



Original Article



Diagnostic Accuracy of MRI in Detecting Stromal Invasion in Early Cervical Cancer Patients Taking Histopathology as Gold Standard

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ABSTRACT

Cervical cancer is a major cause of cancer-related deaths among women. MRI is a non-invasive imaging technique commonly used to evaluate tumor extent, but its diagnostic accuracy in detecting stromal invasion in early cervical cancer remains uncertain. **Objective:** To determine the diagnostic accuracy of MRI in detecting stromal invasion in early cervical cancer patients taking histopathology as gold standard. **Methods:** This Cross-sectional validation was conducted at the Department of Radiology, Faisalabad Medical University (FMU), Faisalabad, form 1st April 2024 to 30th September 2024. A total of 200 patients aged 30-70 years with early cervical cancer were included in the study. All patients underwent pelvic MRI scans using a 1.5 Tesla MRI machine. The MRI findings were assessed for the presence or absence of stromal invasion and compared with histopathology results. All the data was analyzed in SPSS and sensitivity, specificity, and diagnostic accuracy was calculated for MRI against histopathology. **Results:** The overall sensitivity, specificity, Positive Predictive Value (PPV), negative predictive value (NPV), and diagnostic accuracy of MRI in detecting stromal invasion in early cervical cancer patients, were 91.26%, 89.70%, 90.38%, 90.63%, and 90.50%, respectively with histopathology as the gold standard. **Conclusion:** This study concluded that MRI has a high diagnostic accuracy in detecting stromal invasion in early cervical cancer patients.

INTRODUCTION

Cervical cancer is one of the most common cancers among women globally, with early detection and accurate staging being pivotal to improving patient outcomes. Early cervical cancer, particularly at stages where the tumor has not yet invaded deeper tissues, presents an opportunity for treatment strategies that can significantly reduce mortality [1, 2]. One of the key prognostic factors for cervical cancer is the presence or absence of stromal invasion. Accurate assessment of stromal invasion is crucial for determining the appropriate management strategy, which may range from conservative surgery to more aggressive treatments. Magnetic Resonance

Imaging (MRI) has been proposed as a non-invasive imaging modality for assessing stromal invasion in early cervical cancer, but its diagnostic accuracy compared to histopathology the gold standard for diagnosis remains a subject of ongoing research [3]. Histopathology has long been considered the definitive method for evaluating stromal invasion in cervical cancer, providing detailed insights into tumor characteristics at a microscopic level. However, histopathological assessment involves invasive procedures like biopsy and is limited by sampling errors and inter-observer variability [4]. In contrast, MRI offers a promising non-invasive alternative, providing high-



resolution images of soft tissue structures, including the cervix and surrounding tissues. The ability of MRI to visualize stromal invasion could potentially reduce the need for invasive biopsies, offering a more accessible and less traumatic method for clinical decision-making [5]. MRI's role in assessing cervical cancer has gained attention over the years, particularly with advancements in imaging technology that enhance its resolution and accuracy. Several MRI sequences, including T2-weighted imaging, dynamic contrast-enhanced imaging, and diffusion-weighted imaging, have been employed to improve the sensitivity and specificity of detecting cervical cancer and its invasion into adjacent tissues. The use of high-field MRI machines has further improved the precision of these evaluations. While studies suggest that MRI has considerable potential in identifying stromal invasion, the evidence remains mixed regarding its diagnostic accuracy, with some studies showing promising results and others pointing to limitations such as the difficulty in differentiating tumor from normal tissue in certain cases [6, 7]. The challenge lies in accurately correlating MRI findings with histopathological outcomes. Stromal invasion, which refers to the penetration of the tumor into the cervical stroma, can vary in depth and extent. MRI imaging has been shown to have varying degrees of sensitivity and specificity in detecting different stages of stromal invasion, depending on tumor size, location, and the quality of the imaging technique used. Furthermore, MRI's diagnostic performance may be influenced by factors such as the skill of the radiologist and the lack of standardized protocols across different institutions. Therefore, while MRI holds promise, it is essential to evaluate its diagnostic performance against histopathology in large-scale, multicenter studies to validate its clinical utility [8, 9]. In recent years, research has focused on improving the diagnostic performance of MRI through the use of novel imaging biomarkers and machine learning algorithms. These innovations aim to enhance the accuracy of stromal invasion detection, reduce observer bias, and provide more objective and reproducible results. The integration of MRI with histopathological data could lead to more personalized and precise treatment plans for patients with early cervical cancer. However, comprehensive studies comparing MRI with histopathology as the gold standard are still required to establish clear guidelines for its clinical application and to identify potential pitfalls in its use for assessing stromal invasion [10-12].

