

## Research Article

# Comparative efficacy of diffusion-weighted magnetic resonance imaging (DW-MRI) and Fluorodeoxyglucose positron emission tomography (FDG-PET CT) in restaging and post-therapeutic assessment of locally advanced rectal carcinoma

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**Abstract:** **Introduction:** **Aim:** To compare the efficacy of diffusion-weighted magnetic resonance imaging (DW-MRI) and fluorodeoxyglucose positron emission tomography (FDG-PET/CT) in detecting residual tumor, complete response, and nodal involvement in locally advanced rectal carcinoma (LARC), after neoadjuvant chemoradiotherapy (nCRT). **Research Question:** Does DW-MRI demonstrate comparable, superior, or inferior efficacy to FDG-PET/CT in tumor restaging and post-therapeutic assessment of LARC? **Methods:** This retrospective observational study included 12 patients (7 males, 5 females) with histologically proven LARC (cT3–T4 and/or N1). All patients underwent standard nCRT, followed by restaging with both DW-MRI and FDG-PET/CT. FDG-PET/CT assessed metabolic activity using maximal standardized uptake values (SUVmax) at the primary lesion, while DW-MRI utilized b-values of 0 and 1000 s/mm<sup>2</sup>, with mean apparent diffusion coefficient (ADC) map values calculated from tumor regions. Restaging was performed according to mrT and mrN criteria. **Results:** Both modalities identified complete response in 4 patients (33.3%). DW-MRI showed significantly higher ADC values in complete responders ( $1.43 \pm 0.08 \times 10^{-3} \text{ mm}^2/\text{s}$ ) than in non-responders ( $1.04 \pm 0.12 \times 10^{-3} \text{ mm}^2/\text{s}$ ) ( $p = 0.02$ ). FDG-PET/CT demonstrated higher SUVmax in non-responders ( $10.4 \pm 1.7$ ) compared with responders ( $3.2 \pm 0.5$ ) ( $p = 0.01$ ). Direct comparison between the two modalities showed no statistically significant difference ( $p = 0.62$ ), suggesting comparable efficacy. **Conclusion:** DW-MRI offers diagnostic accuracy comparable to FDG-PET/CT in identifying residual disease and complete response in locally advanced rectal carcinoma. Given its non-ionizing nature, lower cost, and broader availability, DW-MRI represents a viable alternative to FDG-PET/CT, particularly in resource-limited settings.

**Keywords:** Diffusion-weighted magnetic resonance imaging (DW-MRI) Fluorodeoxyglucose positron emission tomography/computed tomography (FDG-PET/CT)

## INTRODUCTION

Colorectal cancer is one of the most common malignancies worldwide, with rectal carcinoma accounting for a substantial proportion of cases. Locally advanced rectal carcinoma (LARC), generally characterized by clinical stage T3–T4 tumors and/or regional lymph node involvement, represents a challenging clinical entity due to its increased risk of local recurrence and distant metastatic disease. The introduction of neoadjuvant chemoradiotherapy (nCRT) followed by total mesorectal excision has significantly improved local control and surgical outcomes in patients with LARC. However, tumor response following neoadjuvant therapy is highly variable, ranging from complete pathological response to persistent residual disease, making accurate post-treatment assessment essential for individualized patient management.

Assessment of tumor response after nCRT has gained increasing importance with the emergence of response-adapted treatment strategies. Identification of patients achieving complete response has clinical implications,

particularly with the development of non-operative management approaches such as the watch-and-wait strategy. Therefore, reliable imaging methods capable of accurately differentiating complete responders from patients with residual viable tumor are required to guide treatment decisions and avoid unnecessary surgery or inadequate treatment.

Magnetic resonance imaging (MRI) is considered the primary imaging modality for local evaluation of rectal carcinoma because of its excellent soft tissue contrast and ability to provide detailed assessment of tumor location, depth of invasion, mesorectal fascia involvement, extramural vascular invasion, and regional lymph node status. Standardized high-resolution T2-weighted MRI protocols and magnetic resonance tumor regression grading (mrTRG) have improved the evaluation of treatment response by assessing morphological changes within the tumor bed. However, conventional morphological MRI alone may have limited accuracy after chemoradiotherapy because

residual tumor and treatment-induced fibrosis may demonstrate overlapping imaging appearances.

Diffusion-weighted MRI (DW-MRI) has emerged as an important functional imaging technique that complements conventional anatomical MRI. By evaluating the movement of water molecules within tissues, DWI provides information related to tumor cellularity and microstructural changes. The apparent diffusion coefficient (ADC), derived from diffusion-weighted images, has been investigated as a quantitative biomarker for assessing response after neoadjuvant therapy. Previous studies have demonstrated that changes in ADC values may reflect treatment-induced alterations in tumor cellular density and may assist in differentiating responding tumors from persistent disease.

