The Egyptian Journal of Hospital Medicine (October 2025) Vol. 101, Page 4885-4895

Validity of Magnetic Resonance Imaging in Pre-Operative Assessment of Rectal Cancer

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ABSTRACT

Background: Accurate pre-operative staging of rectal cancer is pivotal for neoadjuvant selection and surgical planning.
Aims: They were to evaluate the diagnostic performance of pelvic MRI (including DWI/ADC) for T/N staging and circumferential resection margin (CRM) and to explore ADC as a biomarker of aggressiveness.
Methods: Prospective study of 65 biopsy-proven rectal adenocarcinoma patients. Females were 61.5% (mean age was 47.2±14.4 years). The patients undergone 1.5-T MRI with high-resolution T2, DWI (b=0/500/1000 s/mm²), and contrast enhancement. Two blinded readers recorded T stage, N stage, CRM status, and mean tumor ADC (three ROIs). Histopathology was the reference.
Results (interpreted): Mean ADC was $0.752\pm0.119\times10^{-3}$ mm²/s (0.5–1.0). MRI called CRM positive in 36.9% versus 24.6% pathologically (κ=0.432, p=0.010), yielding sensitivity 75.0%, specificity 75.5%, accuracy 75.4%, NPV 90.2%, PPV 50.0%—supporting MRI as a strong rule-out test for involved CRM. For T staging, agreement was modest (κ=0.382, p=0.036) with sensitivity 68.4%, specificity 72.5%, accuracy 70.2%; MRI tended to upstage T2 as T3. N staging showed weak, non-significant agreement (κ=0.200, p=0.116) with sensitivity 62.8%, specificity 67.2%, accuracy 68.4%. Lower ADC values were significantly associated with sphincteric invasion, extramural invasion, mesorectal fat stranding, mesorectal fascia invasion, peritoneal involvement, pelvic sidewall affection, and extra-mesorectal adenopathy (all p<0.05).
Conclusion: Pre-operative MRI offers excellent NPV for CRM and moderate accuracy for T staging, while N staging remains challenging. Quantitative ADC correlates with multiple invasive features and may refine risk stratification within multidisciplinary care.
Keywords: rectal cancer; MRI; diffusion-weighted imaging; ADC; circumferential resection margin.

INTRODUCTION

Colorectal cancer is a major worldwide health concern that significantly strains healthcare systems and society at large due to its high incidence and fatality rates. It ranks second among cancers in women and third among cancers in males. Over 1.9 million new cases of colorectal cancer were reported in 2020. About 10–15% of instances of colorectal cancer are localized advanced colorectal cancer (LACRC), owing to age increased, and variations in nutrition, and lifestyle. Patient outcomes are improved by its early discovery and proper treatment [(1)].

Rectal cancer is among the most common causes of cancer-related mortality worldwide, which affects men more frequently than women. While, South-Central Asia and Africa have the lowest incidence rates, Europe and North America have the highest rates [(2)]. A lower socioeconomic standing is linked to a higher chance of developing colorectal cancer, as a result of bad lifestyles like unhealthy diet, smoking, and obesity [(3)]. Magnetic Resonance Imaging (MRI) is a potent method of both functional and morphological imaging. When it comes to rectal cancer staging, it is crucial [(4)].

The purpose of this study is to evaluate patients with rectal cancer pre-operatively using magnetic resonance imaging in conjunction with diffusion studies and to correlate the results of magnetic resonance imaging with the histological information.

PATIENTS AND METHODS

In this investigation, 65 patients with rectal cancer were recruited, presented to the outpatient clinic of colorectal surgery and oncology departments or referred directly to MRI unit in the Radio-Diagnosis Department at Mansoura University hospitals. Philips Gyroscan Intera 1.5T superconducting magnet MRI equipment were used to image all patients using external phased array surface coils (Best, The Netherlands), GE Signa HDxt (Milwaukee, USA) and Siemens Magnetom Avanto (Erlangen, Germany).

All enrolled patients met all:
Inclusion criteria: Age greater than 18 years, rectal adenocarcinoma confirmed by biopsy (0-15 cm until above the anal edge), tumor size as determined by radiography, stage II–III of rectal cancer).

Exclusion criteria: All patients with these criteria should be excluded; people undergoing treatment who have intestinal blockage, prior lower abdominal radiation treatment, another tumor within 5 years, conditions that might make the patient ineligible for this study or materially compromise safety and toxicity evaluation, patients who are contraindicated for MRI due to cardiac pacemaker, cochlear implants, ocular foreign bodies, or claustrophobia.

Received: 07/05/2025
Accepted: 09/07/2025

MRI procedure:

The MRI was conducted using a 1.5-T scanner with phased-array surface coils. The surface coil was positioned on the pelvis of the patient while they were supine. For tumor staging, patients had pelvic MRIs prior to treatment. All patients had to fast for four to six hours before the scans were performed, and within 0.5 to 2 hours before the scan, they had to have a micro enema administered to prepare their bowels. To reduce peristaltic movement, a bolus dose of butylscopolamine (20 mg) was administered intravenously (Buscopan®, Boehringer Ingelheim B.V., Ingelheim, Germany). A contrast-enhanced strategy was used, this entailed injecting 0.2 mL/kg of contrast material based on Gd at a speed of 3.0 mL/s and then continuing at the same rate to deliver a 20 mL saline infusion.

