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Original Research Article

ROLE OF MRI IN ASSESSMENT OF RECTAL CARCINIOMA POST NEOADJUVANT CHEMORADIOTHERAPHY WITH HISTOPATHOLOGY CORRELATION

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ABSTRACT

Background: Neoadjuvant chemoradiotherapy (nCRT) has become a cornerstone in the management of locally advanced rectal carcinoma. Accurate assessment of tumor response following nCRT is essential for guiding surgical decisions and identifying candidates for organ-preserving strategies. MRI, particularly diffusion-weighted imaging (DWI), offers a non-invasive tool to evaluate post-treatment changes. **Aim:** To evaluate the diagnostic accuracy of MRI, with a focus on diffusion-weighted imaging (DWI), in assessing tumor response in rectal carcinoma patients following nCRT, and to correlate imaging findings with histopathological tumor regression grading (pTRG).

Materials and Methods: This retrospective cohort study included 50 patients with histologically proven rectal adenocarcinoma who underwent nCRT followed by MRI (including DWI) and surgical resection. Tumor location, histological grade, and MRI-based tumor regression grading (mrTRG) were documented. ADC values were calculated from DWI and correlated with histopathological tumor regression grading (pTRG).

Results: Among 50 patients (31 males, 19 females; age range 21–73 years), complete MRI response (mrTRG 1) was observed in 13 (26%) patients, partial response (mrTRG 2–3) in 19 (38%), and poor response (mrTRG 4–5) in 18 (36%). Corresponding pathological response (TRG 0) was found in 12 patients (24%). Mean ADC values showed significant differences between responders (1.46×10^{-3} mm²/s) and non-responders (0.87×10^{-3} mm²/s) ($p < 0.001$). MRI-DWI achieved 88.3% sensitivity, 92.0% specificity, and 90% overall diagnostic accuracy in predicting pathological response.

Conclusion: MRI, especially with diffusion-weighted sequences, plays a pivotal role in the post-CRT assessment of rectal carcinoma. It demonstrates high diagnostic accuracy and strong correlation with histopathological outcomes, supporting its use as a reliable tool for evaluating treatment response and guiding individualized management.

Keywords: Rectal carcinoma, MRI, diffusion-weighted imaging (DWI), tumor regression grade, neoadjuvant chemoradiotherapy, ADC values, histopathology.

INTRODUCTION

Colorectal cancer is one of the most prevalent malignancies worldwide, with rectal carcinoma accounting for a significant proportion of cases. The management of locally advanced rectal cancer (LARC) has evolved considerably over the past two decades, with neoadjuvant chemoradiotherapy

(nCRT) becoming the standard preoperative treatment for reducing tumor size, improving resectability, and minimizing the risk of local recurrence.[1,2]

Accurate assessment of tumor response following nCRT is essential for optimal surgical planning and prognostication. In this context, magnetic resonance imaging (MRI) has emerged as a critical imaging modality due to its high soft-tissue resolution and ability to provide detailed anatomical information about the rectal wall and surrounding mesorectal tissues. Post-treatment MRI plays a vital role in evaluating tumor regression, nodal involvement, circumferential resection margin (CRM) status, and extramural vascular invasion (EMVI), which are crucial parameters in deciding whether a patient might benefit from surgery, organ-preserving strategies, or further oncologic treatment.[3,4]

Despite its strengths, MRI interpretation after chemoradiotherapy can be challenging due to treatment-induced changes such as fibrosis and edema, which can obscure residual tumor tissue. Therefore, correlation with histopathological findings post-surgery remains the gold standard for validating MRI accuracy and reliability. MRI is first choice for local staging of rectal cancer and in predicting tumor response. Pelvic MRI has an important role in the therapeutic management of rectal cancer, particularly for the determination of the circumferential resection margin (CRM), evaluation of sphincter invasion, and assessment of the extramural vascular invasion. Post-chemoradiotherapy (CRT) staging aims at assessing treatment response and choosing methods for further treatment such as surgical resection or extended CRT.[5,6] MRI with diffusion restriction is a non-invasive and useful tool for assessing the treatment response of locally advanced rectal cancer. This study aims to determine the role of diffusion-weighted imaging (DWI) in the evaluation of post-treatment tumor response in rectal carcinoma.

