Role of MRI with Diffusion Weighted Imaging in determining response to neoadjuvant chemoradiation in locally advanced carcinoma rectum

Dr Neha Gulia,[1] Dr Paresh kumar Sukhani,[2] Dr Ankit Godara,[3] Dr Jai Chowdhary,[4] Dr Diksha Ahlawat,[5]

[1,5]Junior resident, third year, department of radiology, mahatma Gandhi medical college and hospital, Jaipur
[2]Professor and head, department of radiology, mahatma Gandhi medical college and hospital, Jaipur
[3]Senior resident, department of radiology, mahatma Gandhi medical college and hospital, Jaipur
[4]Professor, department of radiology, mahatma Gandhi medical college and hospital, Jaipur
Corresponding author: Dr Ankit Godara, Senior resident, department of radiology, mahatma Gandhi medical college and hospital, Jaipur. drankitgodara@gmail.com

ABSTRACT

Background: Accurate assessment of tumor response to neoadjuvant chemoradiotherapy (CRT) is crucial for managing locally advanced rectal cancer (LARC). Conventional MRI often fails to distinguish residual tumor from post-radiation changes. Diffusion-weighted imaging (DWI) offers improved specificity by detecting viable cancer cells through water molecule movement.

Objective: To evaluate the diagnostic performance of MRI with DWI for assessing tumor response, tumor regression grade (mrTRG), CRM status, EMVI, and nodal involvement in LARC patients undergoing neoadjuvant CRT.

Methods: A cohort study of 26 patients (mean age 55.3±14.1 years; 76.9% male) with histopathologically proven LARC was conducted between January 2024 and January 2025 at Mahatma Gandhi Medical College and Hospital, Jaipur. Patients underwent 3.0 Tesla MRI with DWI pre- and post-CRT. Tumor length, ADC values, mrTRG, nodal status, CRM, and EMVI were assessed. Diagnostic performance was evaluated using sensitivity, specificity, accuracy, AUC, and correlation analysis.

Results: Post-CRT, good response (mrTRG 2) was seen in 57.7% and complete response (mrTRG 1) in 15.4%. Tumor length significantly decreased (71.2±15.8 mm to 36.9±18.7 mm; $p<0.001$), and ADC values increased (0.97±0.21 to 1.49±0.27 $\times 10^{-3}$ mm²/s; $p<0.001$). Post-CRT ADC ($r=-0.48$, $p=0.01$) and ΔADC ($r=-0.56$, $p=0.003$) showed significant correlation with mrTRG. MRI with DWI demonstrated excellent performance for detecting poor response (mrTRG 3–4): sensitivity 87.5%, specificity 100%, accuracy 96.0%. For CRM involvement: sensitivity 100%, specificity 90.5%, accuracy 92.0%. Qualitative DWI outperformed quantitative ADC parameters (AUC: 0.94 vs. 0.64).

Conclusion: MRI with DWI is a reliable, non-invasive biomarker for assessing tumor response and high-risk features in LARC post-CRT. Qualitative DWI shows excellent diagnostic accuracy, supporting its routine clinical incorporation. Quantitative ADC alone has limited predictive value.

KEYWORDS: Locally Advanced Rectal Cancer (LARC), Diffusion-Weighted Imaging (DWI), Tumor Regression Grade (mrTRG), Neoadjuvant Chemoradiotherapy, Apparent Diffusion Coefficient (ADC).

How to cite this article: Gulia N, Sukhani PK, Godara A, Chowdhary J, Ahlawat D. Role of MRI with Diffusion Weighted Imaging in determining response to neoadjuvant chemoradiation in locally advanced carcinoma rectum. Int J Drug Deliv Technol. 2026;16(64s):1620-1625. DOI: 10.25258/ijddt.16.64s.176