Common two-dimensional T2 weighted (T2W) fast spin-echo scans in three orthogonal directions (with the transverse pictures angled perpendicular) were part of the standard imaging protocol and the axial echo planar imaging (EPI) and coronal pictures that are aligned with the tumor axis, as the sagittal scan indicates. The DWI series was angled in the same plane as the T2W transverse images. Spectral attenuated inversion recovery (SPAIR) fat suppression was used for the DWI sequence (b values 0, 500, 1000 s/mm2; TR/TE 4147/66 ms; EPI factor 77); five signals were obtained; with 20 slices and a 0.5 mm slice gap, the acquisition voxel size measured 1.82 × 2.26 × 5.00 mm, and the acquisition time was 6:44 minutes). The device automatically generated ADC maps of isotropic pictures.

MRI ADC measurement and assessment:

Interpreting rectal MRI scans was done blinded to the pathological findings. On successive tumor slices from the ADC map, we manually delineated the areas of interest (ROIs) (b = 1000 s/mm2). By choosing the mean ADC of the rectal mass that computed using three different areas of interest (ROIs) within the tumor from the images. Based on their isotropic DWI, these regions were marked as restricted within the ADC mapping, and the average of ADC value was then determined. The lymph nodes and main tumor were located using T2W sequencing. In order to prevent the T2W shine-through effect, every ROI that matched the ADC map's greatest cross-sectional tumor size was identified. This method made it easier to distinguish between normal tissue and the tumor (Figure **1**).

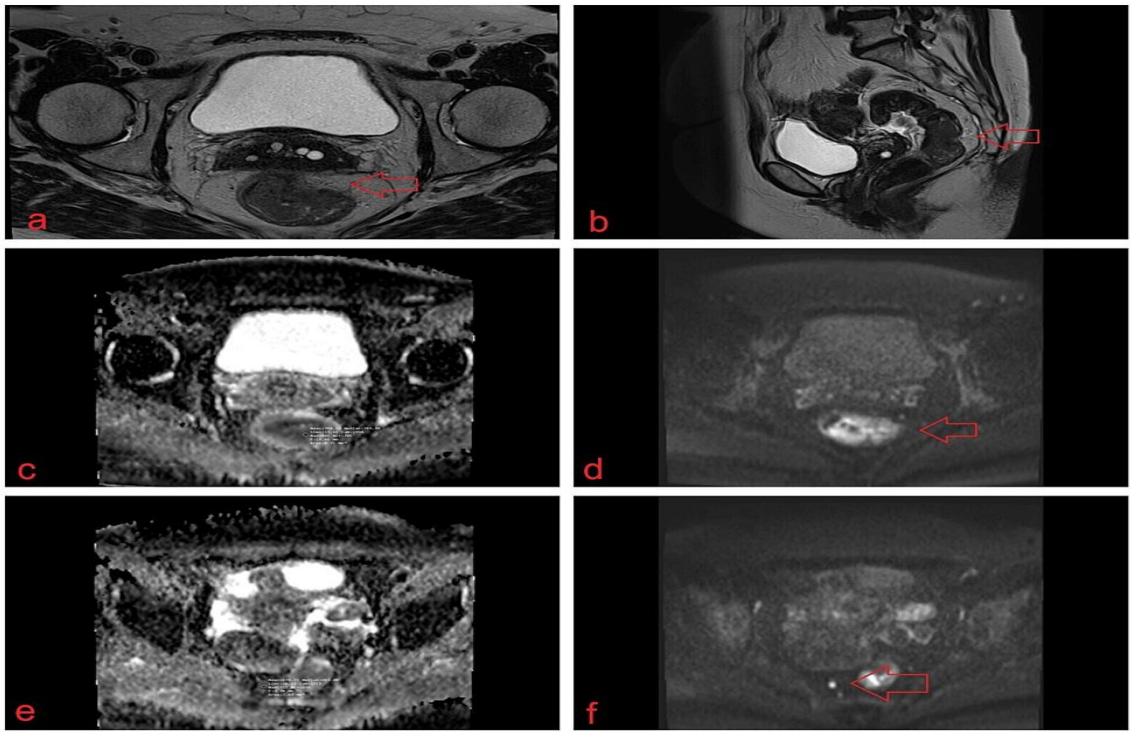
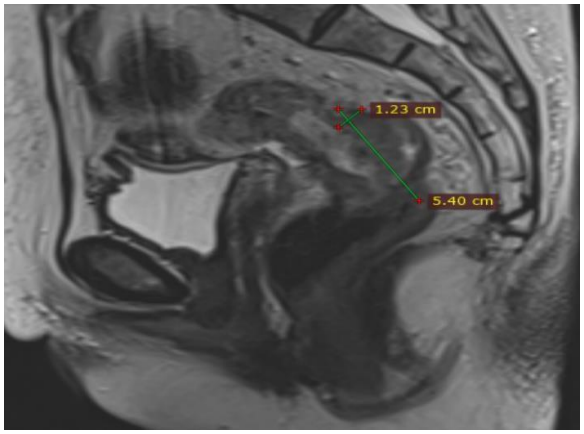


Figure (1): Mesorectal fascia is involved in rectal cancer staged as T3bN2, which is also linked to several enlarged mesorectal lymph nodes. ADC values for suspicious lymph nodes were 0.678 * 10^{-3} mm^2/s and 0.748 * 10^{-3} mm^2/s for rectal cancer. Rectal cancer high-b value (b = 1000 s/mm^2) DWI picture; (c) lymph node ADC map; (d) axial T2; (b) sag T2; (c) lymph node ADC map; and (f) lymph node high-b value (b = 1000 s/mm^2). Diffusion-weighted imaging is known as DWI; apparent diffusion coefficient is known as ADC.