MATERIALS AND METHODS

A retrospective cohort study was conducted among 50 patients who underwent MRI between May 2024 and April 31, 2025 in the Department of Radiology, MNJ Institute of Oncology and Regional Cancer Centre, Hyderabad.

Inclusion Criteria: patients with histopathologically proven rectal adenocarcinoma, those who underwent abdominoperineal resection (APR) before August 2024 at our hospital and those who underwent MRI including DWI/apparent diffusion coefficient (ADC) imaging before and after CRT.

Exclusion Criteria: Patients with recurrent rectal cancer, Contraindications to MRI (e.g., pacemakers, metallic implants), Incomplete therapy or loss to follow-up, Poor image quality or artifacts precluding interpretation.

Patients who had undergone upfront surgery without neoadjuvant CRT and those who did not have MRI with DWI/ADC were excluded from the study.

Subsequently, 50 patients who fulfilled the inclusion criteria were included in the study.

MRI technique

All selected patients had undergone MRI pelvis without contrast as baseline workup and after CRT. All pre- and post-CRT imaging were performed on a 1.5 Tesla MRI.No bowel preparation or laxatives or antispasmodics were given. The MRI protocol included the multiparametric MRI sequences with DWI/ADC. A T2-weighted fast spin-echo sequence, a T1-weighted spin-echo sequence, and an oblique axial DWI sequence were acquired. Routine axial, sagittal, and coronal images were also obtained. We used b factor of 0 and 1000 sec/mm^2 to obtain high b-value DWI images. The total examination time was approximately 30 minutes. The average interval between post-CRT MRI and surgery was eight weeks (range: 1-12 weeks). On the pre-treatment MRI scan, the tumor stage, T2 tumor signals, and diffusion restriction were identified. Tumor response was determined according to the Response Evaluation Criteria in Solid Tumours (RECIST) guidelines.

Complete response (CR) was predefined as the disappearance of measurable tumor volume.

The absence of residual disease was also defined as CR. The absence of tumor signals on T2 and DWI was also defined as CR or no residual disease. Partial response (PR) was defined as a 30% reduction in the tumor's longest dimension. Progressive disease (PD) was defined as a 20% increase in the longest dimension. Stable disease was predefined as no response that failed to meet the criteria of CR, PR, and PD

Histopathological Correlation

Post-operative specimens were assessed for pathological tumor regression, lymph node status, CRM involvement, and tumor staging. The radiological findings were correlated with the final histopathology reports.

Statistical Analysis

Analysis was done using SPSS Statistics, Tumor response and pathological response correlation were determined by the Chi-square test. Diagnostic accuracy, sensitivity, and specificity of MRI in determining tumor response were calculated; a 95% confidence interval was used to determine statistical precession, and p-values were calculated. The diagnostic accuracy of the DWI sequence was calculated using the receiver operating characteristic (ROC) curve analysis.

RESULTS

A total of 50 patients were included in this study, with an age range of 21-73 years; all of them underwent low APR. Of these 50 patients, 31 were males and 19 were females. The average interval between post-

CRT MRI and surgery was eight weeks (range: 1-12 weeks). The location of tumor was categorized as distal rectum and anal canal (n=20), middle rectum (n=12), proximal rectum (n=14), and whole rectum (n=4). All patients underwent pre-treatment colonoscopy-guided biopsy. On histology, 18 had moderately differentiated adenocarcinoma, 25 had well-differentiated adenocarcinoma, and 7 had poorly differentiated adenocarcinomas. Both the pre-CRT local staging based on MRI and the post-CRT pathologic staging of the cases are summarized.

A total of 50 patients with histologically confirmed rectal carcinoma were included in the study. The age range of the patients was 21 to 73 years, with a mean age of 47 years. Of these, 31 patients (62%) were males and 19 patients (38%) were females. All patients underwent low anterior resection (LAR) following neoadjuvant chemoradiotherapy (CRT). The mean interval between post-CRT MRI and surgery was 8 weeks, with a range of 1 to 12 weeks.