Early detection of stromal invasion in cervical cancer is essential for accurate staging and appropriate treatment planning, yet reliance on histopathology is invasive and may delay decision-making. Although MRI is increasingly used as a non-invasive diagnostic tool, limited local validation

studies in Pakistani populations have comprehensively evaluated its diagnostic performance against histopathology, particularly in early-stage cervical cancer patients. This study aimed to address this gap by determining the diagnostic accuracy of MRI in detecting stromal invasion in early cervical cancer using histopathology as the gold standard, thereby assessing its reliability for improved preoperative evaluation.

METHODS

This cross-sectional validation was conducted in the Department of Radiology, Faisalabad Medical University (FMU), Faisalabad, over a period of six months, from April 2024 to September 2024. Approval for the study was obtained from the Ethical Review Committee (ERC) prior to initiating the research (ERC letter No 48. ERC/FMU/2023-24413). A total of 200 patients who presented to the Radiology Department were recruited in the study after applying non-probability, consecutive sampling technique. The sample size was calculated based on a 95% confidence level, a prevalence of stromal invasion estimated at 32%, and a 6.5% margin of precision, ensuring 80% sensitivity and 50% specificity of MRI in detecting stromal invasion in patients with early cervical cancer. Written informed consent was obtained from all participants before inclusion in the study. Inclusion criteria were patients eligible for the study included married and unmarried women aged 30-70 years, presenting with early cervical cancer. This was characterized by frank growth on the cervix measuring less than 4 cm in size, unhealthy cervix, and cervical cancer confirmed through PAP smear, with a duration of more than three months. Exclusion criteria were patients were excluded if they had already been diagnosed with cervical cancer, were undergoing chemotherapy or radiation therapy, had a history of cervical surgery, presented with carcinoma of the uterus, or had contraindications for undergoing MRI. All selected participants underwent an MRI scan of the pelvis using a 1.5 Tesla GE machine. The MRI procedure was conducted by a skilled MRI technician, ensuring high-quality imaging. The protocol included the following sequences: sagittal T2-weighted imaging, axial T1-weighted and T2-weighted imaging, coronal T1-weighted imaging, and coronal T2 fat-suppressed sequences. The images were reviewed to detect the presence or absence of stromal invasion. The MRI findings were interpreted by experienced radiologists with attention to identifying continuous tumor growth within the cervix or the presence of neoplastic glands adjacent to preexisting endocervical glands. The MRI findings were compared with histological results obtained from biopsies. Histological evidence of tumor continuity within the cervix or neoplastic gland presence was considered a significant indicator of stromal invasion. All relevant data were systematically recorded and analyzed using the SPSS software version 25.0. The accuracy of MRI

based on sensitivity (TP/TP+FN*100), specificity (TN/TN+FP*100), PPV (TP/TP+FP*100), NPV (TN+TN+FN*100) and overall diagnosed accuracy (TP+TN/N*100) were calculated against histopathology findings by using a 2x2 contingency table.