INTRODUCTION

Colorectal cancer remains a formidable global health threat, with rectal cancer accounting for nearly one-third of these cases.[1] As lifestyle changes and urbanization drive a rise in incidence, particularly in developing nations like India, many patients are diagnosed with locally advanced rectal carcinoma (LARC).[2] These advanced cases carry a higher risk of recurrence, necessitating a multi-pronged treatment strategy that combines chemotherapy and radiation (CRT) followed by surgery.[3,4] The primary goal of preoperative CRT is to shrink the tumor, yet patient response is incredibly varied. While some experience a "complete response," where the tumor disappears entirely, others see minimal change.[4,5] Traditionally, we only confirm this response through histopathological grading after surgery, but waiting until after the operation limits our ability to make personalized treatment decisions beforehand.[5] Standard MRI, though excellent for initial staging, often fails to distinguish between lingering cancer and the harmless scarring or inflammation left behind by radiation.[5,6] To solve this, Diffusion-Weighted Imaging (DWI) has emerged as a vital tool. By tracking the microscopic movement of water molecules, DWI can "see" through radiation-induced changes to identify viable cancer cells,

offering much higher accuracy than standard scans.[6,7] Integrating DWI into clinical practice allows for a more tailored approach to oncology; for instance, "complete responders" might avoid invasive surgery altogether through "watch-and-wait" strategies, while poor responders can receive more intensive alternative therapies.[7,8] By correlating these advanced imaging findings with the histopathological "gold standard," we can validate DWI as a powerful, non-invasive biomarker.[8,9] This shift toward precise, image-guided assessment is essential for improving survival rates and protecting the quality of life for patients navigating a LARC diagnosis.[9]

STUDY DESIGN AND METHODOLOGY

Between January 2024 and January 2025, a cohort study was conducted at Mahatma Gandhi Medical College and Hospital, Jaipur, to evaluate treatment responses in patients with histopathologically proven locally advanced rectal carcinoma who underwent neoadjuvant chemoradiation. Following institutional ethical clearance and the acquisition of informed consent, patients were scanned using a SIEMENS MAGNETOM VIDA 3.0 Tesla MRI equipped with a pelvic phased-array coil. The imaging protocol prioritized precision, utilizing high-resolution T2-weighted sequences in multiple planes alongside Diffusion-Weighted Imaging (DWI) at b-values of 0, 400, and 800 s/mm^2 to generate quantitative Apparent Diffusion Coefficient (ADC) maps. Radiologists, blinded to pathological outcomes, analyzed these scans to track changes in tumor dimensions, signal intensity, and ADC values, ultimately assigning a Tumor Regression Grade (TRG) based on morphological shifts. These findings were statistically analyzed using paired tests, with a significance threshold of $p < 0.05$, to determine if non-invasive MRI parameters could reliably mirror the physiological changes occurring within the tumor post-therapy. All clinical interventions were strictly supervised by hospital faculty, and the study was conducted with no conflicts of interest.

RESULTS

Demographic and Baseline Characteristics (Tables 1–2)

A total of 26 patients (mean age 55.3±14.1 years; 76.9% male) were included. Most had advanced local disease: T3b (42.3%), T3a (26.9%), and T4a (19.4%). Nodal involvement was present in 69.2%, positive circumferential resection margin (CRM) in 30.8%, and extramural vascular invasion (EMVI) in 23.1%.

Table 1. Gender Distribution of the Study Population

Variable	Category / Value	n / Mean ± SD	% / Range
Age (years)	Mean ± SD	55.3 ± 14.1	15 – 76
Gender	Male	20	76.9
	Female	6	23.1
Total		**26**	**100.0**

Table 2. Pre-Chemoradiation Tumor Staging and Local Invasion

Variable	Category	n	%
T Stage (Pre-CRT)	T2	1	3.8
	T3a	7	26.9
	T3b	11	42.3
	T3c	1	3.8
	T3d	1	3.8
	T4a	5	19.4
Total		**26**	**100.0**
Nodal status	Positive (N1/N2)	18	69.2
	Negative / subcentimetric	8	30.8
Total		**26**	**100.0**
CRM status	Positive	8	30.8
	Negative	18	69.2
Total		**26**	**100.0**
EMVI status	Positive	6	23.1
	Negative	20	76.9
Total		**26**	**100.0**

Tumor Response and Restaging (Tables 3–5)

Post-chemoradiation, MRI Tumor Regression Grade (mrTRG) showed good response (Grade 2) in 57.7% and complete response (Grade 1) in 15.4%. Post-treatment staging revealed T2 (61.6%), T1 (19.2%), and T3 (15.4%); nodal positivity dropped to 57.7%, positive CRM to 19.2%, and positive EMVI to 11.5%. Tumor length significantly decreased (71.2±15.8 mm to 36.9±18.7 mm; $p<0.001$), and ADC values increased (0.97±0.21 to 1.49±0.27 $\times10^{-3}$ mm²/s; $p<0.001$).