Table 1: Tumor Location Distribution

Tumor Location	Number of Patients	Percentage (%)
Distal Rectum / Anal Canal	20	40%
Middle Rectum	12	24%
Proximal Rectum	14	28%
Whole Rectum	4	8%

The distal rectum and anal canal were the most common sites (40%), followed by the proximal rectum (28%). The least involved was the entire rectum (8%). This distribution has clinical relevance in surgical planning and assessing prognosis, as distal tumors may be more challenging to resect with clear margins.

Table 2: Tumor Differentiation on Histopathology

Histological Grade	Number of Patients	Percentage (%)
Well-Differentiated Adenocarcinoma	25	50%
Moderately Differentiated Adenocarcinoma	18	36%
Poorly Differentiated Adenocarcinoma	7	14%

A majority (50%) of tumors were well-differentiated, meaning they resembled normal cells more closely and often indicate a better prognosis. Only 14% were poorly differentiated, which typically have more aggressive behavior and worse outcomes.

Table 3: Tumor Response on Post-CRT MRI (mrTRG)

mrTRG Grade	Response Category	Number of Patients	Percentage (%)
mrTRG 1	Complete Response	13	26%
mrTRG 2–3	Good/Partial Response	19	38%
mrTRG 4–5	Poor/No Response	18	36%

This table categorizes tumor regression as seen on post-CRT MRI using the mrTRG system. Only 13 patients (26%) showed complete response, while 38% had partial regression, and 36% showed little or no response. This highlights the variability in how rectal tumors respond to chemoradiotherapy, and the importance of MRI in evaluating treatment efficacy before surgery.

Table 4: ADC Values by Response Category

Response Group	Mean ADC ($\times 10^{-3}$ mm²/s)	Standard Deviation
Complete Responders	1.46	± 0.14
Partial Responders	1.09	± 0.11
Non-Responders	0.87	± 0.10

Statistical comparison of ADC values between groups showed significant difference ($p < 0.001$).
This table shows the average apparent diffusion coefficient (ADC) values from DWI-MRI, which help quantify tumor cellularity. Higher ADC values correlate with better response, as they suggest more necrosis and less dense tissue post-treatment. There is a statistically significant difference ($p < 0.001$), confirming ADC as a reliable non-invasive biomarker for tumor response.

Table 5: Pathological Tumor Regression (pTRG)

pTRG Grade	Response Type	Number of Patients	Percentage (%)
TRG 0	Complete Pathological Response	12	24%
TRG 1	Good Response	17	34%
TRG 2–3	Poor Response	21	42%

This table presents the gold-standard histopathological response from resected specimens. 24% achieved complete tumor regression (TRG 0), while the largest group (42%) had residual disease. These results correlate well with MRI findings and reinforce the value of MRI-DWI in preoperative planning.

Table 6: Diagnostic Performance of DWI-MRI Compared to Histopathology

Parameter	Value (%)
Sensitivity	88.3%
Specificity	92.0%
Positive Predictive Value	84.6%
Negative Predictive Value	94.1%
Overall Diagnostic Accuracy	90%

This table evaluates how accurately DWI-MRI predicts pathological response. With high sensitivity and specificity, DWI-MRI proves to be a highly effective tool for assessing residual tumor and guiding treatment decisions (e.g., organ preservation vs. surgery).

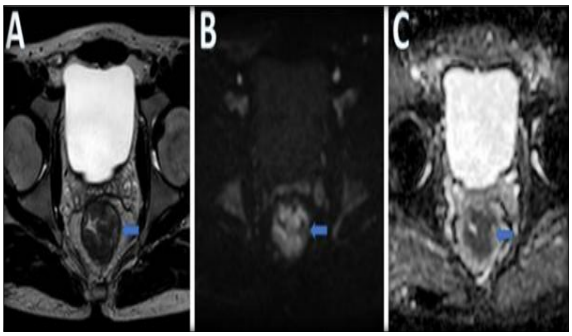

Figure 1: T2W MR axial image. B. DWI. C. ADC image of a 35-year-old man with pathologically proven moderately differentiated adenocarcinoma of the mid- and lower rectum (T3N1M0) showing circumferential tumor with diffusion restriction (blue arrows)