Fluorodeoxyglucose positron emission tomography/computed tomography (FDG-PET/CT) provides an alternative functional approach by evaluating tumor glucose metabolism. Malignant cells demonstrate increased glucose utilization, allowing visualization and quantification of metabolic activity using  $^{18}\text{F}$ -fluorodeoxyglucose uptake. The maximum standardized uptake value (SUV<sub>max</sub>) is widely used as a semi-quantitative metabolic parameter for assessing tumor activity and treatment response. Unlike MRI, which primarily evaluates local anatomical and cellular characteristics, FDG-PET/CT provides whole-body metabolic imaging and may contribute to detection of metabolically active nodal or distant disease.

Although both DW-MRI and FDG-PET/CT provide functional information regarding treatment response, they assess different biological characteristics of tumor tissue. DW-MRI reflects changes related to cellularity and tissue microstructure, whereas FDG-PET/CT evaluates alterations in tumor metabolism. Several studies have investigated the role of these modalities individually; however, direct comparison of their diagnostic performance in post-treatment assessment of LARC remains clinically relevant, particularly in determining their complementary value.

## MATERIALS AND METHODS

### Study Design and Patient Population

This retrospective observational study done in Department of Radiodiagnosis in Sree Mookambika Institute of medical sciences, Kulasekharam included 12 patients with histopathologically confirmed locally advanced rectal carcinoma (LARC), defined as clinical stage T3–T4 and/or node-positive disease. All patients underwent standard neoadjuvant chemoradiotherapy followed by post-treatment evaluation with both diffusion-weighted magnetic resonance imaging (DW-MRI) and fluorodeoxyglucose positron emission

tomography/computed tomography (FDG-PET/CT). Previous studies have demonstrated the potential of ADC measurements as predictors of response following chemoradiotherapy, while FDG-PET/CT studies have highlighted the importance of metabolic changes in identifying residual active disease. Furthermore, advances in standardized MRI assessment criteria, including the MERCURY-based approach and mrTRG, have improved reproducibility of post-treatment rectal MRI interpretation. However, challenges remain in accurately predicting pathological response, emphasizing the need for multimodality assessment.

Therefore, the present study aims to compare the efficacy of diffusion-weighted MRI and FDG-PET/CT in the restaging and post-therapeutic assessment of locally advanced rectal carcinoma following neoadjuvant chemoradiotherapy. By evaluating ADC changes on DW-MRI and SUV<sub>max</sub> changes on FDG-PET/CT, this study investigates the relative contribution of structural and metabolic imaging biomarkers in assessing treatment response and determining the potential complementary role of these modalities in clinical practice.

### IMAGING PROTOCOLS

#### DW-MRI

- Performed on 1.5T MRI using a pelvic phased-array coil with high-resolution T2-weighted images in three planes and DWI ( $b = 0, 1000 \text{ s/mm}^2$ )
- ADC maps were generated, and minimum ADC values were obtained by placing ROIs on the tumor bed.
- Optimal timing for DWI-MRI is typically 6-12 weeks after chemotherapy which allows inflammation and reactive edema to subside while still capturing treatment related changes.

#### FDG-PET/CT

- Patients received  $^{18}\text{F}$ -FDG followed by a standardized 60-minute uptake period.
- Performed using 32 SLICE PET-CT scanner
- PET/CT imaging from skull base to mid-thigh was performed, and SUV<sub>max</sub> was measured as the primary metabolic parameter.

tomography/computed tomography (FDG-PET/CT). Patients younger than 18 years of age and those with evidence of distant organ metastases were excluded from the study.

#### Diffusion-Weighted Magnetic Resonance Imaging (DW-MRI)

Post-treatment pelvic MRI examinations were performed on a 1.5-T MRI scanner using a pelvic phased-array coil. Imaging was conducted approximately 6–12 weeks after completion of neoadjuvant chemoradiotherapy, a time

interval considered optimal for response assessment as treatment-related inflammation and reactive edema have largely subsided while residual tumor-related changes remain detectable.

The MRI protocol included high-resolution T2-weighted fast spin-echo sequences acquired in three orthogonal planes: sagittal, axial oblique (perpendicular to the tumor axis), and coronal oblique (parallel to the tumor axis). Diffusion-weighted imaging was obtained using single-shot echo-planar imaging with b-values of 0 and 1000 s/mm<sup>2</sup>. Apparent diffusion coefficient (ADC) maps were automatically generated on the workstation.

For quantitative analysis, regions of interest (ROIs) were manually placed over the residual tumor bed on ADC maps while carefully avoiding areas of necrosis, cystic degeneration, hemorrhage, and adjacent normal rectal wall. Minimum ADC values were recorded for each lesion and used for subsequent statistical analysis. In addition, qualitative assessment of treatment response was performed using magnetic resonance tumor regression grading (mrTRG).

#### **FDG-PET/CT**

FDG-PET/CT examinations were performed using a 32-slice integrated PET/CT scanner. Patients fasted for at least 6 hours before imaging and received an intravenous injection of 18F-fluorodeoxyglucose (18F-FDG). Following tracer administration, a standardized uptake period of approximately 60 minutes was observed before image acquisition.

Whole-body PET/CT imaging was subsequently performed from the skull base to the mid-thigh region. Attenuation-corrected PET images were reconstructed and fused with corresponding CT images for anatomical localization. A volume of interest was placed over the primary rectal lesion, and the maximum standardized uptake value (SUV<sub>max</sub>) was recorded as the principal metabolic parameter for assessment of residual disease and treatment response.

