Section: Radiodiagnosis

Original Research Article

DIAGNOSTIC ACCURACY OF MAGNETIC RESONANCE IMAGING IN STAGING OF CARCINOMA RECTUM

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Abstract

Background: This study is aimed to assess the accuracy of MRI in the T-category staging of rectal carcinoma .MRI accuracy was assessed using histopathology. **Materials and Methods:** This diagnostic study included 50 patients who were referred for preoperative MRI. Surgery was performed 2–4 weeks after imaging. MRI accuracy was assessed using histopathology. Imaging was performed using a 1.5T SIEMENS MAGNETOM AVANTO scanner, rectal gel for tumour visualisation, and butyl scopolamine to minimise motion artefacts. Optimal coil placement was ensured for tumour localisation. **Result:** Renal carcinoma was common in patients aged 51–70 years, with a male predominance. Most tumours (66%) were in the middle third. In 16% of patients, anal complex involvement, and 86% of patients reported perirectal tumour deposits; 34% were histopathologically CRM positive, and 8% (4 cases) had EMVI. MRI and histopathology showed variations in T and N staging, with MRI overestimating T2 and N1 stages. MRI showed perfect agreement with histopathology for CRM and EMVI (κ=1.00, $p<0.001$) and 100% diagnostic accuracy. MRI T staging showed almost perfect agreement (κ=0.895, $p<0.001$), whereas N staging showed substantial agreement (κ=0.655, $p<0.001$). **Conclusion:** MRI is highly accurate for preoperative rectal cancer staging, with T2W imaging providing the best anatomical details. High-resolution MRI can predict CRM and EMVI, whereas DWI can aid in node assessment.

INTRODUCTION

Magnetic Resonance Imaging (MRI) is a non-radiation imaging modality. The role of MRI in the diagnosis and staging of carcinomas of various organs has increased in recent years. MRI in carcinoma of the rectum was investigated first in 1999, Since then, High-Resolution pelvic MRI has been the primary method for evaluation in rectal cancer.[1,2] High-resolution rectal MRI also plays an important role in evaluating rectal cancer patients to plan management. This is because the paradigm for supplementary treatment to surgery for rectal cancer has shifted from adjuvant to neoadjuvant therapy.[3,4] Neoadjuvant radiation therapy decreases the risk of local recurrence of the tumour and may increase patient survival following rectal cancer surgery.[5,6] New pelvic phased-array multichannel coils provide high spatial resolution, high SNR, and larger FOV imaging for visualisation of the lateral pelvic structures and lymph nodes.[7]

Advances in imaging have helped identify tumours with a poor prognosis that require more intensive treatment. The first advance in the treatment of carcinoma of the rectum was the introduction of the Total Meso Rectal Excision (TME), in which the rectum, along with the entire mesorectal fat containing perirectal lymph nodes, limited by a thin fascial envelope called the Meso Rectal Fascia (MRF) is removed.[8] MRI has been an excellent diagnostic tool for predicting the Circumferential Resection Margin (CRM) as well as MRF invasion in primary rectal cancer.[9,10]

MRI also helps assess resectability after preoperative chemotherapy–radiotherapy (CT-RT) and helps decide between sphincter-saving or more radical surgery. An accurate technique is important for obtaining high-resolution images in the appropriate planes for correct staging. The phased-array external coil has recently replaced the endorectal coil. Non-fat-suppressed 2D T2-Weighted (T2W) sequences in orthogonal planes to the tumour play a major role in primary staging. The diffusion-weighted sequence may be valuable for restaging. Multidetector CT cannot replace MRI in local staging but plays a crucial role in evaluating distant metastases. Positron

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Emission Tomography-Computed Tomography (PET/CT) has no role in the initial staging of rectal cancer and is reserved for cases with resectable metastatic disease before surgery.

Aim

This study aimed to evaluate the accuracy of MRI in correctly classifying the T-category staging of rectal carcinoma based on postoperative findings.

MATERIALS AND METHODS

This diagnostic study was conducted on 50 patients in the Department of Radiology, Kanyakumari Medical College, Asaripallam, between January 2021 and November 2023, for preoperative MR evaluation. The Institutional Ethics Committee approved the study before initiation, and informed consent was obtained from all patients.