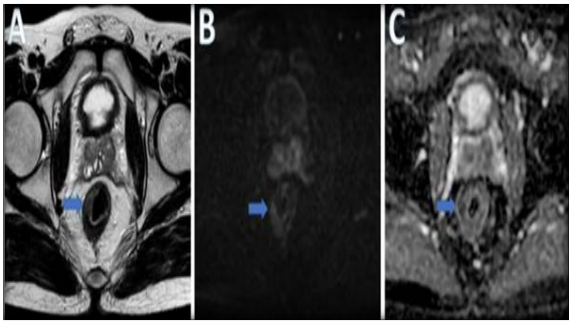

Figure 2: T2W MR axial image. B. DWI. C. ADC image of a 35-year-old man with pathologically proven moderately differentiated adenocarcinoma of the mid- and lower rectum (T3N1M0) showing partial response with slight residual thickening and diffusion restriction at 9 O'clock position (blue arrows)

DISCUSSION

Rectal cancer is one of the most common malignancies of the gastrointestinal tract throughout the world, and it usually affects the elderly population with a slightly higher incidence in males. Histologically, 98% of rectal cancers are adenocarcinoma

Neoadjuvant chemoradiotherapy (nCRT) has become the standard of care in the management of locally advanced rectal carcinoma due to its ability to downstage tumors, increase resectability, and reduce local recurrence. MRI plays a vital role in staging and restaging the rectal carcinoma and deciding on the next appropriate management step. The rectal tumors are usually staged and restaged on MRI. DWI is a sequence of MRI that measures the random Brownian motion of the water molecules within a tissue. Therefore, the changes in tissue cellularity and/or composition would affect the diffusion of the water molecules, which is then measured quantitatively using DWI. Accurate assessment of tumor response post-nCRT is critical for surgical planning, especially in determining eligibility for organ-preserving approaches such as "watch-and-wait" or local excision in cases of complete response. In this context, MRI—particularly with the addition of diffusion-weighted imaging (DWI)—has emerged as an essential tool for post-treatment evaluation.[7,8]

In the present study involving 50 patients, MRI-based tumor regression grading (mrTRG) correlated significantly with histopathological tumor regression (pTRG), demonstrating a high level of diagnostic accuracy. The complete response rate on MRI (mrTRG 1) was 26%, closely matching the 24% complete pathological response (TRG 0), highlighting the strong concordance between imaging and histopathology.

We also observed in our study that the mean ADC values were significantly higher in patients who had a CR as compared to those who did not have CR. Kim et al. also noted a similar trend in the ADC values. Additionally, they also observed that ADC values in the mucinous tumors were also higher when compared to the adenocarcinomas. Hence, careful observation of the ADC values also plays an important role in the determination of CR in this histological category Furthermore, it is very difficult to anticipate the residual disease from inactive mucin in mucinous rectal cancers on conventional MR images. Apart from the evaluation of tumor response in the primary tumor, DWI can also be used to evaluate the nodal metastases. In their study, Van Heeswijk et al,[9] also advocated the supporting role of

DWI plays a pivotal role in differentiating post-treatment fibrosis from residual viable tumor, a task

that conventional T2-weighted MRI alone often struggles with. Our study found that complete responders had significantly higher mean ADC values (1.46×10^{-3} mm²/s) compared to partial (1.09×10^{-3} mm²/s) and non-responders (0.87×10^{-3} mm²/s), with a statistically significant difference ($p < 0.001$). This is consistent with prior research by Kim et al,[5] who also reported increased ADC values in complete responders, suggesting that DWI can serve as a non-invasive biomarker for treatment response. DWI in the selection of patients for organ preservation after CRT and suggested that the absence of lymph nodes in locally advanced rectal tumors after neoadjuvant CRT on restaging DWI can be a reliable predictor of negative nodal status. Therefore, based on our findings, we believe that DWI plays a vital role in the evaluation of post-treatment tumor response. However, there are still some limitations. Firstly, the spatial resolution of DWI is limited, and the poor signal-to-noise ratio of high b-value images makes it impossible to identify the different layers of the rectal wall . Secondly, DWI is imprecise in differentiating CR from near-CR as well as in the differentiation of the residual tumor from inactive mucin.