#### **Image Analysis**

**MRI and PET/CT images were independently** reviewed by experienced radiologists and nuclear medicine physicians who were blinded to the final clinical and histopathological outcomes. Quantitative imaging parameters including minimum ADC values from DW-MRI and SUV<sub>max</sub> values from FDG-PET/CT were documented. These parameters were subsequently compared to evaluate the relative efficacy of DW-MRI and FDG-PET/CT in restaging and post-therapeutic assessment of locally advanced rectal carcinoma following neoadjuvant chemoradiotherapy.

#### **Principles of Diffusion-Weighted Magnetic Resonance Imaging (DW-MRI)**

Diffusion-weighted magnetic resonance imaging (DW-MRI) is a functional imaging technique that evaluates the

random Brownian motion of water molecules within biological tissues. In rectal carcinoma, tissue cellularity and membrane integrity influence water diffusion characteristics. Highly cellular tumors restrict extracellular water movement, resulting in high signal intensity on diffusion-weighted images and correspondingly low apparent diffusion coefficient (ADC) values.

DWI is typically acquired using b-values of 0 and 1000 s/mm<sup>2</sup>, allowing assessment of diffusion restriction within the tumor bed. Quantitative ADC maps generated from these images provide an indirect measure of tumor cellularity. Following effective neoadjuvant chemoradiotherapy, tumor cell death, necrosis, and fibrosis lead to increased extracellular space and reduced diffusion restriction, resulting in elevated ADC values. Conversely, persistently low ADC values after treatment may indicate residual viable tumor due to retained high cellular density.

For post-treatment response assessment, DW-MRI is generally performed 6–12 weeks after completion of chemoradiotherapy. This interval permits resolution of treatment-related inflammatory changes and edema while preserving the ability to detect residual tumor tissue. Consequently, DW-MRI has emerged as a valuable tool for evaluating tumor regression and differentiating treatment-related fibrosis from residual disease in patients with locally advanced rectal carcinoma.

#### **Principles of FDG-PET/CT**

Fluorodeoxyglucose positron emission tomography/computed tomography (FDG-PET/CT) combines metabolic and anatomical imaging for assessment of tumor viability. The technique is based on the increased glucose metabolism exhibited by malignant cells, commonly referred to as the Warburg effect. Following intravenous administration, <sup>18</sup>F-fluorodeoxyglucose (<sup>18</sup>F-FDG), a radiolabeled glucose analogue, is transported into cells via glucose transporters and phosphorylated intracellularly, resulting in tracer accumulation within metabolically active tissues.

The degree of FDG uptake is commonly quantified using the maximum standardized uptake value (SUV<sub>max</sub>), which serves as a semi-quantitative marker of tumor metabolic activity. In patients responding to neoadjuvant chemoradiotherapy, a reduction in viable tumor burden is associated with a significant decline in FDG uptake and SUV<sub>max</sub>. In contrast, persistent or increased FDG uptake following treatment suggests the presence of residual metabolically active tumor tissue.

Beyond assessment of the primary rectal lesion, FDG-PET/CT provides whole-body evaluation and may facilitate detection of metabolically active lymph node involvement and distant metastatic disease. By assessing changes in tumor metabolism that often precede

anatomical alterations, FDG-PET/CT offers morphological imaging in the post-therapeutic complementary information to conventional evaluation of locally advanced rectal carcinoma.

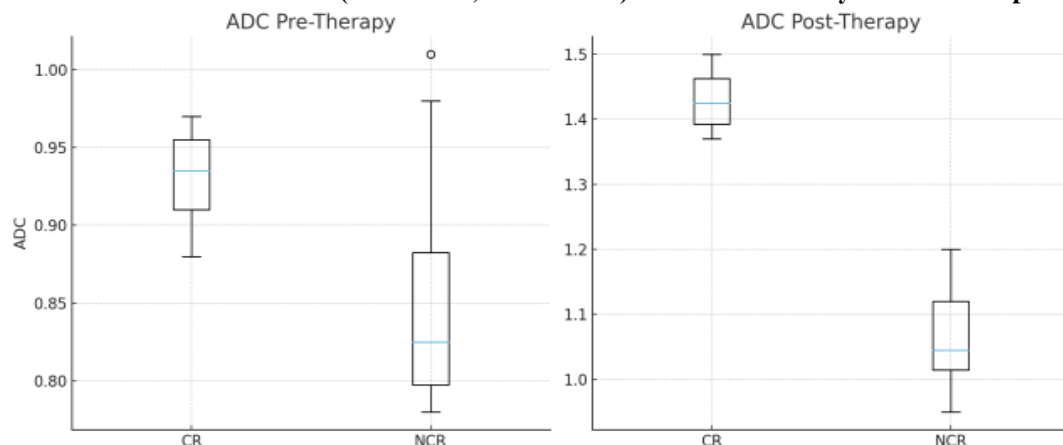
**Table: 1 Complete response was observed in 4 of the 12 patients (33%) and 8 patients were categorized as non-complete responders with LARC treated with neoadjuvant chemoradiotherapy, reflecting a one-third complete response rate consistent with typical outcomes in locally advanced rectal cancer.**