Inclusion Criteria

Patients with complaints of constipation, haematochezia, and altered bowel habits with suspicion of rectal carcinoma, planned for surgery, and diagnosed with rectal carcinoma, following which they underwent NARCT were included.

Exclusion Criteria

Patients with claustrophobia, generalised contraindications to MRI (e.g. orthopaedic implants, pacemakers), unavailable histopathology reports, death before surgery, non-consenting patients, and those not eligible for surgery were excluded.

Methods

Some patients with locally advanced carcinoma underwent NACRT for downstaging, and MRI was taken 4-6 weeks later. Surgery was performed within 2-4 weeks of MR. Preoperative MR results of 50 patients were compared with histopathology results, and the accuracy of MR was assessed. Rectal gel (ultrasound gel) helps visualise the intraluminal component of the tumour, and a spasmolytic agent (butyl scopolamine) is routinely administered at a dose of 40 mg to prevent artefacts caused by peristalsis of the small bowel. The agent has a short half-life when administered intravenously and is therefore injected intramuscularly immediately before placing the patient on the MR imaging table.11

The patient was positioned supine, and a phased-array surface coil was placed on the pelvis such that the lower edge of the coil lay below the pubic bone. For low rectal tumours, the lower edge must lie at least 10 cm below the symphysis pubis, and the upper edge should not be higher than the sacral promontory.[11] Therefore, the referring surgeon must accurately communicate the tumour position (low, mid-, or high rectal) for appropriate coil placement and planning of the sequences. The main pulse sequence was a thin section (3-mm).[12] Our MRI Equipment SIEMENS MAGNETOM AVANTO 1.5 Tesla whole-body MRI scanner.

Statistical Analysis: Data are presented as frequencies and percentages. Cohen's Kappa coefficient was used to measure inter-rater reliability. Significance was defined by P values less than 0.05 using a two-tailed test. Data analysis was performed using IBM SPSS version 22.0.

RESULTS

The incidence of carcinoma was higher in the age group 51-70 years. The youngest patient was 40 years old, and the oldest was 86 years old. Males (52%) were predominant compared to females (48%). Most patients had tumours in the middle third (5–10 cm), accounting for 66% of the total study patients [Table 1].

Table 1: Patient demographics and tumour location.

		N (%)
Age (in years)	≤50	9(18%)
	51-60	15(30%)
	61-70	15(30%)
	71-80	8(16%)
	>80	3(6%)
Sex	Male	26(52%)
	Female	24(48%)
Tumour location in the rectum (Distance from the anal verge)	Distal (0-5 cm)	12(24%)
	Middle (5-10 cm)	33(66%)
	Proximal (10-15 cm)	5(10%)

Regarding the involvement of the anal complex, eight (16%) patients had anal complex involvement, and perirectal tumour deposits in the form of direct infiltration of tumour/nodes/vascular invasion were noted in 43 patients, and 86% of the patients in the study population had perirectal tumour deposits [Table 2].

Table 2: Distribution of anal complex involvement and perirectal tumour deposits

		N (%)
Anal complex involvement status	Absent	42(84%)
	Present	8(16%)
Perirectal tumour deposit	Absent	7(14%)
	Present	43(86%)

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Of these patients, 17 were histopathologically CRM-positive, and 34% were CRM-positive. Only 4 (8%) patients had extramural vascular invasion. The number of patients with the following T staging categories T0, T1, T2, T3, and T4 in MRI were 4, 14, 13, 7, and 12. The number of patients with the following T staging categories T0, T1, T2, T3, and T4 in histopathology were 4, 14, 17, 3, and 12. On MR imaging, a greater number of patients were in N1 staging, followed by N0 and N2 staging. Pathologically, most patients were of N0 staging, followed by N1 and N2 staging [Table 3].