Table 3. MRI Tumor Response Grade (mrTRG)

mrTRG Grade	Interpretation	n	%
Grade 1	Complete response	4	15.4
Grade 2	Good response	15	57.7
Grade 3	Moderate response	6	23.1
Grade 4	Poor response	1	3.8
Grade 5	No response	0	0
Total		**26**	**100.0**

Table 4. Post-Chemoradiation Treatment Response and Restaging

Variable	Category	n	%
Post-CRT T stage	T1	5	19.2
	T2	16	61.6
	T3	4	15.4
	Not assessable	1	3.8
Total		**26**	**100.0**
Post-CRT nodal status	Positive	15	57.7

	Negative / subcentimetric	11	42.3
Total		**26**	**100.0**
Post-CRT CRM status	Positive	5	19.2
	Negative	21	80.8
Total		**26**	**100.0**
Post-CRT EMVI status	Positive	3	11.5
	Negative	23	88.5
Total		**26**	**100.0**

Table 5. Pre- and Post-Chemoradiation Tumor Parameters

Parameter	**Pre-Chemoradiation (Mean ± SD)**	**Post-Chemoradiation (Mean ± SD)**	**Mean Difference**	**Statistical Test**	**p-value**
Tumor length (mm)	71.2 ± 15.8	36.9 ± 18.7	34.3	Paired t-test	< 0.001
ADC value ($\times 10^{-3}$ mm²/s)	0.97 ± 0.21	1.49 ± 0.27	−0.52	Paired t-test	< 0.001

Association with Tumor Regression (Tables 6–7)
Post-CRT ADC (r=−0.48, p=0.01) and ΔADC (r=−0.56, p=0.003) showed significant moderate-to-strong negative correlations with mrTRG, unlike pre-CRT ADC (r=−0.21, p=0.30).

Table 6. Association Between MRI/DWI Response and Tumor Regression Grade

MRI/DWI Response	**Good Response (mrTRG 1–2)**	**Poor Response (mrTRG 3–4)**	**Total**
Restricted diffusion (post-CRT)	16	6	22
No diffusion restriction	3	1	4
Total	**19**	**7**	**26**

Table 7. Correlation Between ADC Parameters and Tumor Regression Grade

Parameter	**Correlation coefficient (r)**	**p-value**	**Interpretation**
Pre-CRT ADC vs mrTRG	−0.21	0.30	Weak, not significant
Post-CRT ADC vs mrTRG	−0.48	0.01	Moderate, significant
ΔADC vs mrTRG	−0.56	0.003	Moderate to strong, significant

Diagnostic Performance (FIG 1–4)
MRI with DWI had excellent performance for detecting poor response (mrTRG 3–4): sensitivity 87.5%, specificity 100%, accuracy 96.0%. For post-CRT CRM involvement: sensitivity 100%, specificity 90.5%, accuracy 92.0%. ROC analysis showed qualitative DWI had the highest AUC (0.94) for poor response prediction, outperforming ΔADC (AUC 0.64). Qualitative DWI also demonstrated excellent utility for CRM (AUC 0.95), EMVI (AUC 0.90), and nodal metastasis (AUC 0.89).

FIGURE 1. Diagnostic Performance of MRI with DWI for Detection of Poor Tumor Response (mrTRG 3–4)

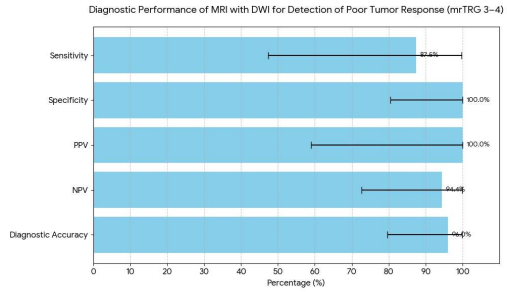


FIGURE 2. Diagnostic Performance of MRI with DWI for Detection of CRM Involvement Post-Chemoradiation.

