

*Research Article***DW-MRI with Whole Tumor Volume Analysis as A Predictor of Response in Rectal Cancer Treatment****Ahmed M. Sayed¹, Mohsen A. M², Moustafa Abdel Kader² and Amany S. Gergis³**¹ Department of Radiology, Minia Oncology Center² Department of Radiology, Faculty of Medicine, Minia University³ Department of Clinical Oncology, Faculty of Medicine, Minia UniversityDOI: [10.21608/mjmr.2022.270107](https://doi.org/10.21608/mjmr.2022.270107)**Abstract**

Background: The treatment of rectal cancer has shifted from a primarily surgical approach with radiation therapy or combined chemotherapy and radiation therapy (CRT) toward the preoperative use of neoadjuvant CRT. This shift has resulted in a decrease in the local recurrence rate and an increase in the rates of long-term survival and sphincter preservation. The aim of the study is to investigate & describe the role of whole tumor volume analysis generated from diffusion weighted imaging (DW-MRI), in patients with rectal cancer, as a predictor of response to chemoradiotherapy (CRT).

Methods: This study included forty patients diagnosed with rectal cancer. They managed according to national treatment protocols. Magnetic resonance imaging (MRI) including diffusion-weighted imaging (DWI), before and after CRT was done to all patients. Endoscopy and/or surgery was done to obtain biopsy for histopathological analysis which is the reference standard for pathologic complete response (pCR). **Results:** the tumor volume was shown to be substantially correlate with tumor response, with the responding group (33.5cm³) having a smaller tumor volume than the non-responding group (65 cm³). **Conclusion:** histogram analysis of the ADC can evaluate the biologic heterogeneity of a tumor, which may have prognostic and predictive consequences.

Keywords: DW-MRI, Rectal cancer, Tumor Volume Analysis**Introduction**

In men, colorectal cancer is the third most prevalent cancer, while in women, it is the second most common.⁽¹⁾ To minimize both under- and overtreatment, imaging has become an important tool in preoperative decision-making.⁽²⁾

Rectal Magnetic resonance R imaging has been utilised to assess chemo-radiotherapy (CRT) utilising morphologic and/or functional Magnetic resonance imaging sequences, however the diagnostic performance of these techniques is variable. Most rectal cancers acquire fibrosis after neoadjuvant (CRT), resulting in lower signal intensity with T2-weighted imaging.⁽³⁾

The Apparent diffusion coefficient (The ADC) can be used to describe tumours and measure treatment-induced changes that may occur before morphologic changes do. Furthermore, by identifying areas of variable diffusivity, histogram analysis of the ADC can evaluate the biologic heterogeneity of a tumour, which may have prognostic and predictive implications.⁽⁴⁾

Histogram techniques are especially well suited to assessing tumor heterogeneity because they may detect various micro-environments that are disguised by mean ADC values. The Brownian motion of water molecules is measured using the ADC technique. Reduced diffusion is associated with poor ADC values in solid tumours. ADC levels are higher in post-

treatment malignancies due to cell death and the removal of restrictive barriers, although high ADC values can also be seen in necrotic foci.⁽⁵⁾

Recent research has discovered that combining the whole-tumor ADC mean with the tumour volume accurately predicts Pathological Complete Response.⁽⁶⁾

Other research has shown that the Apparent Diffusion Coefficient value may be used as a quantitative and objective marker to assess the pathologic response of preoperative CRT in rectal cancer.⁽⁷⁾

Materials and methods

This study included forty patients diagnosed with rectal cancer. They managed according to national treatment protocols.

Detailed history taking and Magnetic resonance imaging (MRI) including diffusion-weighted imaging (DWI), before and after CRT was done to all patients. Endoscopy and/or surgery

was done to obtain biopsy for histopathological analysis which is the reference standard for pathologic complete response (pCR).

Apparent Diffusion coefficient (ADC)

