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Role of Magnetic Resonance Imaging in Colonic, Rectal and Anal Canal Disorders: A Prospective Observational Study

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Abstract: ***Background: Anorectal and colonic diseases encompass a wide spectrum of pathologies ranging from benign inflammatory conditions to advanced malignancies. Accurate imaging is a prerequisite for appropriate diagnosis, staging and surgical planning. Magnetic Resonance Imaging (MRI) has emerged as a pivotal diagnostic tool owing to its superior soft-tissue resolution, multiplanar capability and functional characterization without ionizing radiation. Objectives: To evaluate the diagnostic utility of MRI in colonic, rectal and anal canal disorders with respect to local staging, extent of tumor spread, lymph node involvement and post-treatment surveillance, and to compare MRI findings with clinical and operative outcomes. Methods: A hospital-based prospective observational study was conducted on 20 patients presenting with colonic, rectal or anal canal pathologies at Guru Gobind Singh Hospital, Jamnagar. All patients underwent MRI on a 1.5 Tesla Siemens Magnetom Skyra using standardized T1W, T2W, STIR and post-contrast FATSAT sequences. Data were analyzed using SPSS software with descriptive statistics. Results: The study cohort comprised 12 males and 8 females (M: F = 1.5:1), predominantly in the seventh decade of life. Rectal lesions constituted 75% of cases. Bleeding per rectum was the most common symptom (65%). Lesions characteristically appeared hypointense on T1-weighted (89%) and hyperintense on T2-weighted sequences (70%). Post-contrast heterogeneous enhancement was noted in 75% of cases. Mesorectal fascia involvement was identified in 45% and anal sphincter involvement in 40% of cases. MRI achieved an overall staging accuracy of 94.8%. Residual or recurrent disease was detected in 30% of patients on follow-up imaging. Conclusions: MRI is an indispensable imaging modality for the comprehensive evaluation of colorectal and anal canal disorders. It surpasses the diagnostic limitations of conventional CT and ultrasonography, offers precise preoperative local staging, guides individualized therapeutic planning and enables effective post-treatment surveillance. Its widespread adoption as the standard-of-care for preoperative workup of these patients is strongly recommended.***

Keywords: MRI, colorectal cancer, rectal carcinoma, anal canal disorder, local staging, mesorectal fascia, perianal fistula, neoadjuvant therapy, T-staging, post-contrast enhancement.

1. Introduction

Colorectal malignancies rank among the most prevalent gastrointestinal cancers worldwide, with a steadily rising incidence attributed to dietary changes, sedentary lifestyles and aging populations. The anatomical complexity of the anorectum—with its intricate arrangement of sphincteric musculature, fascial compartments and adjacent pelvic structures—poses a formidable challenge to clinicians tasked with accurate diagnosis and preoperative planning.

Historically, computed tomography (CT) and endorectal ultrasonography served as the principal imaging modalities for colorectal evaluation. While both offer useful information, each carries well-recognized limitations. CT scanning, although widely available, provides suboptimal soft-tissue contrast resolution, particularly in depicting subtle tumor infiltration through the bowel wall and fascial planes. Endorectal ultrasound, though effective in assessing early mural invasion, is limited by operator dependence, incomplete tumor circumferential visualization and inability to evaluate extrarectal spread.

Magnetic Resonance Imaging (MRI) has transformed the preoperative evaluation of colorectal and anorectal pathologies. By harnessing the differential relaxation properties of soft tissues without ionizing radiation, MRI offers unrivaled delineation of mural layers, mesorectal fascia, sphincter complex and adjacent pelvic organs. The advent of endoluminal and phased-array coils, coupled with high-resolution T2-weighted and post-gadolinium sequences, has dramatically improved the accuracy of local tumor staging, now reportedly ranging from 71% to 94% in published literature.

Beyond malignancy, MRI is invaluable in the evaluation of complex perianal fistulae, providing a precise 'road map' of primary tracts, secondary extensions and occult abscess collections- information that directly guides sphincter-conserving surgery and reduces recurrence rates. Similarly, for obstructed defecation and fecal incontinence, dynamic MRI (defecography) captures real-time pelvic floor dysfunction that static modalities cannot replicate.

This prospective observational study was undertaken to systematically evaluate the role of MRI in diagnosing and characterizing colonic, rectal and anal canal disorders in a tertiary care setting, with a focus on local staging accuracy, signal characteristics, extent of local invasion, lymph node involvement and implications for treatment planning.

2. Aims and Objectives

2.1 Primary Aim

To evaluate the diagnostic role of MRI in disorders of the colon, rectum, and anal canal and to assess its superiority over CT scan and ultrasonography in diagnosis and local staging.