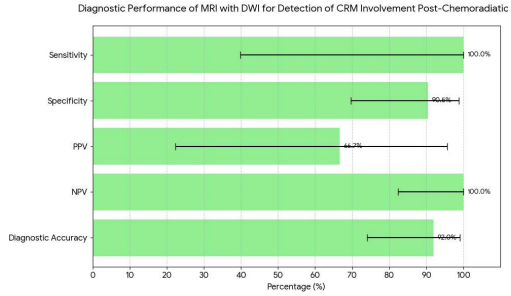


FIGURE 3. Receiver Operating Characteristic (ROC) Curve Analysis of ADC Parameters for Prediction of Poor Response.

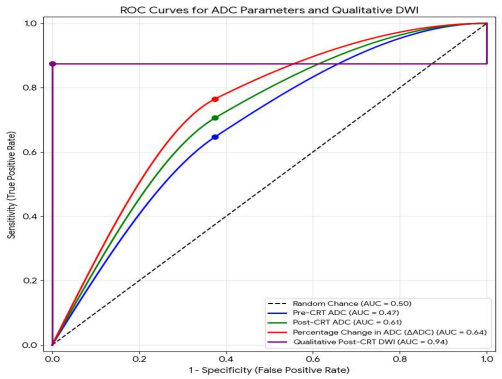
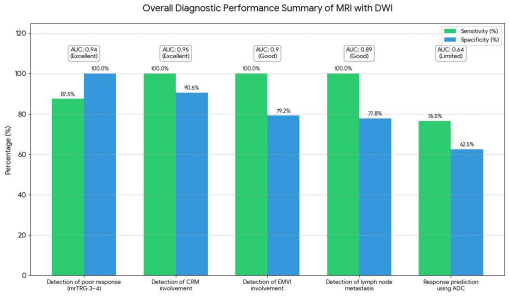


FIGURE 4. Overall Diagnostic Performance Summary of MRI with DWI



DISCUSSION

Accurate assessment of tumor stage and response to neoadjuvant chemoradiotherapy is essential in the management of locally advanced rectal cancer. Magnetic resonance imaging, particularly when combined with diffusion-weighted imaging (DWI), plays a central role in baseline staging, treatment planning, restaging, and prediction of oncologic outcomes. Reliable evaluation of tumor regression, nodal status, circumferential resection margin involvement, and high-risk features such as extramural vascular invasion directly influences surgical strategy and long-term prognosis. The present study analyzes the demographic profile, pre-treatment tumor characteristics, post-treatment response patterns, and the diagnostic performance of MRI with DWI. The following discussion interprets these findings and compares them with previously published data to better define the clinical value of MRI and DWI in response assessment and risk stratification.

Demographic Characteristics

The mean age was 55.3±14.1 years, with a male predominance (76.9%, n=20). Marouf et al.[10] reported a similar mean age (51.7 years) but less pronounced male predominance (57.9%). Both studies confirm rectal cancer commonly affects middle-aged to older males.

Pre-Chemoradiation Staging

Most patients presented with advanced disease: T3b (42.3%), T3a (26.9%), and T4a (19.4%). Nodal involvement was present in 69.2%, positive CRM in 30.8%, and EMVI in 23.1%. Bayram et al.[11] reported a higher T3 rate (94.4%) and nodal positivity (94.3%), with comparable CRM involvement (22.9%), though EMVI was not evaluated.

MRI Tumor Response Grade (mrTRG)

Good response (Grade 2) was observed in 57.7% and complete response (Grade 1) in 15.4%. Niu et al.[12] reported similar findings (Grade 2: 68.5%, Grade 1: 9.3%) and demonstrated that lower mrTRG grades were significantly associated with improved overall and progression-free survival.