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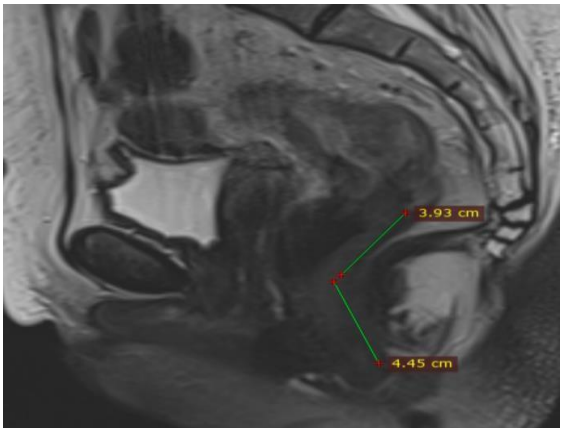

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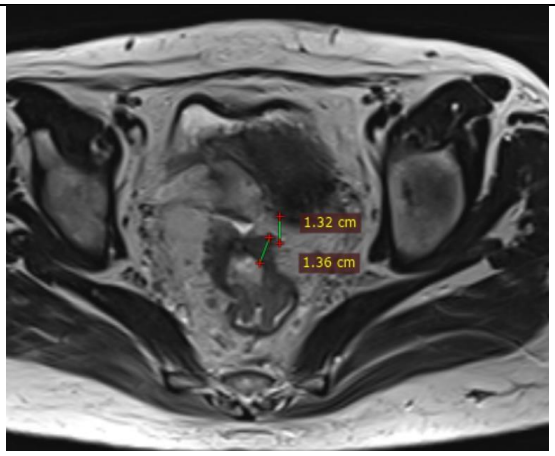

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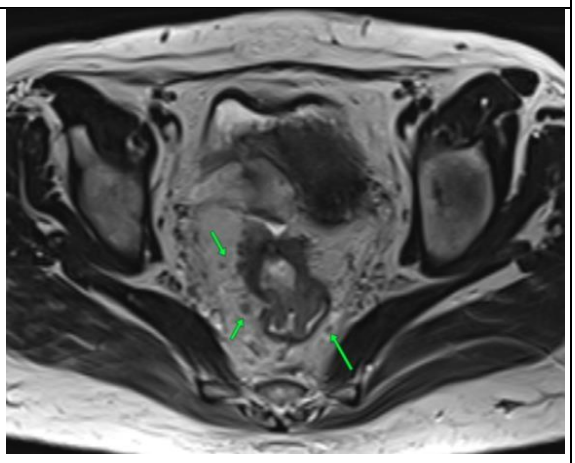

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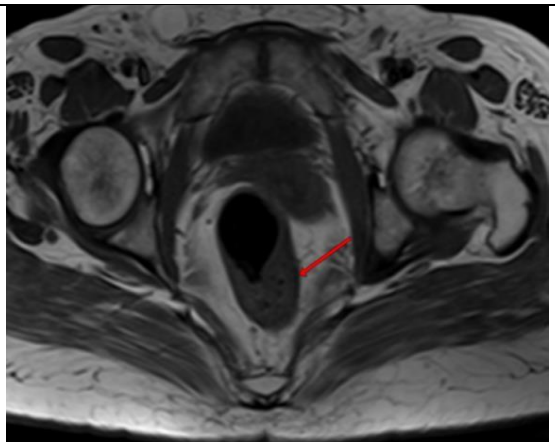

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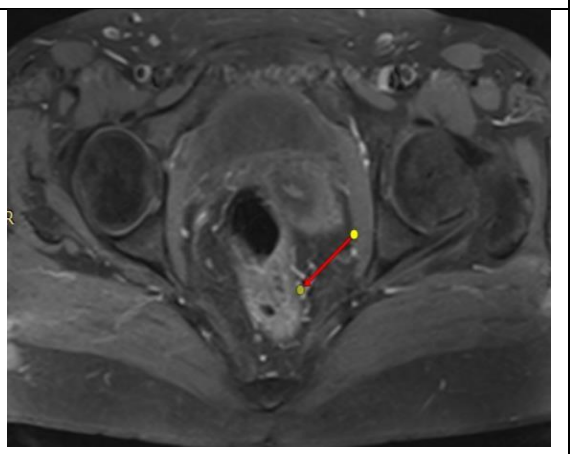

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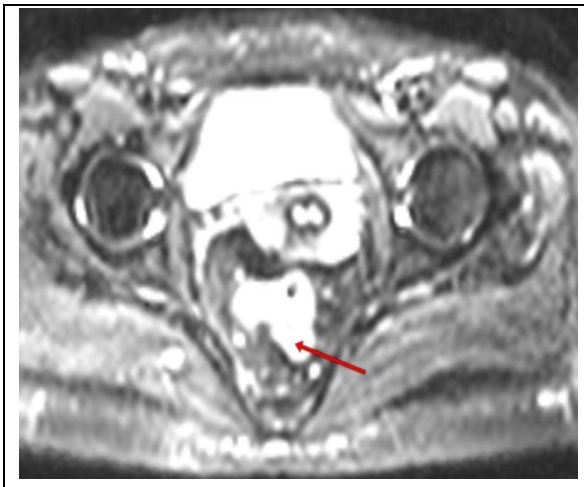

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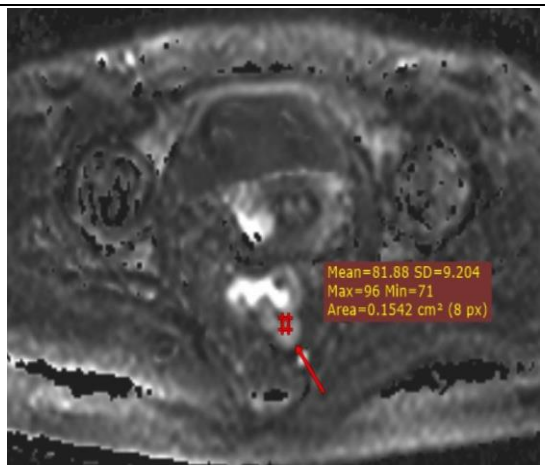