Table 3: Comparison of MRI and histopathology findings in tumour staging and prognostic markers

		N (%)	
		MRI	**Histopathology**
Circumferential Resection Margin	Positive	17(34%)	17(34%)
	Negative	33(66%)	33(66%)
Occurrence of EMVI	Positive	4(8%)	4(8%)
	Negative	46(92%)	46(92%)
T staging	T0	4(8%)	4(8%)
	T1	14(28%)	14(28%)
	T2	13(26%)	17(34%)
	T3	7(14%)	3(6%)
	T4	12(24%)	12(24%)
N staging	No	17(34%)	28(56%)
	N1	25(50%)	15(30%)
	N2	8(16%)	7(14%)

All patients with MRI-CRM positivity were histopathologically positive. Similarly, MRI-CRM-negative patients were histopathologically negative for CRM. Hence, the Measure of agreement κ=1.00 with significant differences ($p<0.001$). This suggests almost perfect agreement, and the study is highly significant.

MRI EMVI-positive patients were histopathologically confirmed; hence, the diagnostic accuracy of MRI was 100. The Measure of agreement κ=1.00 with significant differences ($p<0.001$). This suggests almost perfect agreement, and the study is highly significant.

The Measure of Agreement Kappa for MRI T staging was 0.895, with significant differences ($p<0.001$). Hence, the inference is that the Kappa agreement is almost perfect and the MRI accuracy of T staging is highly significant.

The Measure of Agreement Kappa for MRI N staging in comparison with histopathology was 0.655 with significant differences ($p<0.001$). Hence, the level of agreement in MRI N staging was substantial [Table 4].

Table 4: Diagnostic accuracy of MRI

		Diagnostic accuracy					P value
		Sensitivity	**Specificity**	**PPV**	**NPV**	**Accuracy**	
CRM		100	100	100	100	100	<0.001
EMVI		100	100	100	100	100	<0.001
T staging	T0	100	100	100	100	100	<0.001
	T1	100	100	100	100	100	
	T2	76.5	100	100	89.2	92	
	T3	100	91.5	42.9	100	92	
	T4	100	100	100	100	100	
N staging	N0	60.7	100	100	66.7	78	<0.001
	N1	100	71.4	60	100	80	
	N2	100	97	87.5	100	98	

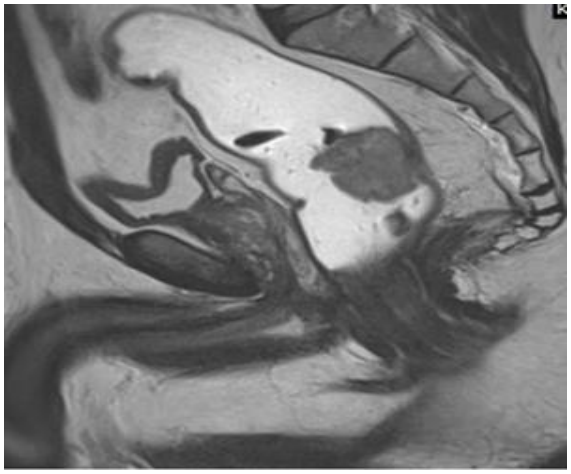

Figure 1: MRI T2W sagittal images showing a polypoidal morphology in T1 staging

MRI T2W sagittal images demonstrated a polypoidal morphology characteristic of T1 staging [Figure 1]. Semi-annular morphology was commonly observed in T and N staging using MRI T2W axial images [Figure 2]. Among the patients, 22 presented with semi-annular growth, as seen in sagittal MRI T2W images (Figure 3). MRI T2W coronal sequences also confirmed semi-annular tumour morphology [Figure 4]. Circumferential tumour involvement was observed in MRI T2W coronal images [Figure 5].

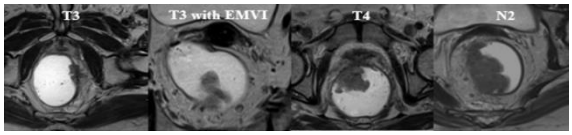

Figure 2: MRI T2W axial images of semi-annular morphology in T and N staging

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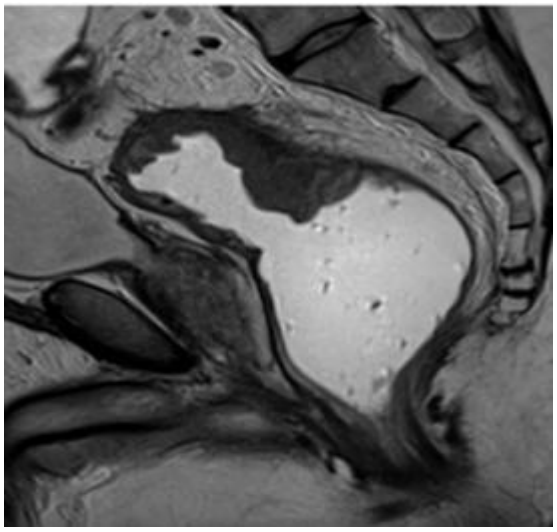