Patient ID	Sex	Age	Response	SUVmax Pre-Therapy	SUVmax Post-Therapy	ADC (Pre)	ADC (Post)
1	M	62	Non Complete Responder	15.2	11.0	0.78	0.95
2	M	55	Complete Responder	10.5	1.8	0.95	1.40
3	F	59	Non Complete Responder	14.8	9.6	0.82	1.00
4	M	67	Complete Responder	12.2	2.1	0.92	1.45
5	F	48	Non Complete Responder	16.0	12.4	0.80	1.05
6	M	61	Non Complete Responder	13.6	10.2	0.85	1.10
7	F	54	Complete Responder	9.7	1.5	0.88	1.50
8	M	60	Non Complete Responder	11.9	8.7	0.83	1.02
9	F	57	Non Complete Responder	17.1	13.5	0.79	1.04
10	F	66	Non Complete Responder	10.4	10.2	0.98	1.18
11	M	50	Complete Responder	11.0	1.9	0.97	1.37
12	M	62	Non Complete Responder	12.5	5.4	1.01	1.20

**Table 2. Pre- and Post-nCRT ADC (mean ± SD, ×10<sup>-3</sup> mm<sup>2</sup>/s) values stratified by treatment response category**

Response Group	Mean ADC Pre	SD (Pre)	Mean ADC Post	SD (Post)
Complete Responder (CR)	0.93	0.04	1.43	0.06
Non-Complete Responder (NCR)	0.86	0.09	1.07	0.09

**FIGURE 1. Pre- and Post-nCRT ADC (mean ± SD, ×10<sup>-3</sup> mm<sup>2</sup>/s) values stratified by treatment response category**

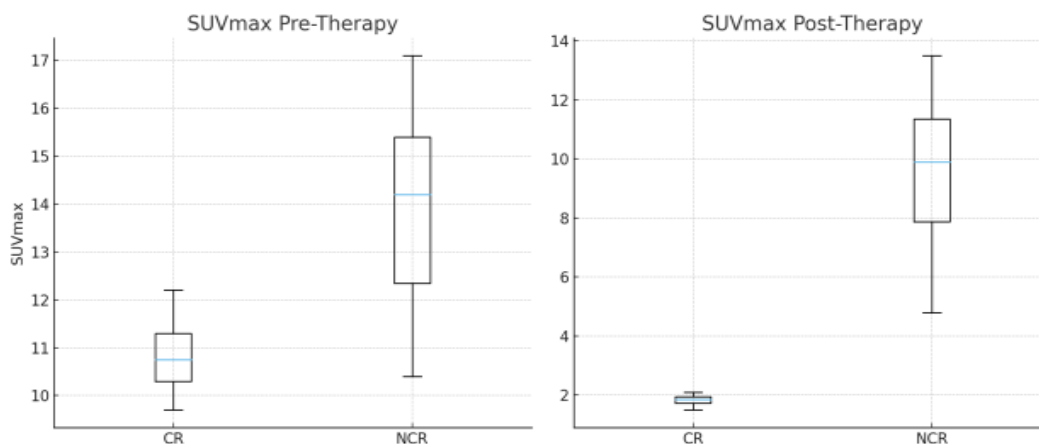


**Table 2. Pre- and Post-nCRT Mean SUVmax values stratified by treatment response category**

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Response Group	Mean SUVmax Pre-Therapy	SD (Pre)	Mean SUVmax Post-Therapy	SD (Post)
Complete Responder (CR)	10.85	1.05	1.83	0.25
Non-Complete Responder (NCR)	13.94	2.25	9.45	3.07

**FIGURE 2. Pre- and Post-nCRT Mean SUVmax values stratified by treatment response category**



**Table 4: Diagnostic performance comparison of DWI-MRI and FDG PET-CT in assessing treatment response**

Response Category	n	Histopathology	Correctly detected by DWI-MRI	Correctly detected by FDG PET-CT
Complete Responders	4	No residual tumor	4	4
Non-Complete Responders	6	Residual lesions	6	5
		Treatment-related inflammatory changes	1	2

**Table 5: Diagnostic performance comparison of DWI-MRI and FDG PET-CT in assessing treatment response**

Modality	Sensitivity	Specificity	PPV	NPV	Accuracy
DWI-MRI	100	83.3	85.7	100	92.0
FDG PET-CT	83.3	100	100	85.7	91.7

**TUMOUR RESPONSE ASSESSMENT**

Interpretation (DW-MRI)	Imaging Feature
Residual viable tumor	- High signal on high-b DWI + low ADC - Persistent intermediate T2 signal
Complete response(Likely fibrosis)	Low signal on high-b DWI & Low T2 signal
Mucin	- High T2 signal with corresponding high DWI signal (shine-through) & High T2 signal