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Figure (2): MRI showing the rectal area before surgery. DWI and ADC maps, which show the upper and middle third rectal mass lesion, are shown in (a), (b) sagittal high-resolution T2WI, (c), (d) axial high-resolution T2WI, (e), and (f) pre- and post-contrast T1 (g). The maximal length of the lesion is 5.4 cm, and its maximum thickness is 1.2 cm. At the post-contrast study, the lower end had moderate T2 SI and heterogeneous augmentation, measuring about 8.4 cm from the anal verge (red arrow in f). It involved two quadrants circumferentially, from 1-7 o'clock with EMDI opposite to 11-2 o'clock about 13 mm and distance from mesorectal fascia about 13mm. There were numerous mesorectal adenopathies identified (green arrow in d). The observed ADC values were approximately 0.81 X10-3 mm2 /s, indicating restricted diffusion. The histopathological staging was T3 N0 with (-ve CRM) and no EMV, while the MRI-based staging was cT3c N2 with (-ve CRM) and no EMVI.

Ethical Considerations:

The study was approved by the Research Ethics Committee of Mansoura University. Written informed consent was obtained from all patients before enrollment. The consent form explicitly detailed their agreement to participate and to permit publication of anonymized data, ensuring confidentiality and privacy. All procedures were conducted in accordance with the ethical principles of the World Medical Association Declaration of Helsinki for research involving human subjects.

Statistical analysis

Using SPSS software, version 25 (SPSS Inc., PASW Statistics for Windows version 25), data analysis was carried out. The SPSS Inc., Chicago. To explain qualitative data, percentages and numbers were used. The mean ± standard deviation (SD) was used to characterize quantitative data. Data standard deviation after the Kolmogorov-Smirnov test for determining whether the distribution of the data is normal. The significance of the findings was assessed at the (≤0.05) level.

RESULTS

Study Population and Demographics:

The study cohort comprised 65 patients with rectal cancer recruited from the MRI unit at Mansoura University Hospitals. The patient population showed a pronounced female predominance with 40 women's (61.5%) compared to 25 men's (38.5%). The age range was 24-80 years, with an average of 47.2 ± 14.37 years. The age group of 41-50 years old accounted for 36.9% of cases.

Clinical Presentation Profile:

The clinical manifestations revealed a distinct symptom hierarchy with bleeding per rectum being the overwhelmingly predominant symptom affecting 87.7% of the patients. Secondary presentations included abdominal pain (10.8%), weight loss (6.2%), and painful defecation (3.1%). This symptom profile aligns with typical rectal cancer presentations, where rectal bleeding serves as the primary warning sign.

Apparent Diffusion Coefficient (ADC) Values:

The study analyzed quantitative imaging parameters with ADC values averaging $0.752 \pm 0.119 \times 10^{-3}$ mm²/s with a range of $0.5\text{-}1.0 \times 10^{-3}$ mm²/s. These values serve as important biomarkers for tumor characterization and correlate significantly with various tumor characteristics.

T2 Signal Intensity Distribution:

Regarding T2 signal intensity characteristics, the vast majority of tumors (90.8%) demonstrated intermediate signal intensity, while low and high intensity signals were observed in 6.2% and 3.1% of the cases respectively. This predominance of intermediate signal

intensity reflects the typical imaging appearance of rectal adenocarcinomas.

Rectal Segment Involvement:

The anatomical distribution analysis showed upper rectal involvement was most common at 56.9%, followed by middle rectal at 55.4%. Lower rectal involvement was observed in 24.6% of cases. Combination patterns included upper and middle rectal involvement (27.7%) and middle and lower involvement (12.3%). Distal anorectal junction involvement occurred in 18.5% of cases.

Invasion Patterns and Distal Resectability:

The study documented various invasion patterns critical for surgical planning. Sphincteric invasion was reported in 12.3% of the cases, while extramural invasion was significantly more common at 78.5%. Mesorectal fat stranding was present in 81.5% of the cases, and mesorectal fascia invasion occurred in 78.5%. Extramural vascular invasion (EMVI) was identified in 18.5% of the cases.

Extra-rectal Extension:

The analysis of regional spread patterns revealed peritoneal involvement in 24.6% of cases and pelvic sidewall affection in 24.6%. Extra-mesorectal adenopathies were present in 30.8% of cases, while other pelvic viscera involvement was documented in 18.5%. Pelvic collection was rare, occurring in only 3.1% of cases.

Lymph Node and Bone Marrow Assessment:

Multiple lymph nodes were affected in 55.4% of the cases, indicating significant nodal involvement. Pelvic bone marrow signal intensity was abnormal in 6.2% of cases, suggesting potential bone marrow infiltration or reactive changes.

Evaluation of Circumferential Resection Margin (CRM):

The examination of the margin condition of circumferential resection revealed notable differences between MRI and pathological assessment. MRI identified positive CRM in 24 cases (36.9%), while pathological examination confirmed positive CRM in 16 cases (24.6%) **(figure 3)**. This indicates that MRI tends to overestimate CRM involvement compared to the gold standard pathological assessment.