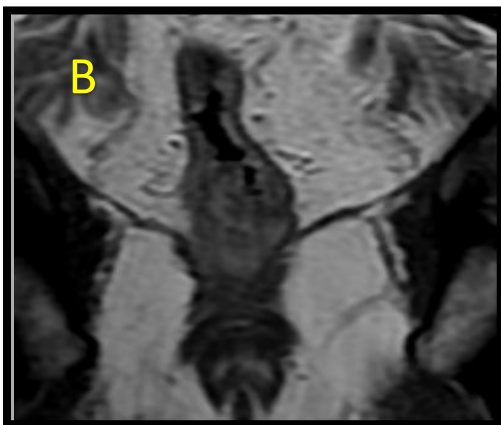
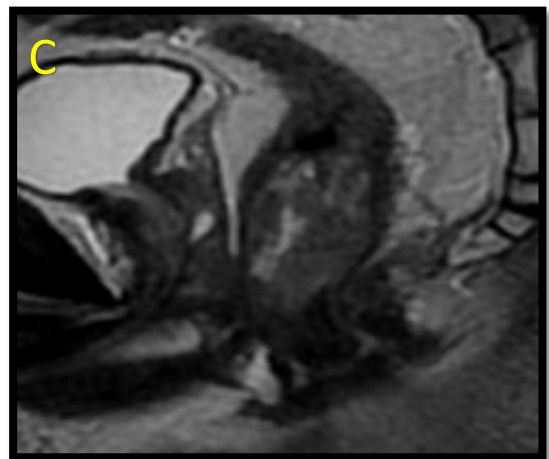
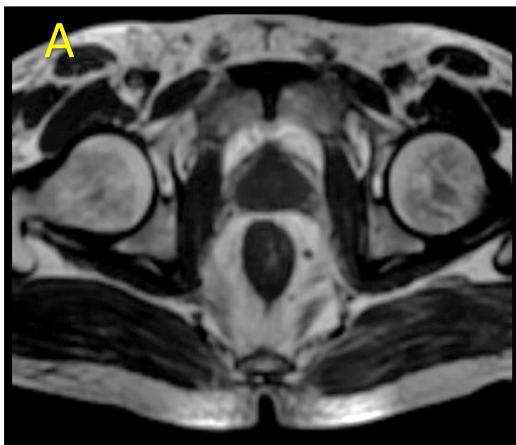
Measurement :