Our results demonstrated a high sensitivity (88.3%) and specificity (92%) for MRI-DWI in detecting complete pathological response (pCR), findings that are strongly supported by existing literature. Kim et al,[5] were among the first to show that diffusion-weighted MRI improves detection of residual tumor post-CRT, allowing better discrimination between viable tumor and fibrotic tissue. Similarly, Lambregts et al,[6] demonstrated that MRI-based tumor regression grading (mrTRG) correlates well with histopathological findings, as seen in our study where mrTRG 1 matched with pTRG 0 in a large subset of patients. Patel et al,[3] in the MERCURY trial, established that MRI response post-CRT predicts long-term survival, highlighting the prognostic significance of accurate imaging. This further validates the clinical importance of imaging-based response assessment beyond surgical planning. Beets-Tan et al,[8] and Glynne-Jones et al,[11] through ESGAR and ESMO guidelines, respectively, emphasized MRI—including DWI—as the preferred modality for post-CRT evaluation in rectal cancer. Their expert consensus aligns with our methodology and supports the integration of DWI into standard MRI protocols.

Curvo-Semedo et al,[10] directly compared conventional T2 MRI volumetry with DWI and concluded that DWI is superior in identifying complete responders. Our findings also show higher mean ADC values in complete responders (1.46×10^{-3} mm²/s), consistent with their results. Van Heeswijk et al,[9] conducted a systematic review and emphasized that DWI significantly enhances the accuracy of MRI in the detection of tumor response, especially in distinguishing fibrosis from residual tumor. Our experience reflected this utility, particularly in complex post-CRT cases. Sclafani et al,[12] further support these findings in their review, acknowledging the added diagnostic value of functional imaging techniques like DWI in response assessment. Padhani et al,[13] in their consensus recommendations, highlight the standardization and validation of DWI as an oncologic imaging biomarker. This supports the future potential of ADC values to be used not just qualitatively, but quantitatively, in clinical protocols.

Table 7: Comparison with Other Studies

Study	Sensitivity	Specificity	Conclusion
Kim et al,[5]	85%	89%	ADC useful in detecting complete responders
Lambregts et al,[6]	90%	93%	DWI improves diagnostic performance of MRI
Present study	88.3%	92.0%	DWI-MRI shows strong correlation with histopathology

The sensitivity and specificity of DWI-MRI in detecting complete pathological response in our study were 88.3% and 92.0% respectively, with an overall diagnostic accuracy of 90%. These values are comparable to previous studies such as those by Patel et al. (2016) and Lambregts et al,[6] reaffirming the reliability of MRI, particularly DWI sequences, in post-CRT assessment.

Interestingly, 40% of tumors in our study were located in the distal rectum or anal canal, where surgical margins are harder to achieve and the role of organ preservation becomes even more critical. Thus, the ability of DWI to identify complete responders with high confidence could support less aggressive management strategies in selected patients. Despite these promising findings, MRI and DWI are not without limitations. Post-CRT changes such as edema and inflammation may mimic residual tumor or obscure viable cancer tissue. Interobserver variability, although found to be low in this study ($\kappa = 0.82$), still poses a challenge in routine clinical settings. In addition, ADC thresholds are not standardized across institutions, which limits generalizability.

Overall, our findings are in agreement with the growing body of literature that positions MRI, especially when complemented with DWI and ADC analysis, as the most reliable non-invasive modality for evaluating tumor response post-CRT in rectal cancer. The high correlation between mrTRG and pTRG, alongside robust ADC value differentiation, reinforces the potential of MRI-DWI in clinical decision-making—especially in selecting candidates for less invasive management strategies such as the "watch-and-wait" approach.

CONCLUSION

The results of our study suggest that DWI is very useful in the evaluation of post-treatment tumor response with excellent diagnostic accuracy. Furthermore, DWI is also very valuable in the evaluation of metastatic nodes, and the absence of nodal disease on the DWI is a reliable predictor of negative nodal metastases. Therefore, DWI also aids in making an appropriate treatment plan and helps in the selection of patients for organ preservation after CRT.

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