Post-Chemoradiation Restaging

Significant downstaging was observed, with yT2 (61.6%) and yT1 (19.2%) post-treatment. Nodal positivity persisted in 57.7%. Zager et al.[13] reported pooled concordance of 63.9% for T staging and 60.9% for nodal staging. Residual T3 disease (15.4%) aligns with Soto Garcia et al.[14] (15–25% near-complete regression). Post-CRT CRM positivity (19.2%) and EMVI positivity (11.5%) were markedly lower than reported by Niu et al.[12] (77.8% and 70.4%, respectively), suggesting better local control in our cohort.

Association Between MRI/DWI and mrTRG

Among 22 patients with restricted diffusion, 72.7% had good response. Niu et al.[12] reported fair agreement between mrTRG and pathological TRG (κ=0.287–0.391). Lambregts et al.[15] showed adding DWI improved sensitivity for complete response from 28–40% to 52–64% and enhanced interobserver agreement ($\kappa\approx$0.5 vs. 0.2–0.3). Marouf et al.[10] reported improved accuracy after DWI (79.5% vs. 60% with MRI alone).

Diagnostic Performance for Poor Response (mrTRG 3–4)

MRI with DWI demonstrated excellent performance: sensitivity 87.5%, specificity 100%, accuracy 96.0%, PPV 100%, NPV 94.4%. In comparison, Niu et al.[12] reported lower performance (sensitivity 75.0%, specificity 21.4%), and Lambregts et al.[15] reported sensitivity of 52–64%. Marouf et al.[10] reported overall accuracy of 79.5%. Our results thus show superior diagnostic accuracy for detecting poor tumor response.

Overall Diagnostic Performance

Qualitative DWI showed excellent accuracy for poor response (AUC 0.94), CRM involvement (AUC 0.95, sensitivity 100%, specificity 90.5%), EMVI (AUC 0.90), and lymph node metastasis (AUC 0.89). In contrast, ΔADC showed limited predictive value (AUC 0.64, sensitivity 76.5%, specificity 62.5%), indicating that qualitative DWI outperforms quantitative ADC parameters in response assessment.

LIMITATIONS

The sample size was relatively small, which may limit the generalizability of the findings Second, it was conducted at a single center, which may

introduce selection bias. Third, interobserver variability was not formally assessed, although previous literature suggests that DWI can improve agreement between readers. Larger multicentric studies with standardized imaging protocols and long-term survival follow-up are needed to further validate these findings.

CONCLUSION

MRI with diffusion-weighted imaging is a reliable and clinically valuable tool for baseline staging, response assessment, and post-chemoradiation restaging in locally advanced rectal cancer. It provides accurate evaluation of tumor regression, circumferential resection margin status, extramural vascular invasion, and nodal involvement, all of which are critical for surgical planning and prognostication.

Our study demonstrates excellent diagnostic performance of qualitative DWI, particularly in identifying poor tumor responders and high-risk pathological features. The strong sensitivity, specificity, and overall accuracy observed support the routine incorporation of DWI into standard rectal cancer MRI protocols. However, quantitative ADC-based assessment appears less reliable as a standalone predictive marker.