Interpretation(FDG-PET/CT)	Imaging Feature	Relation to mass
Residual viable tumor	Persisting FDG uptake; reduced but not eliminated SUV	Corresponding to residual mass on MRI
Complete metabolic response (CMR) / no viable tumor	Absence (or near absence) of FDG uptake in previously involved area, normalization of SUV values, reduced metabolic volume	No residual mass
Post-treatment fibrosis / scar tissue / necrosis (non-viable tissue)	Often low or no FDG uptake; minimal metabolic activity;	Morphologic residual mass or wall thickening on MRI
Post-treatment inflammatory changes / radiation-induced changes / healing reaction	May show increased or persistent FDG uptake — sometimes diffuse, mild-to-moderate uptake	May not correspond to obvious mass

### TUMOR RESTAGING

- MR based tumor regression grade (mrTRG) using T2 + DWI for evaluating response after neoadjuvant chemoradiotherapy. It provides a non-invasive estimate of residual tumor versus fibrosis, helping classify complete/near-complete responders and guide decisions such as surgery or watch-and-wait.
- Scoring systems established by the Magnetic Resonance Imaging and Rectal Cancer European Equivalence Study (MERCURY) study group

Score	Description
mrTRG1	Minimal or no visible fibrosis (appearing as a thin linear scar), with low signal intensity on T2WI, and absence of tumor signal (intermediate signal intensity)
mrTRG2	Prominent fibrosis without tumor signal
mrTRG3	Mainly fibrotic but with noticeable, measurable areas of tumor signal
mrTRG4	Mostly tumor signal with negligible fibrosis
mrTRG5	Exclusive tumor presence or an increase in tumor size over baseline

### NODAL RESTAGING

- Restaging rectal MRI shows significant lymph node regression or complete resolution and provides higher staging accuracy than baseline imaging.
- The modality can reliably identify patients without residual nodal disease, with negative predictive values approaching 95%.
- Short-axis diameter is the most predictive parameter at restaging, with suspicious thresholds of: >5 mm (mesorectal/superior rectal), >4 mm (internal iliac), >6 mm (obturator), and >10 mm (M1 nodes).

## RESULTS

### Patient Characteristics and Treatment Response Distribution

A total of 12 patients with locally advanced rectal carcinoma who completed neoadjuvant chemoradiotherapy and underwent post-treatment assessment with both DW-MRI and FDG-PET/CT were included in the study. The study population consisted of 7 males and 5 females, with an age range of 48–67 years.

Based on histopathological correlation and post-treatment imaging assessment, complete response was observed in 4 of 12 patients (33.3%), with no residual viable tumor identified. The remaining 8 patients (66.7%) were categorized as non-complete responders. Among these, 6 patients demonstrated residual viable tumor, while 2 patients showed treatment-related inflammatory changes without viable residual disease.

### Diffusion-Weighted MRI Findings and ADC Analysis

Quantitative assessment of diffusion characteristics demonstrated an increase in apparent diffusion coefficient (ADC) values following neoadjuvant chemoradiotherapy, reflecting reduced tumor cellularity and increased extracellular space after treatment response.

Patients achieving complete response showed higher ADC values compared with non-complete responders both before and after treatment. The mean pre-treatment ADC value in complete responders was  $0.93 \pm 0.04 \times 10^{-3} \text{ mm}^2/\text{s}$ , which increased to  $1.43 \pm 0.06 \times 10^{-3} \text{ mm}^2/\text{s}$  following chemoradiotherapy. In comparison, non-complete responders demonstrated a lower mean pre-treatment ADC value of  $0.86 \pm 0.09 \times 10^{-3} \text{ mm}^2/\text{s}$ , with a post-treatment increase to  $1.07 \pm 0.09 \times 10^{-3} \text{ mm}^2/\text{s}$ .

The greater increase in ADC values among complete responders suggests a more pronounced reduction in tumor cellularity following treatment, whereas persistently lower ADC values in non-complete responders indicated residual viable tumor or incomplete treatment response.

#### **FDG-PET/CT Findings and SUVmax Analysis**

##### **FDG-PET/CT demonstrated a reduction in metabolic activity following neoadjuvant chemoradiotherapy in both**

response groups; however, the decline in SUVmax was substantially greater among complete responders.

Complete responders demonstrated a mean pre-treatment SUVmax of  $10.85 \pm 1.05$ , which decreased to  $1.83 \pm 0.25$  after treatment. Non-complete responders showed higher baseline metabolic activity with a mean pre-treatment SUVmax of  $13.94 \pm 2.25$ , followed by a reduction to  $9.45 \pm 3.07$  after therapy.

The marked reduction in SUVmax among complete responders indicated metabolic suppression of viable tumor tissue, whereas persistent FDG uptake among non-complete responders suggested residual metabolically active disease.

#### **Comparative Diagnostic Performance of DW-MRI and FDG-PET/CT**

The diagnostic performance of DW-MRI and FDG-PET/CT in assessing treatment response was evaluated using histopathological findings as the reference standard.

DW-MRI correctly identified all 4 complete responders and all 6 patients with residual viable tumor. Among the 2 patients with treatment-related inflammatory changes, DW-MRI correctly classified 1 patient, while 1 case was interpreted as suspicious for residual disease. Based on these findings, DW-MRI demonstrated a sensitivity of 100%, specificity of 83.3%, positive predictive value (PPV) of 85.7%, negative predictive value (NPV) of 100%, and overall accuracy of 92.0%.