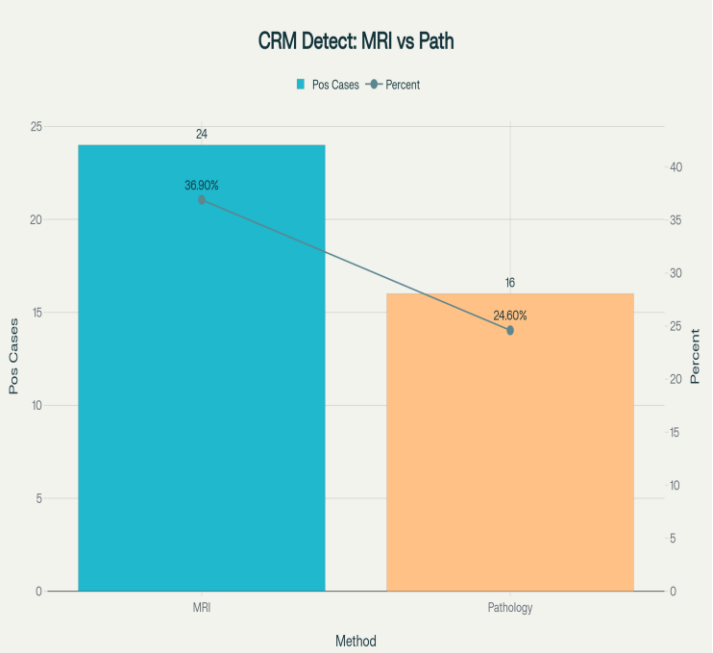

Figure (3): Comparison of CRM Detection: MRI vs Pathology.

CRM Performance Metrics:

MRI demonstrated **moderate diagnostic performance for CRM detection** with the following metrics compared to pathology **(Table 1)**:

Table (1): Comparison of Circumferential Resection Margin (CRM) Detection: MRI vs Pathology, □: Kappa agreement coefficient

Radiological Findings	Pathological findings				?? □	P
	CRM negative (n= 49)		CRM positive (n= 16)			
	No	%	No	%		
CRM negative (n= 41)	37	75.5	4	25	0.432	0.010*
CRM positive (n= 24)	12	24.5	12	75		
Sensitivity	75 %					
Specificity	75.5 %					
Accuracy	75.4 %					
NPV	90.2 %					
PPV	50 %					

*: P < 0.05; NPV: negative predictive value, and PPV: positive predictive value.

The analysis showed mild statistically significant agreement between MRI and pathology in CRM detection. The high NPV (90.2%) indicates that MRI is reliable in ruling out CRM involvement, while the lower PPV (50.0%) suggests that positive MRI findings should be interpreted with caution.

Tumor Staging Assessment:

T-Stage Distribution:

- **Radiological T-Stage Findings**

MRI assessment revealed that the T3 stage was the most prevalent, accounting for 60.0% of cases, followed by T4 stage in 24.6% of cases (**Figure 4)**. The remaining 15.4% comprised other T-stages.

- **Histopathological T-Stage Findings**

Pathological examination confirmed T3 as the predominant stage in 69.2% of cases, with T2 and T4 stages each representing 9.2% of cases **(Figure 4)**.

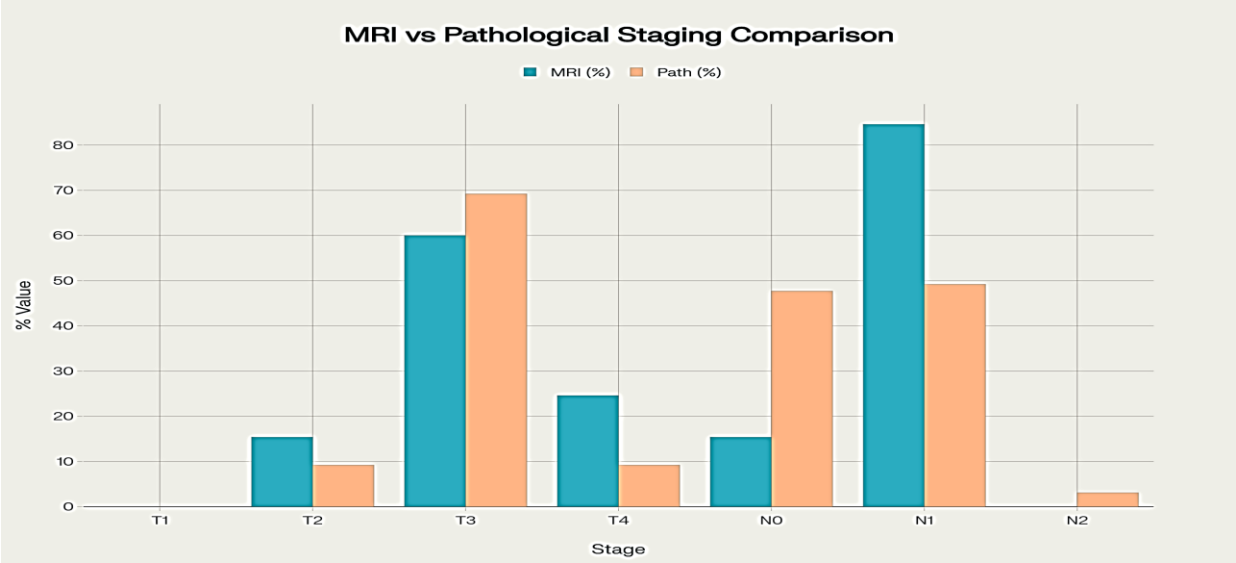

Figure (4): Grouped bar chart comparing MRI staging percentages to pathological staging percentages for T and N stages.

- **T-Stage Performance Metrics**

MRI performance for T-stage detection showed MRI and histology have a weakly statistically significant agreement in detecting T-stages **(Table 2)**.

Table (2): MRI T staging performance metrics, □: Kappa agreement coefficient

Radiological Findings	Pathological findings								□	P
	T0 (n= 8)		T2 (n= 6)		T3 (n= 45)		T4 (n= 6)			
	No	%	No	%	No	%	No	%		
T2 (n= 10)	2	25	6	100	2	4.4	0	0	0.382	0.036*
T3 (n= 39)	4	50	0	0	33	73.3	2	33.3		
T4 (n= 16)	2	25	0	0	10	22.2	4	66.7		
Sensitivity	68.4 %									
Specificity	72.5 %									
Accuracy	70.2 %									
NPV	76.8 %									
PPV	68.8 %									

*: P < 0.05; NPV: negative predictive value, and PPV: positive predictive value.