Table 1: Histopathological Categories

| Category | Histopathology | | Total |
|----------|----------------|----------|-------|
| | Positive | Negative | |
| MRI | Positive | (TP) | TP+FP |
| | Negative | (FN) | TN+FN |
| Total | TP+FN | TN+FP | N |

RESULTS

Total 200 females were enrolled in the study with the mean age of 43.84 ± 8.5 years. The majority of patients (74.0%) belonged to the 30-to-50-year age range. There were 36 (18%) were unmarried while remaining 82% were married. Mean duration of symptoms was 5.41 ± 1.75 months. On MRI, the mean size of lesion was noted as 2.93 ± 0.94 cm. Out of 200 females, 70.5% were premenopausal, (Table 2).

Table 2: Descriptive Analysis of Baseline Parameters (n = 200)

| Variables | Mean \pm SD/Frequency (%) |
|------------------------------|-----------------------------|
| Age (Years) | 43.84 ± 8.5 |
| Age range 30-50 Years | 148 (74%) |
| Age range 51-70 Years | 52 (26%) |
| Marital Status | |
| Unmarried | 36 (18%) |
| Married | 164 (82%) |
| Duration of Disease (Months) | 5.41 ± 1.75 |
| < 6 Months | 157 (78.50%) |
| > 6 Months | 43 (21.50%) |
| Size of Nodule (cm) | 2.93 ± 0.94 |

Table 4: Stratification of Diagnostic Accuracy of MRI according to different Variables

| Variables | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) | DA (%) | p-Value |
|----------------------------|-----------------|-----------------|---------|---------|--------|---------|
| Age (Years) | | | | | | |
| 30-50 | 91.46% | 90.91% | 92.59% | 89.55% | 91.22% | <0.001 |
| 51-70 | 90.48% | 83.10% | 82.61% | 93.10% | 88.46% | <0.001 |
| Duration of Disease | | | | | | |
| ≤6 months | 91.14% | 88.46% | 88.89% | 90.79% | 89.81% | <0.001 |
| >6 months | 91.67% | 94.74% | 95.65% | 90.00% | 93.02% | <0.001 |
| Size of Lesion (cm) | | | | | | |
| <3 | 93.26% | 88.57% | 91.21% | 91.18% | 91.19% | <0.001 |
| >3 | 78.57% | 92.59% | 84.62% | 89.29% | 87.80% | <0.001 |
| Menopausal Status | | | | | | |
| Pre-menopausal | 90.41% | 86.76% | 88.0% | 89.39% | 88.65% | <0.001 |
| Post-menopausal | 93.33% | 96.55% | 96.55% | 93.33% | 94.92% | <0.001 |

*Chi-square test was applied

DISCUSSION

New advanced MRI techniques allow improved analysis of tumour biology and the tumour microenvironment. They can improve TNM staging and show promise for tumour

| | |
|--------------------------|--------------|
| < 3 cm | 159 (79.50%) |
| > 3 cm | 41 (20.50%) |
| Menopausal Status | |
| Premenopausal | 159 (79.50%) |
| Postmenopausal | 41 (20.50%) |

In MRI positive patients, 94 True Positive (TP), 10 False Positive (FP), 09 False Negative (FN) whereas were 87 True Negative (TN). Overall sensitivity, specificity, PPV, NPV and diagnostic accuracy of MRI in detecting stromal invasion in early cervical cancer patients, taking histopathology as gold standard was 91.26%, 89.70%, 90.38%, 90.63% and 90.50% respectively, Table 3.

