DOI: https://doi.org/10.54393/pjhs.v6i4.2113

PAKISTAN JOURNAL OF HEALTH SCIENCES
(LAHORE)
https://thejas.com.pk/index.php/pjhs
ISSN (E): 2790-9352, (P): 2790-9344
Volume 6, Issue 04 (April 2025)

Original Article

OPEN ACCESS

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

Nosheen Ahmad[1*], Maryum Mukhtar[2], Aamna Gilani[2], Adeela Abid Bukhari[3], Amber Manzoor[4] and Ayesha Liaqat[2]

[1]Faisalabad Medical University, Faisalabad, Pakistan
[2]Madina Teaching Hospital, Faisalabad, Pakistan
[3]Department of Radiology, Shifa International Hospital, Faisalabad, Pakistan
[4]Department of Radiology, Mujahid Hospital, Faisalabad, Pakistan

ARTICLE INFO

Keywords:
Cervical Cancer, Magnetic Resonance Imaging, Stromal Invasion, Histopathology, Diagnostic Accuracy

How to Cite:
Ahmad, N., Mukhtar, M., Gilani, A., Bukhari, A. A., Manzoor, A., & Liaqat, A. (2025). Diagnostic Accuracy of MRI in Detecting Stromal Invasion in Early Cervical Cancer Patients Taking Histopathology as Gold Standard: Detecting Stromal Invasion in Cervical Cancer. Pakistan Journal of Health Sciences, 6(4), 53-57. https://doi.org/10.54393/pjhs.v6i4.2113

***Corresponding Author:**
Nosheen Ahmad
Faisalabad Medical University, Faisalabad, Pakistan
drnosheenahmad@hotmail.com

Received date: 27th September, 2024
Revised date: 3rd April, 2025
Acceptance date: 11th April, 2025
Published date 30th April, 2025

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-

DOI: https://doi.org/10.54393/pjhs.v6i4.2113

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].

METHODS

This study 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) andoverall 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)	(FP)	TP+FP
	Negative	(FN)	(TN)	TN+FN
Total		TP+FN	TN+FP	N

DOI: https://doi.org/10.54393/pjhs.v6i4.2113

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 ± 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
< 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).

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%	0.000
51-70	90.48%	93.10%	87.10%	93.10%	88.46%	0.000
Duration of Disease						
≤6 months	91.14%	88.46%	88.89%	90.79%	89.81%	0.000
>6 months	91.67%	94.74%	95.65%	90.00%	93.02%	0.000
Size of Lesion (cm)						
<3	93.26%	88.57%	91.21%	91.18%	91.19%	0.000
>3	78.57%	92.59%	84.62%	89.29%	87.80%	0.000
Menopausal Status						
Pre-menopausal	90.41%	86.76%	88.0%	89.39%	88.65%	0.000
Post-menopausal	93.33%	96.55%	96.55%	93.33%	94.92%	0.000

* 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 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

DOI: https://doi.org/10.54393/pjhs.v6i4.2113

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 MI 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].

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, review and editing: MM, AG, AM, AL
All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

Source of Funding

The author received no financial support for the research, authorship and/or publication of this article.

REFERENCES

[1] Balcacer P, Shergill A, Litkouhi B. MRI of cervical cancer with a surgical perspective:staging, prognostic implications and pitfalls.Abdominal Radiology.2019Jul;44:2557-71.doi:10.1007/s00261-019-01984-7.
[2] Chikaraddi AK, Kanakaraddi S, Kalwad P, Kadole A, Budni S. Cervical Cancer Diagnostics Using Machine Learning Algorithms. In2024 5th International Conference for Emerging Technology (INCET).2024 May:1-6. doi: 10.1109/INCET61516.2024.10593538.
[3] Avesani G, Perazzolo A, Amerighi A, Celli V, Panico C, Sala E *et al.* The Utility of Contrast-Enhanced Magnetic Resonance Imaging in Uterine Cervical Cancer:A Systematic Review.Life.2023Jun;13(6):1368.doi:10.3390/life13061368.
[4] Smith GE and Gormly KL. Magnetic resonance imaging in the staging of cervical carcinoma: a pictorial review. Journal of Medical Imaging and Radiation Oncology. 2008Oct;52(5):427-33.doi:10.1111/j.1440-1673.2008.01999.x.
[5] Chen J, Kitzing YX, Lo G. Systematic Review-Role of MRI in Cervical Cancer Staging. Cancers.2024May;16(11):1983. doi: 10.3390/cancers16111983.
[6] Bi Q, Bi G, Wang J, Zhang J, Li H, Gong X *et al.* Diagnostic accuracy of MRI for detecting cervical invasion in patients with endometrial carcinoma: a meta-analysis. Journal of Cancer.2021Jan;12(3):754.doi:10.7150/jca.52797.
[7] Wu LM, Xu JR, Gu HY, Hua J, Haacke EM, Hu J. Predictive value of T2-weighted imaging and contrast-enhanced MR imaging in assessing myometrial invasion in endometrial cancer: a pooled analysis of prospective studies. European Radiology.2013Feb;23: 435-49. doi: 10.1007/s00330-012-2609-9.
[8] Xiao M, Yan B, Li Y, Lu J, Qiang J. Diagnostic performance of MR imaging in evaluating prognostic factors in patients with cervical cancer:a meta-analysis.European Radiology.2020Mar;30:1405-18.doi:10.1007/s00330-019-06461-9.
[9] Lin G, Huang YT, Chao A, Lin YC, Yang LY, Wu RC *et al.* Endometrial cancer with cervical stromal invasion: diagnostic accuracy of diffusion-weighted and dynamic contrast enhanced MR imaging at 3T. European Radiology.2017May;27:1867-76.doi:10.1007/s00330-016-4583-0.
[10] Ren J, Li Y, Yang JJ, Zhao J, Xiang Y, Xia C *et al.* MRI-based radiomics analysis improves preoperative diagnostic performance for the depth of stromal invasion in patients with early stage cervical cancer. Insights into Imaging.2022 Jan; 13(1): 17. doi: 10.1186/