N-Stage (Lymph Node) Assessment:

- **Radiological Findings**

  MRI demonstrated lymph node involvement in 84.6% of cases **(Table 3)**, indicating widespread nodal involvement in the study population.

- **Histopathological N-Stage Distribution**

  As shown in table 3 pathological examination notably revealed less nodal involvement compared to MRI data.

- **N-Stage Performance Metrics**

Notably, there was weak non-statistically significant agreement between MRI and pathology for N-stage detection **(Table 3)**, indicating this as the most challenging parameter for MRI assessment.

Table (3): MRI N staging performance metrics, □: Kappa agreement coefficient

Radiological Findings	Pathological findings						□	P
	N0 (n= 31)		N1 (n= 32)		N2 (n= 2)			
	No	%	No	%	No	%		
N0 (n= 10)	10	32.3	0	0	0	0	0.200	0.116
N1 (n= 32)	14	45.2	18	56.3	0	0		
N2 (n= 23)	7	22.6	14	43.8	2	100		
Sensitivity	62.8 %							
Specificity	67.2 %							
Accuracy	68.4 %							
NPV	66.8 %							
PPV	72.6 %							

*: P < 0.05; NPV: negative predictive value, and PPV: positive predictive value.

Comparative Performance Analysis:

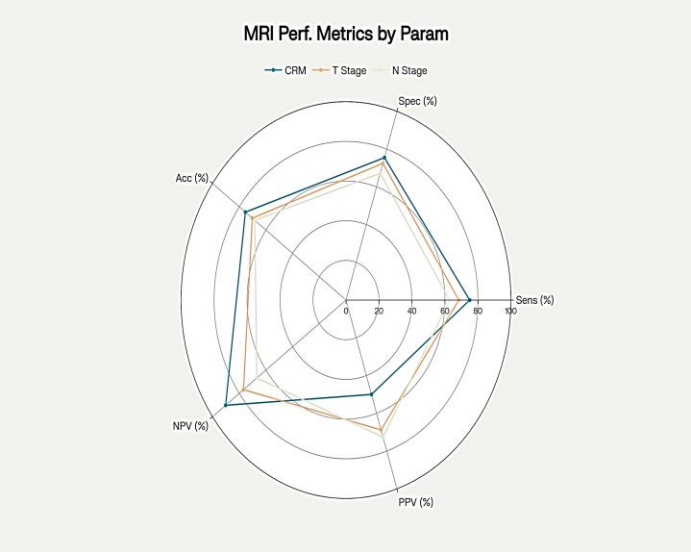

Figure (5): MRI Performance Metrics Comparison: detection using CRM, T Stage, and N Stage.

The radar chart above illustrates the comparative performance of MRI across different parameters. CRM detection showed the highest overall performance, particularly with excellent NPV (90.2%), while N-stage detection demonstrated the lowest performance metrics across all parameters **(Figure 5)**.

Pathological Characteristics:

- **Histological Types**

The pathological analysis revealed diverse tumor types [table 4].

Table (4): Distribution of Pathological Types in Rectal Cancer Cases

Pathological Type	Cases	Percentage
Invasive moderately differentiated adenocarcinoma	39	60%
Mucoid adenocarcinoma	8	12.3%
Poorly differentiated adenocarcinoma	8	12.3%
Signet ring carcinoma	4	6.2%
Other subtypes	6	9.3%

Quantitative Imaging Biomarkers and Correlations:

- ADC Values and Invasion Patterns

Cases with various invasion patterns showed significantly lower ADC values compared to non-invasive cases. This included Sphincteric invasion, Extramural invasion, Mesorectal fat stranding and Mesorectal fascia invasion **(Table 5)**.

Table (5): association between the tumor's local invasive status and its ADC value

Variables	ADC value (10^{-3} mm²/s)	Test of significance	P value
T2 signal intensity			
Low (n= 4)	**0.7**	**t = -1.631**	**0.103**
Intermediate (n= 59)	**0.751 0.121**		
High (n = 2)	**0.9**		
Sphincteric invasion			
No (n= 57)	**0.770 ± 0.115**	**t = 3.514**	**0.001***
Yes (n= 8)	**0.625 ± 0.046**		
Extramural invasion			
No (n= 14)	**0.829 ± 0.120**	**t = 2.862**	**0.006***
Yes (n= 51)	**0.731 ± 0.110**		
Mesorectal fat stranding			
No (n= 12)	**0.817 ± 0.140**	**t = 2.137**	**0.037***
Yes (n= 53)	**0.738 ± 0.110**		
Mesorectal fascia invasion			
No (n= 41)	**0.788 ± 0.103**	**t = 3.401**	**0.001***
Yes (n= 24)	**0.692 ± 0.121**		

P: probability; data are expressed as Mean ± SD; t: Independent samples t-test ; *: significant at p< 0.05.

- **ADC Values and Regional Spread**

Similarly, peritoneal involvement, pelvic sidewall affection, and extra-mesorectal adenopathies were all associated with significantly lower ADC values compared to cases without these features, suggesting ADC as a potential biomarker for tumor aggressiveness **(Table 6)**.