Figure 3: MRI T2W sagittal images showing a semi-annular morphology

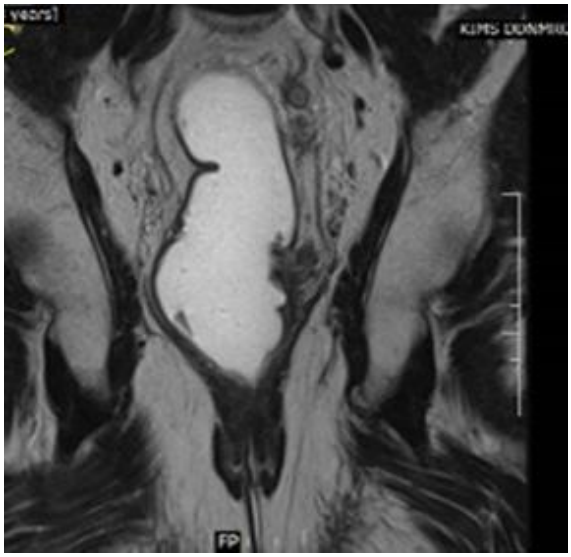

Figure 4: MRI T2W coronal images showing a semi-annular morphology

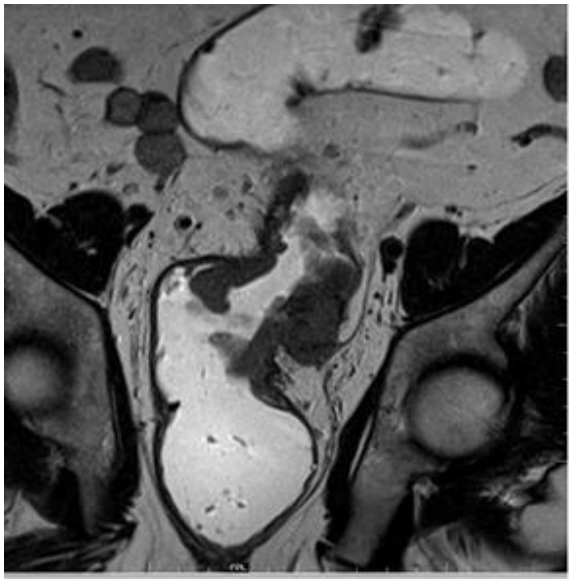

Figure 5: MRI T2W coronal images showing a circumferential morphology

DISCUSSION

In our study, the highest incidence was in the 51-70 age group with a mean age of 61.6 years, and male predominance, consistent with global cancer statistics by Haggar and Boushey, reported there was a slight increase in incidence in males and the incidence was rising sharply after age 50.[13]

In our study, the tumour was mostly located in the middle third of the rectum, followed by the distal and proximal thirds. Of the 12 cases in the distal third, eight showed anal involvement. Among them, 22 presented with semi-annular growth, 20 with circumferential growth, and 4 with polypoidal intraluminal growth patterns. Four patients with locally advanced carcinoma showed complete tumour response to NACRT, classified as T0 (profound hypointense signal with no irregular wall thickening on T2WI). Perirectal tumour deposits were found in 84% of cases on MRI, corroborated by histopathological findings.

The MERCURY trial by Patel et al. identified positive CRM as the most reliable prognostic factor for five-year survival, surpassing the T and N stages.[14] A retrospective study by Brown et al. showed a 100% accuracy rate for invasion depth assessment using a 1.5-T MRI with a phased-array coil.[15] A study by Kennedy et al. in 98 patients undergoing TME, MRI assessment of T and N staging, extramural tumour spread, threatened CRM, extramural venous invasion (EMVI), and serosal involvement showed a weighted agreement of 94% with histopathology. Ten patients were under staged, and 13 were overstaged.[15]