Table 3: Diagnostic accuracy of MRI taking Histopathology as Gold Standard

| Variables | Category | Histopathology | |
|-----------|----------|----------------|----------|
| | | Positive | Negative |
| MRI | Positive | 94 (TP) | 10 (FP) |
| | Negative | 09 (FN) | 87 (TN) |

Sensitivity: 91.26%, Specificity: 89.70%, PPV: 90.38%, NPV: 90.63%, Diagnostic Accuracy: 90.50%

It was also stratified data for age, duration of disease, size of lesion and marital status to check the impact of these effect modifiers on accuracy of MRI. It was observed that in females with young age, overall accuracy of MRI was high (91.22%) as compared to older females (88.5%). Similarly, in females with symptoms <6 months, accuracy of MRI was less (89.8%) as compared to females with symptoms >6 months (93.02%). In females with lesion size <3cm, accuracy of MRI was 91.2% than >3 cm lesion size (87.8%) and more accuracy was achieved in post-menopausal females (94.9%) than pre-menopausal females (88.65%), (Table 4).

classification and for assessing the risk of tumour recurrence. They may be helpful for developing optimised and personalised therapy for patients with cervical cancer

[13]. MRI plays a key role in preoperative staging and the evaluation of treatment responses of patients affected by cervical cancer. This is due to the ability to identify the involvement of adjacent structures such as the vagina and parametrium as well as lymph nodes. In those patients eligible for neoadjuvant treatment, the assessment of treatment response could help to plan a proper strategy to improve survival outcomes while minimizing side effects [14]. The findings of this study affirm the pivotal role of MRI as a non-invasive and highly effective imaging modality in diagnosing and staging early-stage cervical cancer. MRI's excellent soft tissue resolution and ability to accurately determine tumor size, position, and extent of invasion have been well-documented in recent literature. In this study, MRI demonstrated a sensitivity of 91.26%, specificity of 89.70%, PPV of 90.38%, NPV of 90.63%, and diagnostic accuracy of 90.50% in detecting stromal invasion, with histopathology serving as the gold standard. Thus, the chances of false positive (8.7%) and false negative findings (10.3%) were very low. MRI is an accurate technique for evaluating bladder or rectum involvement, with a sensitivity of 71 - 100% and specificity of 88-91% [15-17]. Amin Ml *et al.*, conducted a similar study on 20 females with pathologically proven cervical cancer and observed that MRI showed 100% sensitivity, 77.8% specificity, and 90% diagnostic accuracy. They concluded that MRI can be a reliable imaging tool to grade the cervical cancer and better treatment planning [18]. A growing body of evidence has reported that MRI could play a relevant role in the pre-operative staging of cervical cancer [19]. Data from the literature reported that MRI has an accuracy of 85-95% for the assessment of metastatic lymph nodes [20, 21]. Many retrospective studies have shown that the accuracy of MRI in the early stages of cervical cancer is higher than the advanced stages [22]. In a meta-analysis published in 2020 by Woo S *et al.*, the pooled sensitivity and specificity of five studies using MRI in bladder wall infiltration assessment were 84 and 95%, respectively [12].

This study was limited by its single-center design, non-probability consecutive sampling, and relatively short study duration, which may affect generalizability to broader populations. Additionally, potential inter-observer variability among radiologists and lack of advanced MRI techniques such as radiomics may influence diagnostic precision. Future multicenter studies with larger diverse populations, standardized MRI protocols, and incorporation of advanced imaging technologies are recommended to further validate and enhance MRI's diagnostic role in cervical cancer staging.

CONCLUSIONS

The findings of this study suggest that MRI exhibits high diagnostic accuracy in detecting stromal invasion among early-stage cervical cancer patients. Moreover, MRI

significantly enhances the capability to identify parametrial invasion in these patients, leading to improved patient care through accurate diagnosis and the implementation of appropriate pre-operative management protocols for cervical carcinoma. Consequently, we advocate for the primary utilization of MRI as the imaging modality of choice for precise detection of parametrial invasion in cervical cancer patients, aiming to mitigate morbidity and mortality associated with the condition.

Authors' Contribution

Conceptualization: NA

Methodology: NA

Formal analysis: NA, MM, AG, AAB, AM, AL

Writing and Drafting: MM, AG, AM, AL

Review and Editing: MM, AG, AM, AL

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

All the authors declare no conflict of interest.

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