Table (6): association between the tumor's regional spread condition and the ADC value

Variables	ADC value (10^{-3} mm²/s)	Test of significance	P value
Peritoneal involvement			
No (n= 49)	**0.769 ± 0.108**	**t = 2.082**	**0.041***
Yes (n= 16)	**0.700 ± 0.137**		
Pelvic side wall affection			
No (n= 49)	**0.778 ± 0.110**	**t = 3.211**	**0.002***
Yes (n= 16)	**0.675 ± 0.113**		
Extra mesorectal adinopathies			
No (n= 45)	**0.776 ± 0.107**	**t = 2.460**	**0.017***
Yes (n= 20)	**0.700 ± 0.130**		
Other pelvic viscera involvement			
No (n= 53)	**0.764 ± 0.106**	**t = 1.716**	**0.091**
Yes (n= 12)	**0.700 ± 0.160**		
Pelvic collection			
No (n= 63)	**0.748 ± 0.118**	**t = -1.819**	**0.074**
Yes (n= 2)	**0.9**		

P: probability; data are expressed as Mean ± SD; t: Independent samples t-test; *: significant at p< 0.05.

DISCUSSION

Early detection of colorectal cancer is vital for improving surviving rates, which is capable of lowering colorectal mortality by almost 50%**.** Early diagnosis and correct staging of Colorectal cancer is essential for the treatment of cancer patients, predominantly in personalized treatment strategies. Currently, among imaging modalities, MRI is the most popular and extensively studied in the loco-regional staging of colorectal cancer [(5)]. Nowadays, the optimum method is believed to be magnetic resonance imaging for assessing patients' pelvises who have colorectal cancer. It is a dependable method with remarkable specificity of up to 92% and great reproducibility. MRI can be used to help design surgical procedures and to categorize individuals for pre-operative chemotherapy or radiation therapy [(6)]. MRI plays a major role in the local staging of rectal cancer, which should be done often for both primary staging and post-treatment evaluation [(7)].

Various functional and molecular imaging methods, encompassing DWI and dynamic contrast-enhanced imaging (DCE), are helpful instruments for determining the response of tumors to treatment and offering insights on their phenotype**.** By using DW-MRI, biologic tissues can be noninvasively characterized based on their water diffusion characteristics [8].

In our investigation, 65 individuals with rectal cancer identified by endoscopy and histopathology or CT colonography were included. All of 65 patients in our investigation were photographed with 1.5T MRI devices that use superconducting magnets. Each selected patient was exposed to full history taking, clinical examination, and MRI examination of the pelvis by external phased array surface coils. Rectal cancer is largely associated with age. We included 65 patients who met the study's eligibility requirements, which were between 24 and 80 years old, with an average age of 47.2 ± 14.37 years. The same conclusion was drawn by **Sun *et al.*** [(10)] who stated that rectum cancer is frequently discovered in the sixth decade of life. These observations are in line with **Basma *et al.*** [10] who discovered that the average age of the subjects in the study was about 60 ± 8.6 years, Also, some studies, found that peak rectal cancer has been induced around 50 years or more [11].

Despite our study, the gender ratio was 1.6:1.0 among female to male patients which is contrary to **Vliegen *et al.*** [12] who found that the ratio was 3:2 among male to female. This is probably because of his much wider group exceeding 400 patients.

According to the clinical presentation, bleeding per rectum was the most common clinical manifestation in 87.7%, then abdominal pain in 10.8%, weight reduction in 6.2% followed by painful defecation in 3.1%. These findings are consistent with **Abdelhamid** [13] who discovered that in 57.9% of his research participants, bleeding via rectum was the most common presenting symptom. Also, **Gamal Eddin *et al.*** [10] discovered that 18 / 24 patients (75%), had bleeding per rectum (17).

In accordance with what described by **Kaur *et al.*** [6] **and Schäfer *et al.*** [14]**,** in few instances of our analysis, hypo-intense conjectures surrounding the tumor on the rectal wall inside the mesorectal fat revealed the related desmoplastic reaction, in our study we found that 53/65 of the patients have desmoplastic reaction with by percent 81%.

Keeping with **Kaur *et al.*** [6] **and Schäfer *et al.*** [14] as regarding the anterior peritoneal reflection (APR), they considered APR as an important parameter because its affection denoted T4a rectal tumors. We identified it as a narrow, linear, hypo-intensity that extended from the bladder dome's upper posterior border to the junction of the rectum's lower third and upper two-thirds.

In our investigation, it was determined that the thick linear hypo-intensity at the APR's anatomical location was involved, only 24.6% of participants in our study showed the anterior peritoneal reflection being invaded. This roughly corresponds with **Gollub *et al.*** [15] who had APR involvement in 26 % of their patient group.

In accordance with what described by **Jhaveri *et al.*** [16] recognizing extra-mural vascular invasion (EMVI) as a noteworthy and distinct risk factor for tumor recurrence, both locally and distantly. In our investigation, it was primarily linked to T3 malignancies. The meso-rectal vein is usually seen as little linear hypo-intensities in the meso-rectal fat that surrounds the rectal wall. Growth of mesorectal veins with intermediate signal strength of the rectal mass was used in our investigation to identify EMVI. In more severe cases, nodularity of the afflicted vein was observed, indicating invasion beyond the venous wall and the formation of "Tumor deposits" in the meso-rectal fat, as they are known, in our study only 18% of the cases show positive EMVI and this is in agreement with **Gamal Eddin *et al.*** [10] who found that 16% of the study cases showed positive EMVI.

With regard to the circumferential resection margin status, we discovered that 41 out of 65 cases were CRM positive utilizing a cut-off distance of roughly 1 mm across the mesorectal fascia and the tumor, 24/65 of Patients' CRM was negative. Based on the pathological analysis, 49 /65 CRM-positive instances were found, 75.4% of MRIs were accurate, with 75% sensitivity and 75% specificity, this is agreed with **Gamal Eddin *et al.*** [10] who stated that MRI accuracy in detection of CRM was 79.1% with sensitivity 80%, specificity 77.8% (17), and also with **Moreno *et al.*** [17], they stated that MRI has a 76% sensitivity and an 88% specificity in identifying the circumferential margin's involvement.