DOI: https://doi.org/10.54393/pjhs.v6i4.2113

s13244-022-01156-0.
[11] Shi J, Dong Y, Jiang W, Qin F, Wang X, Cui L *et al.* MRI-based peritumoral radiomics analysis for preoperative prediction of lymph node metastasis in early-stage cervical cancer: a multi-center study.Magnetic Resonance Imaging.2022May;88:1-8.doi:10.1016/j.mri.2021.12.008.
[12] Woo S, Atun R, Ward ZJ, Scott AM, Hricak H, Vargas HA. Diagnostic performance of conventional and advanced imaging modalities for assessing newly diagnosed cervical cancer:systematic review and meta-analysis.European Radiology.2020Oct;30:5560-77. doi: 10.1007/s00330-020-06909-3.
[13] Dappa E, Elger T, Hasenburg A, Düber C, Battista MJ, Hötker AM. The value of advanced MRI techniques in the assessment of cervical cancer: a review.Insights into Imaging.2017Oct;8:471-81.doi:10.1007/s13244-017-0567-0.
[14] Ditto A, Leone Roberti Maggiore U, Evangelisti G, Bogani G, Chiappa V, Martinelli F *et al.* Diagnostic Accuracy of Magnetic Resonance Imaging in the Pre-Operative Staging of Cervical Cancer Patients Who Underwent Neoadjuvant Treatment:A Clinical-Surgical-Pathologic Comparison.Cancers.2023Mar;15(7):2061.doi:10.3390/cancers15072061.
[15] Sala E, Rockall AG, Freeman SJ, Mitchell DG, Reinhold C. The added role of MR imaging in treatment stratification of patients with gynecologic malignancies: what the radiologist needs to know. Radiology.2013Mar;266(3):717-40.doi:10.1148/radiol.12120315.
[16] Patel-Lippmann K, Robbins JB, Barroilhet L, Anderson B, Sadowski EA, Boyum J. MR imaging of cervical cancer.Magnetic Resonance Imaging Clinics.2017Aug;25(3):635-49.doi:10.1016/j.mric.2017.03.007.
[17] Balleyguier C, Sala E, Da Cunha T, Bergman A, Brkljacic B, Danza F *et al.* Staging of uterine cervical cancer with MRI: guidelines of the European Society of Urogenital Radiology.European radiology.2011May;21:1102-10.doi: 10.1007/s00330-010-1998-x.
[18] Amin MI, Amin AE, Badr SE, Ebaid NY. 1H magnetic resonance spectroscopy in the differentiation between low-and high-grade cervical carcinoma: is it efficient?.Polish Journal of Radiology.2024Aug;89:e378.doi:10.5114/pjr/190840.
[19] Lu H, Wu Y, Liu X, Huang H, Jiang H, Zhu C *et al.* The role of dynamic contrast-enhanced magnetic resonance imaging in predicting treatment response for cervical cancer treated with concurrent chemoradiotherapy. Cancer Management and Research.2021Aug:6065-78.doi:10.2147/CMAR.S314289.
[20] de Boer P, Adam JA, Buist MR, van de Vijver MJ, Rasch CR, Stoker J *et al.* Role of MRI in detecting involvement of the uterine internal os in uterine cervical cancer: systematic review of diagnostic test accuracy. European Journal of Radiology.2013 Sep;82(9):e422-8. doi: 10.1016/j.ejrad.2013.04.027.
[21] 21. Hricak H, Gatsonis C, Chi DS, Amendola MA, Brandt K, Schwartz LH *et al.* Role of imaging in pretreatment evaluation of early invasive cervical cancer: results of the intergroup study American College of Radiology Imaging Network 6651-Gynecologic Oncology Group 183.Journal of Clinical Oncology.2005Dec;23(36):9329-37.doi:10.1200/JCO.2005.02.0354.
[22] Charles-Edwards E, Morgan V, Attygalle AD, Giles SL, Ind TE, Davis M *et al.* Endovaginal magnetic resonance imaging of stage 1A/1B cervical cancer with A T2-and diffusion-weighted magnetic resonance technique: effect of lesion size and previous cone biopsy on tumor detectability.Gynecologic Oncology.2011Mar;120(3):368-73.doi:10.1016/j.ygyno.2010.10.013.