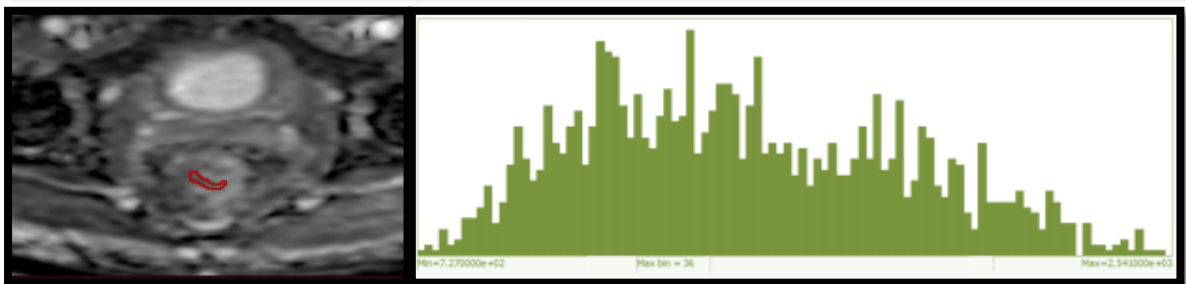
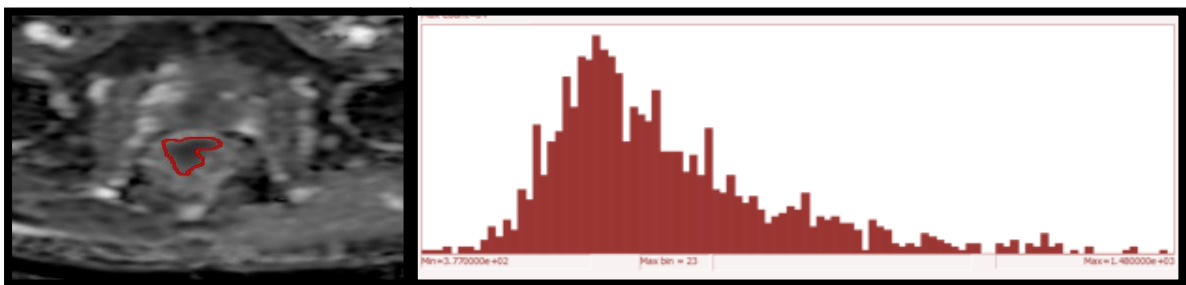
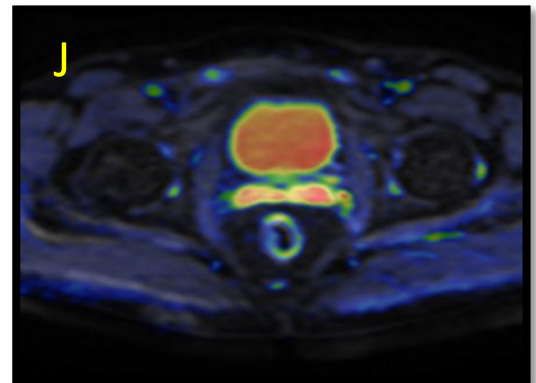
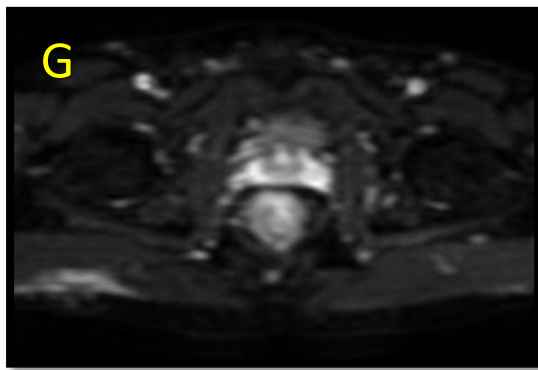
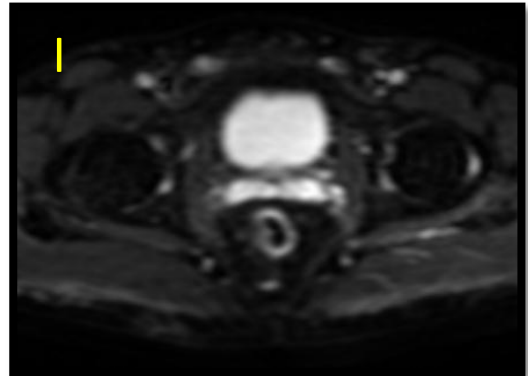
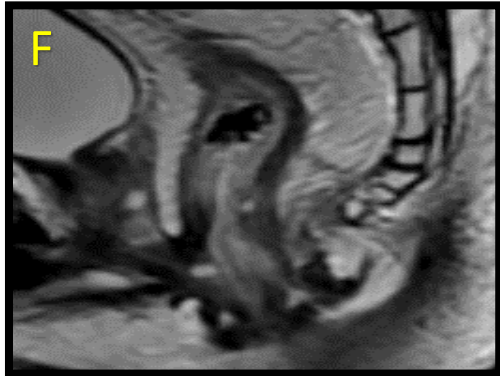
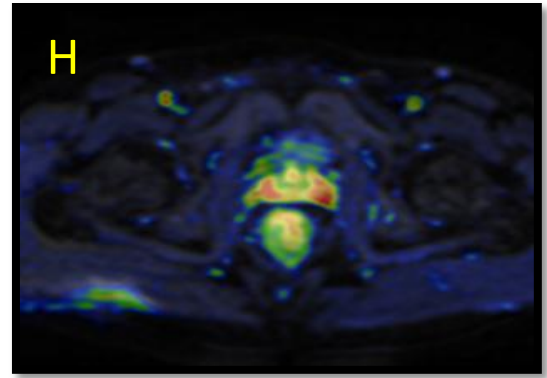
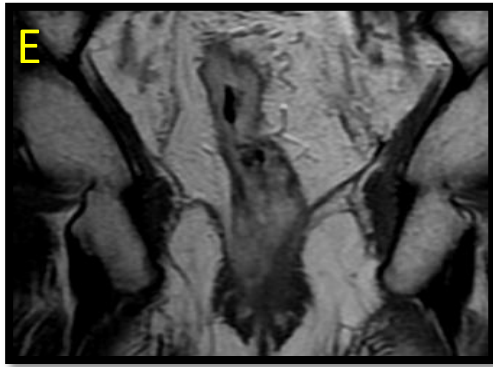
The mean ADC was calculated by positioning multiple regions of interest (ROI) over the tumor in consecutive image sections & then the mean ADC was calculated.

ADC histogram and Whole Tumor Volume Analysis has been done, and comparison of the pre and post CRT was done for evaluation of the skewness and kurtosis of the histogram of the ADC values.

Results

the tumor volume was shown to be substantially correlate with tumor response, with the responding group (33.5 cm³) having a smaller tumor volume than the non-responding group (65 cm³).





	<i>Group</i>			P value
	<i>DP</i>	<i>DR</i>	<i>CR</i>	
Volume cm³(pre)	65 (49-82.8)	33 (21.5-52.5)	40 (29.5-47.5)	0.017*
Volume cm³ (post)	75 (49.3-90)	12 (6-18.5)	0 (0-0)	<0.001*

Discussion

Rectal cancer treatment has changed from a surgical approach with radiation therapy or combination chemotherapy and radiation therapy (CRT) to the use of neoadjuvant CRT before surgery. The local recurrence rate has decreased, but long-term survival and sphincter preservation rates have increased as a result of this change.