An important source of information on tissue characteristics is the diffusion coefficient that appears (ADC). ADC is a quantitative biomarker that has been

shown to have a number of uses and measures diffusion in biological systems [18].

Regarding the DWI interpretation in our study, restriction in the DWI was found with high SI on the DWI and low SI on the ADC map as well as initially low ADC values of the tumor range between 0.5 and 1. And the mean ADC was $0.752 \pm 0.119 \times 10^{-3}$ mm²/s. These results were similar to those obtained by **El-Kady *et al.*** [19] who found that the ADC values range from 0.4 to 1×10^{-3} mm^2 /s (mean = 0.7×10^{-3} mm^2 /s). The predominant ADC value was 0.8×10^{-3} mm^2 /s and also was similar to those obtained by **Blazic *et al.*** [20] who found the same ADC value for their patients (0.8 x 10-3 mm2 /s).

As regard to the correlation between the ADC value and the tumor invasion in our study showed that the cases with sphincteric invasion, extramural invasion, mesorectal fat stranding, and mesorectal fascia invasion had significantly lower ADC value compared to cases without invasion to these regions. This is agreed with **Akashi *et al.*** [21] who found that there is a negative relationship between tumor aggressiveness and ADC value. In fact, mesorectal fascia invasion, lymph node involvement, and histological differentiation are all correlated with the ADC score in rectal cancer. Also, these findings were concurred by **Elmi *et al.*** [22] who demonstrated that patients which had tumor recurrence had lower baseline ADC values.

The primary worldwide recommendations state that MRI imaging provides the foundation to restage and stage locoregionally in rectal cancer**.** The connection between the tumor and the muscularis propria, as well as the invasion of nearby organs, are directly associated with a tumor's stage [23].

Due to the limitations of MRI in differentiating between T1 and T2, 10 / 65 Patients were classified as T2 (the T1 and T2 stages were merged into a T1 stage, in our investigation); 39 / 65 patients were set up as T3, and 16 / 65 patients were positioned as T4 using MRI staging, the most common stage reported was T3 in 60% These results are similar with those obtained by **Gamal Eddin *et al.*** [10] who showed predominance of T3 stage in their study.

Following histological analysis of the 65 neoplasms, 6/65 were classified as T2, 45/65 as T3, and 6/65 as T4. Our study's discrepancy among MRI and pathological findings was caused by certain tumors' desmoplastic response, which could cause T2 cancers to be mistakenly recognized as T3 as T3 tumors. Additionally, It might lead to fat planes in the rectum to disappear and overestimate T3 tumors as T4 tumors.

In our result MRI showed 68.4% sensitivity, 72.5% specificity, 70.2% accuracy, 76.8% NPV, and 68.8% PPV in the detection of the T stage compared to pathology, this is in agreement with **Mari *et al.*** [24]**,** They discovered a 64.7% overall concordance between the T stage's MRI preoperative findings and ultimate pathology, and this is close to **Zhao *et al.*** [25] who claimed that overall MRI sensitivity in T staging consisted of 85.7%, 78.3% total specificity, and 83.3% overall accuracy, and also close to **Moreno *et al.*** [17] they stated that MRI's T stage sensitivity was 87% (95% CI: 81%-92%) and its specificity was 75% (95% CI: 68%-80%)(25) , also **Wei *et al.*** [26] shown that when reevaluating T-sage, globally, MRI's sensitivity was 81% (95% CI), 67%–90%, and its specificity was 67% (95% CI, 51%–80%).

The evaluation of lymph node extension is still a contentious deciding element. In addition to measuring lymph node size, MRI can identify nodal morphology, which significantly improves the specificity of identifying nodal compromise [6]**.** According to both MRI and histopathology, the most common stage identified in our cases was the N1 stage, which is in line with **Gamal Eddin *et al.*** [10].

In our results, MRI showed 62.8% sensitivity, 67.2% specificity, 68.4% accuracy, 66.8% NPV, and 72.6% PPV in the detection of N stage compared to pathology, this is close to **Park *et al.*** [4] who stated that node-by-node sensitivity and positive predictive value were found to be 58.0% and 61.7%, respectively, on preoperative MRI, and also with **Xu *et al.*** [27] who stated the N stage's MRI accuracy was 63%. Also, these findings agreed with **Gagliardi *et al.*** [28] who stated that sensitivity for malignant lymphadenopathy was of 67%, specificity 71% and accuracy of 69%.

In contrary, **Ang *et al.*** [29] discovered that the T stage MRI accuracy for 114 patients having rectal surgery was 56.6%, and the N stage MRI accuracy was 55.8% when MRI and pathologic data were compared. Perirectal LNs may be too tiny for MRI to show, and it could be challenging to differentiate reactive LN enlargement from involved nodes, according to the disparity between MRI and pathologic data [6].

So, our results support the idea that there is a real problem in global practice with Some differences in T and N staging between pathologic assessment and MRI.

As previously mentioned, the original schematic approach for assessment of cases cancer rectum was provided by **Nougaret *et al.*** [30] and this approach emphasized on the analysis of the tumour MRI characteristics and its respectability features.

CONCLUSION

Rectal MRI, combining high-resolution morphologic with diffusion imaging sequences, offers a reliable preoperative assessment tool for rectal cancer. Its excellent NPV for CRM and correlation of ADC values with tumor invasiveness support its role in multidisciplinary treatment plan. Future enhancements such as integrating quantitative imaging biomarkers and artificial intelligence will add further to personalize therapy and improve outcomes.

Financial support and sponsorship: Nil.
Conflict of Interest: Nil.

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