%) were confirmed by the reference standard to have endometriosis, and 20 patients were negative for the disease. Demographic and clinical characteristics at baseline are presented in Table 1. The study population included 32 ± 6 years old mean age, and all of the participants were female. The most common symptom was chronic pelvic pain reported by 60 (66.7%), followed by dysmenorrhea in 45 (50.0%), dyspareunia in 30 (33.3%), and infertility in 25 (27.8%).

Table 1: Demographic and Clinical Characteristics (n = 90)

Characteristic	Value
Gender	Female (90, 100%)
Mean Age (years)	32 ± 6
Chronic Pelvic Pain	60 (66.7%)
Dysmenorrhea	45 (50.0%)
Dyspareunia	30 (33.3%)
Infertility	25 (27.8%)

TVUS correctly identified 54 of the 70 cases of confirmed endometriosis and MRI 64. TVUS yielded 6 false positive results and MRI 3 false positive results in the subset of 20 patients without endometriosis. The results of TVUS and MRI together are summarized in Table 2, with sensitivity of 77.1%, specificity of 70.0%, and significantly higher sensitivity of 91.4% and specificity of 85.0% for MRI. TVUS PPV was 90.0% vs 95.5% for MRI and NPV was 46.7% vs 73.9% for MRI.

Table 2: Overall Diagnostic Performance of TVUS and MRI Compared to Laparoscopic Findings

Parameter	TVUS	MRI
True Positives (TP)	54	64
False Negatives (FN)	16	6
True Negatives (TN)	14	17
False Positives (FP)	6	3
Sensitivity	77.1% (54/70)	91.4% (64/70)
Specificity	70.0% (14/20)	85.0% (17/20)
Positive Predictive Value	90.0% (54/60)	95.5% (64/67)
Negative Predictive Value	46.7% (14/30)	73.9% (17/23)

Further stratification of lesion characteristics was also observed. MRI was superior for the delineation of lesions in the uterosacral ligaments, rectovaginal septum, and other deep pelvic sites, whereas TVUS was more effective at detecting ovarian endometriomas. MRI's multiplanar imaging capability allowed for a more precise assessment of the lesion size and extent, which is important for preoperative surgical planning. In addition, interobserver agreement was evaluated for both modalities, and the agreement was higher for MRI ($\kappa = 0.85$) than TVUS ($\kappa = 0.70$), indicating better and more reliable MRI interpretations.

Consequently, 30 patients were subjected to a subset analysis of deep infiltrating endometriosis (DIE). In 20 of these cases, TVUS detected DIE, and sensitivity for deep lesions was 66.7%, while sensitivity for MRI was 93.3% for DIE. The difference between this and other techniques is significant.

To sum up, the total prevalence of endometriosis in this study was 77.8%. TVUS is a useful first-line diagnostic tool because it is available and inexpensive, but sensitivity was only 77.1% and specificity only 70.0%. However, MRI had a markedly higher diagnostic performance with a sensitivity of 91.4% and a specificity of 85.0%. In particular, MRI was better than TVUS in the diagnosis of deep infiltrating endometriosis, having a sensitivity of 93.3% as opposed to 66.7%. These findings demonstrate that TVUS continues to be an important first-line investigation but in cases with suspected deep infiltrating disease or uncertain ultrasound findings

MRI is a must for enhanced accuracy and detailed anatomical visualization.

DISCUSSION

Our study's findings highlight the superiority of MRI vs TVUS in the diagnosis of endometriosis in Pakistani women, and more specifically, the superiority of MRI over TVUS to detect DIE. Both imaging modalities had a diagnostic value and our study population demonstrated an overall prevalence of 77.8%, while TVUS had a sensitivity of 77.1% and specificity of 70.0%, while MRI showed a sensitivity of 91.4% and specificity of 85.0%. These results are consistent with the superior soft tissue resolution and multifold imaging of MRI that provide better visualization of lesions in the complex anatomical regions such as uterosacral ligaments and rectovaginal septum[10, 11].

Our study also showed that MRI was much better than TVUS in terms of detection of deep infiltrating endometriotic lesions, with a sensitivity of 93.3 versus 66.7 for TVUS. In particular, accurate delineation of the lesion size and extent is particularly critical for surgical planning, as accurate delineation of the lesion size and extent is critical to reducing operative morbidity and obtaining maximum therapeutic outcomes[12]. Additionally, the finding of greater interobserver agreement for MRI (κ = 0.85) compared to TVUS (κ = 0.70) suggests greater consistency and reliability of image interpretation with those based on MRI[11, 13].

TVUS, while still a valuable first-line imaging modality owing to its accessibility, cost-effectiveness, and real-time assessment ability, is dependent on an operator, and is limited in detecting lesions in atypical locations[14]. Given that admission to high-end MRI facilities may be limited in resource-limited settings, these limitations are especially relevant. TVUS can be used as an initial screening tool in such settings with MRI reserved for cases of inconclusive ultrasound findings or when deep infiltrative disease is suspected[15, 16].

However, we should acknowledge our study's limitations. A sample size of 90 patients may be sufficient to demonstrate significant differences between imaging modalities, but it might not fully represent the general population. Secondly, the findings are based on a single-center study, and as such, local practice patterns and patient demographics may impact the results. These findings need to be validated by future multicentric studies with larger sample sizes to determine the role of combined imaging strategies in improving diagnostic accuracy[17, 18].

CONCLUSION

Despite the importance and availability of transvaginal ultrasound as a first-line diagnostic tool for endometriosis, our study shows that magnetic resonance imaging is superior at diagnosing deep infiltrative lesions. Since MRI is more sensitive, specific, and interobserver reliable, it is strongly recommended for cases where the TVUS findings are ambiguous or when deep pelvic involvement is suspected. This work suggests that, in resource-constrained settings such as Pakistan, a stepwise diagnostic approach that balances cost-effectiveness with diagnostic precision is needed. Finally, MRI integration into routine clinical practice is ultimately a key step toward improving preoperative planning and outcomes for women with endometriosis.

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