Our study demonstrated better agreement, achieving a 100% correlation between MRI and histopathology for the CRM. CRM was positive in 34% and negative in 66% of cases, with MRI showing 100% sensitivity, specificity, positive and negative predictive values, and accuracy. The high accuracy can be attributed to the consideration of anatomical variations in the peritoneal reflection. CRM positivity was determined based on direct tumour infiltration, metastatic node proximity (<1 mm), or EMVI proximity (<1 mm) to the mesorectal fascia. The measure of agreement Kappa was 1.00 ($p<0.001$), indicating perfect agreement and high significance. Lee et al. studied 200 patients and reported MR-EMVI sensitivity and specificity of 76.19% and 79.75%, respectively (AUC: 0.830). MR-EMVI was the only significant MRI factor in DFS ($p = 0.027$), with mean DFS being 57.56 months in MR-EMVI (+) patients versus 72.46 months in yMR-EMVI (-) patients.[16]

In our study, EMVI was positive in four cases and negative in 46. The MRI criterion for EMVI was an intermediate T2 signal intensity in extramural vessels contiguous to the tumour. When correlated with histopathology, MRI had 100% sensitivity, specificity, and accuracy. The measure of agreement Kappa was 1.00 ($p<0.001$), indicating almost perfect agreement. Suzuki et al. studied 37 patients with

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locally advanced disease and divided them into compliant and non-compliant imaging protocol groups. Compliant imaging (T2W sagittal, axial, and coronal sequences for low rectal tumours) showed a better correlation with histopathology in assessing anterior organ involvement (sensitivity 86%, specificity 94%) compared to non-compliant imaging (sensitivity 50%, specificity 33%).[17]

Our study also used T2W imaging for local tumour staging, correlating MRI T staging with histopathology. Among these, T2 is the most common. Comparison with histopathology showed that the T0, T1, and T4 stages had 100% accuracy. T2 had a sensitivity of 76.5%, specificity of 100%, and accuracy of 92%. T3 had 100% sensitivity, 91.5% specificity and 92% accuracy. Most discrepancies were observed between T2 and T3 due to fibrotic and desmoplastic changes mimicking extramural spread. The Kappa measure of agreement was 0.895 ($p<0.001$), indicating almost perfect agreement.

Monaghan et al. reported that approximately 8% of the population showed a complete NACRT response with no viable tumours on histopathology. MRI findings of profound hypointense signal with no irregular thickening on T2W and no DWI restriction correlated with 100% accuracy for detecting complete tumour response.[18] Brown et al. found size to be a poor predictor of nodal status. Nodes defined by irregular borders or mixed signal intensity had 85% sensitivity and 97% specificity.[15] Kim et al. studied 30 patients post-chemoradiation and compared T2W-MRI and DWI for nodal assessment. The addition of DWI did not improve accuracy, as T2W-MRI alone was sufficiently accurate.[19]

Limitations: The main limitation of our study is the sample size of 50 which represents a small patient population. Some patients diagnosed with rectal carcinoma during the study period did not undergo surgery due to advanced disease state. Therefore, they were not included in this study. A small degree of suspicion should be considered whether the node reported to have a nodal deposit was the node reported to be positive in histopathology. For a few patients, there was a time gap of up to one month between MRI staging and surgery. This delay was due to the patient's decision-making. This delay could have caused some disagreement between the MRI N staging and histopathology N staging.

CONCLUSION

MRI is an accurate imaging modality for the preoperative staging of rectal carcinoma. In the local staging of rectal carcinoma, MR imaging has a high contrast resolution that allows for the distinction of even small interruptions of the muscularis propria and the relationship of neoplastic tissue with the pelvic anatomical structures. The highest diagnostic performance was achieved using T2W imaging. T2W imaging provides good anatomical and morphological information about tumours.

The increased accuracy of predicting CRM by high-resolution MRI has made MR Imaging mandatory in cases of rectal carcinoma before surgery. The increased detection of extramural vascular invasion by HR-MRI plays a role in predicting relapse-free survival rates. Contrast-enhanced MRI did not provide any additional information. In addition, the size criterion does not play a role in assessing metastatic nodes. The inclusion of morphology and irregular margins as criteria added more value to the assessment of nodal status. DWI has no role in predicting the morphology of nodes; however, it plays an important role in assessing the number of nodes.

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