REFERENCES

1. Zhang X, Fan H, Han S, Zhang T, Sun Y, Yang L, Li W. Global burden of colon and rectal cancer and attributable risk factors in 204 countries and territories from 1990 to 2021. BMC Gastroenterol. 2025 May 2;25(1):332. doi: 10.1186/s12876-025-03948-2. PMID: 40316922; PMCID: PMC12048922.
2. Bishehsari F, Mahdavinia M, Vacca M, Malekzadeh R, Mariani-Costantini R. Epidemiological transition of colorectal cancer in developing countries: environmental factors, molecular pathways, and opportunities for prevention. World J Gastroenterol. 2014 May 28;20(20):6055-72. doi: 10.3748/wjg.v20.i20.6055. PMID: 24876728; PMCID: PMC4033445.
3. Lișcu HD, Verga N, Atasiei DI, Ilie AT, Vrabie M, Roșu L, Poștaru A, Glăvan S, Lucaș A, Dinulescu M, Delea A, Ionescu AI. Therapeutic Management of Locally Advanced Rectal Cancer: Existing and Prospective Approaches. J Clin Med. 2025 Jan 30;14(3):912. doi: 10.3390/jcm14030912. PMID: 39941583; PMCID: PMC11818342.
4. Bunjo Z, Sammour T. The Landmark Series: Neoadjuvant Therapy for Locally Advanced Rectal Cancer. Ann Surg Oncol. 2025 Jul;32(7):4935-4944. doi: 10.1245/s10434-025-17299-5. Epub 2025 Apr 22. PMID: 40263223; PMCID: PMC12130126.
5. Kokaine L, Gardovskis A, Gardovskis J. Evaluation and Predictive Factors of Complete Response in Rectal Cancer after Neoadjuvant Chemoradiation Therapy. Medicina (Kaunas). 2021 Sep 30;57(10):1044. doi: 10.3390/medicina57101044. PMID: 34684080; PMCID: PMC8537499.
6. Torkzad MR, Påhlman L, Glimelius B. Magnetic resonance imaging (MRI) in rectal cancer: a comprehensive review. Insights Imaging. 2010 Sep;1(4):245-267. doi: 10.1007/s13244-010-0037-4. Epub 2010 Aug 15. PMID: 22347920; PMCID: PMC3259411.
7. Baliyan V, Das CJ, Sharma R, Gupta AK. Diffusion weighted imaging: Technique and applications. World J Radiol. 2016 Sep 28;8(9):785-798. doi: 10.4329/wjr.v8.i9.785. PMID: 27721941; PMCID: PMC5039674.
8. Horvat N, Carlos Tavares Rocha C, Clemente Oliveira B, Petkovska I, Gollub MJ. MRI of Rectal Cancer: Tumor Staging, Imaging Techniques, and Management. Radiographics. 2019 Mar-Apr;39(2):367-387. doi: 10.1148/rg.2019180114. Epub 2019 Feb 15. PMID: 30768361; PMCID: PMC6438362.
9. Couwenberg AM, Varvoglis DN, Grieb BC, Marijnen CAM, Ciombor KK, Guillem JG. New Opportunities for Minimizing Toxicity in Rectal Cancer Management. Am Soc Clin Oncol Educ Book. 2023 Jun;43:e389558. doi: 10.1200/EDBK_389558. PMID: 37307515; PMCID: PMC10450577.
10. Marouf RA, Tadros MY, Ahmed TY. Value of diffusion-weighted MR imaging in assessing response of neoadjuvant chemo and radiation therapy in locally advanced rectal cancer. Egypt J Radiol Nucl Med. 2015;46(3):553-61.
11. Bayram I, Bakir B, Kartal MGD, Kunduz E, Bayram O, Turkay R, et al. The role of MRI with diffusion-weighted imaging in restaging rectal cancers after neoadjuvant chemoradiotherapy. S Afr J Radiol. 2016;20(1):a967. doi:10.4102/sajr.v20i1.967
12. Niu S, Chen Y, Peng F, Wen J, Xiong J, Yang Z, Peng J, Bao Y, Ding L. The role of MRI after neochemoradiotherapy in predicting pathological tumor regression grade and clinical outcome in patients with locally advanced rectal adenocarcinoma. Front Oncol. 2023 Jun 12;13:1118518. doi:

10.3389/fonc.2023.1118518. PMID: 37377906; PMCID: PMC10292078.
13. Zager Y, Horesh N, Abdelmasseh M, et al. The predicting value of post neoadjuvant treatment magnetic resonance imaging: a meta-analysis. Surg Endosc. 2024;38(11):6846-6853. doi:10.1007/s00464-024-11084-3
14. Soto Garcia JC, Pelaez A, Llaverias S, et al. Rectal cancer restaging: Imaging insights into MRI evaluation and treatment response assessment. ECR 2024 Educational Exhibit. doi:10.26044/ecr2024/C-14399
15. Lambregts DM, Vandecaveye V, Barbaro B, Bakers FC, Lambrecht M, Maas M, Haustermans K, Valentini V, Beets GL, Beets-Tan RG. Diffusion-weighted MRI for selection of complete responders after chemoradiation for locally advanced rectal cancer: a multicenter study. Ann Surg Oncol. 2011 Aug;18(8):2224-31. doi: 10.1245/s10434-011-1607-5. Epub 2011 Feb 23. PMID: 21347783; PMCID: PMC3136702.