FDG-PET/CT correctly identified all 4 complete responders and 5 of the 6 patients with residual viable tumor. Both patients with treatment-related inflammatory changes were correctly classified as having no viable residual tumor. FDG-PET/CT demonstrated a sensitivity of 83.3%, specificity of 100%, PPV of 100%, NPV of 85.7%, and overall accuracy of 91.7%.

#### **Comparative Interpretation of Imaging Parameters**

Overall, both imaging modalities demonstrated comparable diagnostic accuracy for post-treatment response assessment. DW-MRI showed higher sensitivity for detecting residual viable tumor, reflecting its ability to identify cellular changes associated with residual disease. FDG-PET/CT demonstrated higher specificity, reflecting its ability to distinguish

metabolically inactive post-treatment changes from active tumor tissue.

The combined evaluation of functional MRI parameters (ADC values) and metabolic parameters (SUVmax) demonstrated clear differences between complete and non-complete responders. Complete responders showed increased post-treatment ADC values and marked reduction in SUVmax, whereas non-complete responders demonstrated lower ADC elevation and persistent FDG uptake after therapy. These findings suggest that DW-MRI and FDG-PET/CT provide complementary information for restaging and treatment response assessment in patients with locally advanced rectal carcinoma following neoadjuvant chemoradiotherapy.

#### **Limitations and Interpretation Pitfalls**

##### **Challenges in MRI-Based Response Assessment**

Although diffusion-weighted magnetic resonance imaging (DW-MRI) has significantly improved the evaluation of treatment response in locally advanced rectal carcinoma (LARC), accurate interpretation of post-neoadjuvant treatment changes remains challenging. One of the major limitations of restaging MRI is the difficulty in differentiating residual viable tumor from treatment-related fibrosis. Following chemoradiotherapy, the tumor bed undergoes complex alterations including fibrosis, desmoplastic reaction, edema, inflammation, and scar formation. Dense fibrosis may appear as low signal intensity on T2-weighted images and can obscure small residual tumor foci, resulting in potential understaging. Conversely, irregular fibrosis, spiculated scar tissue, and persistent wall thickening may mimic residual malignancy, leading to overstaging.

The addition of diffusion-weighted imaging provides functional information by assessing changes in water molecule mobility related to tumor cellularity. However, DWI interpretation also has limitations. Residual viable tumor cells may be sparse or scattered within a predominantly fibrotic tumor bed and may not demonstrate sufficient diffusion restriction, resulting in false-negative findings. Conversely, treatment-related inflammatory changes, edema, granulation tissue, cellular debris, and mucinous changes may demonstrate restricted diffusion or high signal intensity due to T2 shine-through effects, potentially mimicking residual tumor. Quantitative ADC measurements may also demonstrate variability related to MRI field strength, scanner characteristics, b-value selection, image quality, and region-of-interest placement, which may influence reproducibility.

#### **Complex Tumor Regression Patterns and Nodal Assessment**

Tumor regression following neoadjuvant chemoradiotherapy is often heterogeneous and does not

always result in a uniform fibrotic scar. Post-treatment appearances may include irregular wall thickening, mixed signal intensity, and complex fibrotic changes, making assessment of complete response challenging. This limitation is particularly important when MRI findings are used to select patients for organ-preserving approaches such as watch-and-wait strategies.

Restaging of lymph node disease remains another major challenge. Following treatment, metastatic lymph nodes may decrease in size, lose their typical morphological features, or become radiologically occult despite persistent microscopic disease. Conversely, benign reactive lymph nodes may persist and mimic metastatic involvement, resulting in false-positive interpretations. Therefore, absence of visible lymphadenopathy on post-treatment MRI does not completely exclude residual nodal disease.

Mucinous tumors represent an additional diagnostic challenge. Mucin pools, particularly acellular mucin following treatment, may demonstrate high signal intensity on T2-weighted images and may be difficult to distinguish from residual tumor containing viable cells. Therefore, conventional MRI-based tumor regression assessment may have reduced accuracy in mucinous adenocarcinomas.

#### **FDG-PET/CT Interpretation Challenges**

FDG-PET/CT provides complementary metabolic information; however, it is also associated with specific limitations. Persistent FDG uptake following chemoradiotherapy may reflect treatment-induced inflammation rather than residual malignancy, resulting in false-positive findings. Conversely, small-volume residual disease may not demonstrate sufficient metabolic activity for detection, leading to false-negative results. Mucinous adenocarcinomas may also show relatively low FDG uptake due to lower cellular density and reduced metabolic activity, potentially decreasing PET sensitivity.

## **DISCUSSION**

Accurate assessment of treatment response after neoadjuvant chemoradiotherapy (nCRT) remains a critical component in the management of locally advanced rectal carcinoma (LARC), as it influences subsequent therapeutic decisions, including the possibility of organ-preserving strategies. In the present study, patients were categorized into complete responders (CRs) and non-complete responders (NCRs), allowing comparison of functional imaging biomarkers derived from diffusion-weighted magnetic resonance imaging (DW-MRI) and fluorodeoxyglucose positron emission tomography/computed tomography (FDG-PET/CT).