Patients who obtain a full response with CRT should have their therapy altered based on their particular risk of local recurrence, and less invasive treatment options (compared to normal rectal surgery) may be used.

The depth of tumor invasion into the rectal wall or mesorectal fascia can be determined by magnetic resonance imaging (MR imaging). MR imaging is utilized to determine the treatment approach because of its excellent accuracy in detecting local tumor development and lymph node involvement—both of which are critical for decision making.

Rectal cancer is considered one of the most frequent gastrointestinal malignancies, accounting for 50 percent to 70 percent of colorectal cancer cases⁽⁸⁾. Surgery, in combination with radiation, chemotherapy, and targeted therapy, are the alternatives during management of rectal cancer. Accurate staging is a critical step in guiding treatment decisions. TNM stage, tumour differentiation degree, and the presence of peritumor lymphatics, vascular infiltration, and nerve infiltration will all influence the rate of rectal cancer recurrence following surgery.⁽⁹⁾

In our study, the tumor volume was shown to be substantially correlate with tumor response, with the responding group (33.5 cm³) having a

smaller tumor volume than the non-responding group (65cm³).

In harmony with some studies like Lee E. S., et al., (2018) as significant correlations between tumor volume and pathologic complete response pCR have been reported.⁽¹⁰⁾ Regarding these findings, pre-treatment tumor volume and TNM stage were considered as a predictor for post chemotherapy response. In our study, the rectal cancer tumor volume was significantly larger in participants who had pelvic lymph node metastasis, compared to those who did not.

Conclusion

Although MR imaging is extensively used for initial staging of rectal cancer, it has limitations when used for restaging following CRT because it is difficult to distinguish fibrosis, desmoplastic response, and colloid from remaining viable tumor. Traditional MR imaging is exclusively utilized for anatomical imaging.

The ADC has been used to describe tumors and measure treatment-induced changes that may occur before morphologic changes do.

Furthermore, by identifying areas of variable diffusivity, histogram analysis of the ADC can evaluate the biologic heterogeneity of a tumor, which may have prognostic and predictive consequences.

References

1. Natally Horvat, Carlos Tavares Rocha C, Clemente Oliveira B, et al., MRI of Rectal Cancer: Tumor Staging, Imaging Techniques, and Management, RadioGraphics 2019; (39): 367–387.
2. Kaur H, Choi H, You YN, et al., MR imaging for preoperative evaluation of primary rectal

- cancer: practical considerations. *Radio Graphics* 2012;32(2):389–409.
3. Horvat N, Veeraraghavan H, Khan M, et al., MR Imaging of Rectal Cancer: Radiomics Analysis to Assess Treatment Response after Neoadjuvant Therapy. *Radiology* 2018; 287, (3):833-843.
 4. Lambregts DMJ, Vandecaveye V, Barbaro B, et al., Vandecaveye V, Barbaro B, et al., Diffusion-weighted MRI for selection of complete responders after chemoradiation for locally advanced rectal cancer: a multicenter study. *Ann Surg Oncol* 2011;18,(8):2224–2231.
 5. Baliyan, V., Das, C. J., Sharma, R., et al., Diffusion weighted imaging: Technique and applications. *World journal of radiology*, 2016;9(8), 785-798.
 6. Liang, C.-Y., Chen, M.-D., Zhao, X.-X., et al., Multiple mathematical models of diffusion-weighted magnetic resonance imaging combined with prognostic factors for assessing the response to neoadjuvant chemotherapy and radiation therapy in locally advanced rectal cancer. *European Journal of Radiology*, 2109;110, 249-255.
 7. Yu, J., Xu, Q., Song, J.-C., et al., The value of diffusion kurtosis magnetic resonance imaging for assessing treatment response of neoadjuvant chemoradiotherapy in locally advanced rectal cancer. *European radiology*, 2017;5(27):1848-1857.
 8. Fujima ‘N., Yoshida, D., Sakashita, T., et al., Prediction of the treatment outcome using intravoxel incoherent motion and diffusional kurtosis imaging in nasal or sinonasal squamous cell carcinoma patients. *European Radiology*, 2016;2: 201-210
 9. Lee, E. S., Kim, M. J., Park, S. C., et al., Magnetic Resonance Imaging-Detected Extramural Venous Invasion in Rectal Cancer before and after Preoperative Chemoradiotherapy: Diagnostic Performance and Prognostic Significance. *European Radiology*, 2018;28(2), 496-505.
 10. Shi, L., Zhang, Y., Nie, K., et al., Machine learning for prediction of chemoradiation therapy response in rectal cancer using pre-treatment and mid-radiation multi-parametric MRI. *Magnetic Resonance Imaging*, 2019; 6:33-40.