The maximum standardized uptake value (SUV<sub>max</sub>), although widely used for metabolic assessment, is influenced by several technical and physiological factors, including patient blood glucose levels, tracer uptake time, scanner calibration, reconstruction methods, and imaging protocols. These factors may affect SUV reproducibility and should be considered when comparing metabolic response between patients or institutions.

#### **Study-Specific Limitations and Role of Combined Imaging Assessment**

The present study has several limitations. The retrospective study design may introduce selection bias, while the small sample size of 12 patients limits statistical power and restricts generalizability of the findings. As a single-center study, variations in imaging protocols, scanner characteristics, and institutional practices may influence the applicability of results to other populations. In addition, potential interobserver variability in mrTRG assessment, ADC measurement, and SUV<sub>max</sub> evaluation may affect imaging interpretation.

Neither DW-MRI nor FDG-PET/CT can reliably detect microscopic residual disease; therefore, complete radiological or metabolic response does not always correspond to pathological complete response. Histopathological assessment remains the reference standard for definitive evaluation of treatment response.

Despite these limitations, DW-MRI and FDG-PET/CT provide complementary information in the post-treatment evaluation of LARC. DW-MRI offers detailed assessment of local tumor characteristics and tissue response, whereas FDG-PET/CT provides metabolic evaluation and whole-body assessment for nodal and distant metastatic disease. Integration of morphological, functional, and metabolic imaging parameters may improve diagnostic confidence and enhance the accuracy of post-treatment restaging in patients with locally advanced rectal carcinoma.  
for cholesteatoma.

Our findings demonstrated that both ADC values obtained from DW-MRI and SUV<sub>max</sub> values derived from FDG-PET/CT reflected treatment-induced biological changes following chemoradiotherapy. Complete responders showed a greater increase in post-treatment ADC values compared with non-complete responders, indicating reduced tumor cellularity and increased extracellular space associated with tumor necrosis, fibrosis, and treatment response. In contrast, non-complete responders demonstrated relatively lower post-treatment ADC values, suggesting persistent cellular tumor components. These findings support the established role of DWI as a functional imaging technique capable of detecting microscopic changes in

tumor architecture beyond conventional morphological assessment.

Similarly, FDG-PET/CT demonstrated significant differences in metabolic response between complete and non-complete responders. Complete responders showed a marked reduction in SUVmax following therapy, reflecting decreased glucose metabolism and loss of viable tumor activity. Persistent FDG uptake in non-complete responders suggested residual metabolically active disease. These findings highlight the complementary role of PET/CT in evaluating tumor viability, particularly in cases where morphological changes on MRI may be difficult to interpret.

MRI-based tumor regression assessment, particularly magnetic resonance tumor regression grading (mrTRG), integrates high-resolution T2-weighted morphological evaluation with functional information from DWI to improve differentiation between fibrosis and residual viable tumor. This approach has demonstrated clinical value in identifying patients with complete or near-complete response and may support selection of patients for non-operative management strategies such as the watch-and-wait approach. However, interpretation remains challenging due to overlapping appearances between fibrosis, inflammation, mucinous changes, and residual tumor.

The present findings are consistent with the principles established by the MERCURY study group, which demonstrated the importance of standardized MRI assessment for local staging and treatment response evaluation in rectal cancer. Incorporation of structured

## CONCLUSION

DWI-MRI exhibited a modestly higher sensitivity than FDG-PET/CT, while both techniques demonstrated similar specificity and overall accuracy, suggesting that DWI-MRI may offer a slight advantage in identifying residual tumour after therapy.

Importantly, the study's findings highlight that DWI-MRI is not only comparable but clinically practical,

MRI criteria, including assessment of tumor regression pattern, mesorectal fascia involvement, and nodal characteristics, improves reproducibility and facilitates more accurate post-treatment evaluation. However, nodal restaging remains a limitation, as treated lymph nodes may become radiologically occult despite microscopic residual disease, while benign reactive nodes may mimic metastases.

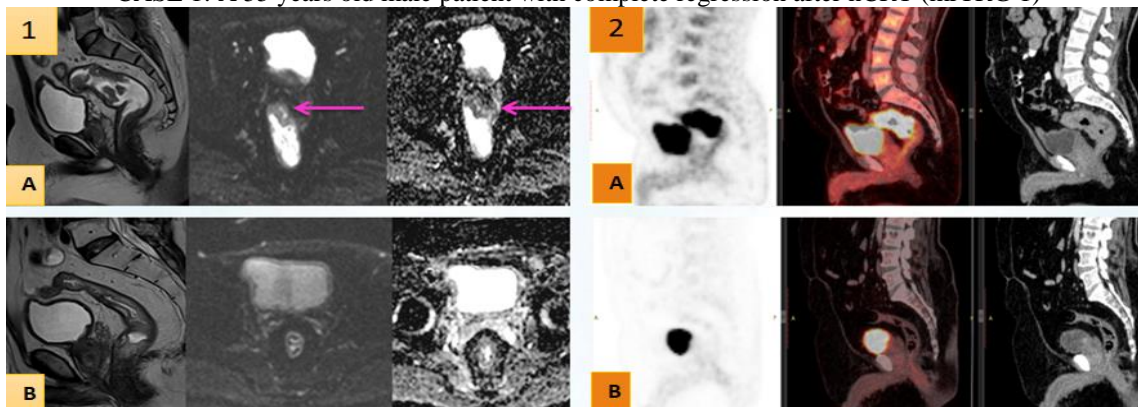
Although DW-MRI provides excellent local assessment of tumor response, FDG-PET/CT contributes additional metabolic information and whole-body evaluation for detection of nodal and distant metastatic disease. In this study, DW-MRI demonstrated higher sensitivity for identifying residual viable tumor, whereas FDG-PET/CT showed higher specificity, reflecting their different biological targets. DW-MRI evaluates cellular density and water diffusion changes, while FDG-PET/CT evaluates glucose metabolism. Therefore, these modalities should be considered complementary rather than competing techniques.

The combined interpretation of ADC changes, mrTRG assessment, and SUVmax response may provide a more comprehensive evaluation of treatment efficacy in LARC. A multimodality approach may improve confidence in identifying complete responders, reduce unnecessary surgery in selected patients, and assist in personalized treatment planning. However, larger prospective studies with standardized imaging protocols and pathological correlation are required to validate these findings and establish the optimal role of combined DW-MRI and FDG-PET/CT assessment in routine clinical practice.

Given its non-ionizing nature, superior soft-tissue contrast, lower operational cost, and widespread availability make it more feasible for repeated follow-up and routine restaging, and practical alternative to PET/CT for post-therapy restaging, especially in centres with limited access to PET/CT.

PET/CT retains an important complementary role, especially in evaluating nodal and distant metastatic disease.

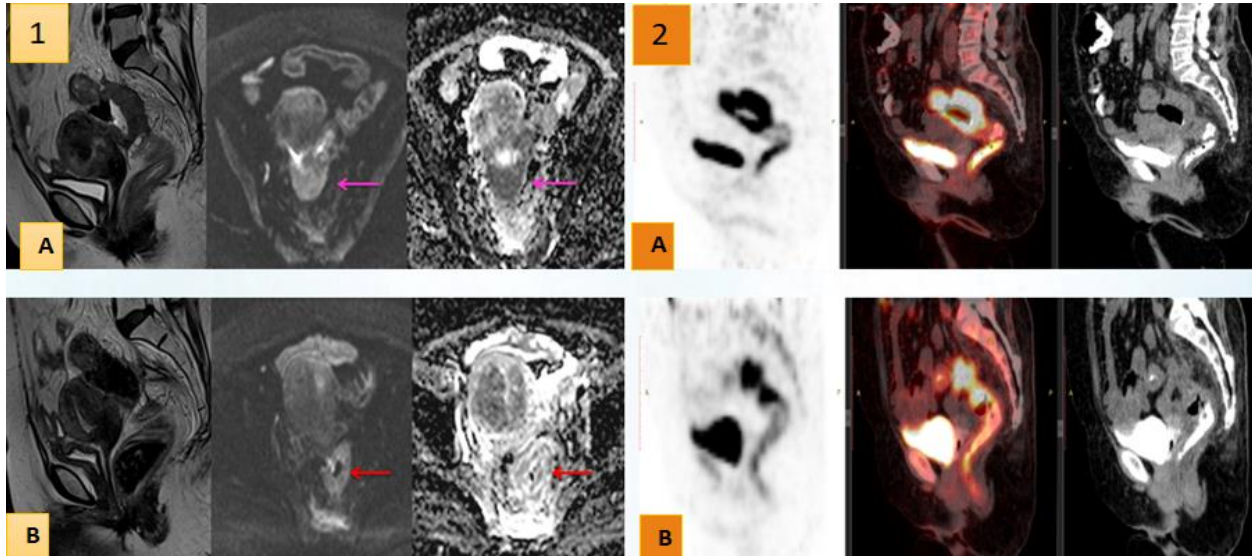
CASE 1: A 55 years old male patient with complete regression after nCRT (mrTRG 1)



**In image 1-** (A) Initial , (B) post therapy sagittal T2WI, axial DWI & ADC images, ADC values significantly increased from  $0.95 \times 10^{-3} \text{ mm}^2/\text{s}$  to  $1.40 \times 10^{-3} \text{ mm}^2/\text{s}$  post therapy

**In image 2 -** (A)- Initial , (B) post therapy sagittal FDG PET, fused PET/CT & CT images shows intense uptake (SUVmax :15.2) initially to (SUVmax :1.8) post therapy.

#### CASE 2:



**In image 1-** (A) Initial , (B) post therapy sagittal T2WI, axial DWI & ADC images, ADC values  $0.87 \times 10^{-3} \text{ mm}^2/\text{s}$  initially to  $0.90 \times 10^{-3} \text{ mm}^2/\text{s}$  post therapy.

**In image 2 -** (A) Initial , (B) post therapy sagittal FDG PET, fused PET/CT & CT images shows (SUVmax :10.5) initially to (SUVmax :11.0) post therapy.

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