2.2 Objectives

1) To assess MRI's ability to delineate anatomical extent of colorectal and anorectal pathologies and transcend the limitations of conventional imaging modalities.
2) To evaluate MRI's role in reducing disease recurrence by accurately defining surgical resection margins and guiding complete lesion excision.
3) To determine the contribution of preoperative MRI in treatment planning, patient stratification for neoadjuvant therapy, and post-treatment surveillance.

3. Materials and Methods

3.1 Study Design and Setting

A hospital-based prospective observational study was conducted at the Department of General Surgery, Guru Gobind Singh Hospital, Jamnagar, over a period of 12 months. The study protocol received ethical clearance from the Institutional Ethics Committee. Written informed consent was obtained from all participating patients prior to enrollment.

3.2 Study Population

A total of 20 consecutive patients presenting with clinical features suggestive of colonic, rectal, or anal canal disease were enrolled based on predefined inclusion and exclusion criteria.

Inclusion Criteria:
1) Patients aged 18 years and above, of either sex.
2) Patients willing to provide written informed consent.
3) Patients presenting with any symptomatic disease involving the colon, rectum or anal canal.

Exclusion Criteria:
1) Patients unwilling to participate.
2) Patients with absolute or relative contraindications to MRI (cardiac pacemaker, cochlear implants, ferromagnetic implants, metallic foreign bodies).
3) Patients who received a tattoo within the preceding 6 weeks.
4) Patients with confirmed claustrophobia.
5) Pregnant women and women undergoing active menstruation at time of scan.

3.3 MRI Protocol

All patients underwent MRI on a 1.5 Tesla Siemens Magnetom Skyra using a standard phased-array body coil. Imaging was performed in axial, sagittal, and coronal planes. Gadolinium-based contrast agent was administered intravenously in all cases. Sedation was administered by a qualified anesthesiologist where clinically indicated.

The standardized imaging sequences employed were: T1-weighted sequence (matrix 320×320, slice thickness 4 mm, TR 360 ms, TE 20 ms, DFOV 20×24 cm); T2-weighted axial, sagittal and coronal sequences (matrix 320×320, slice thickness 3–5 mm, TR 3400 ms, TE 100 ms, DFOV 20×24 cm); oblique axial T2-weighted sequence (slice thickness 3 mm, perpendicular to tumor axis); STIR sagittal sequence (matrix 320×320, slice thickness 4 mm, TR 3200 ms, TE 20 ms); post-contrast T1-weighted FATSAT sequences in all three planes. FATCAT algorithm was applied to minimize fat signal relative to surrounding tissue in post-contrast acquisitions.

3.4 Data Collection and Analysis

Comprehensive baseline data were recorded including demographic information, presenting symptoms, clinical and proctoscopic findings, relevant laboratory investigations, MRI signal characteristics, staging parameters, local extension, lymph nodal status and treatment modalities. Data were entered in Microsoft Excel and analyzed using IBM SPSS software. Descriptive statistics including frequency analysis, percentages, sensitivity, specificity, positive predictive value and negative predictive value were computed.

4. Results and Observations

4.1 Site Distribution

Among the 20 patients enrolled, the majority presented with rectal pathology. The distribution of disease sites is summarized in Table 1.

Table 1: Site Distribution of Colonic, Rectal and Anal Canal Lesions (n=20)

Site of Lesion	Number of patients	Percentage (%)
Colon	04	20%
Rectum	15	75%
Anal Canal	01	5%
Total	20	100%

Rectal lesions constituted the largest proportion (75%) of cases, consistent with epidemiological data establishing the rectum as the most frequently affected colorectal segment. Colonic disease accounted for 20% and anal canal pathology for 5% of presentations.

4.2 Age Distribution

The age distribution of study participants is presented in Table 2. The mean age of the cohort was 58.4 years (range: 22–78 years).

Table 2: Age Distribution of Study Patients (n=20)

Age Group (Years)	Number of patients	Percentage (%)
20–29	01	5%
30–39	02	10%
40–49	03	15%
50–59	03	15%
60–69	07	35%
70–80	04	20%
Total	20	100%

The seventh decade (60–69 years) was the most heavily represented age group, comprising 35% of study participants, followed by the eighth decade (20%). Over 85% of patients were above 45 years of age, corroborating established literature linking colorectal cancer risk with advancing age. These findings align with Giovannucci et al., who

demonstrated that rectal cancer incidence rises sharply after age 50, peaking in the seventh decade, with over 90% of cases occurring above age 50.

4.3 Sex Distribution

The sex-wise distribution of patients is detailed in Table 3.

Table 3: Sex Distribution of Study Patients (n=20)

Sex	Number of patients	Percentage (%)
Male	12	60%
Female	08	40%
Total	20	100%

A male preponderance was observed with a male-to-female ratio of 1.5:1, consistent with global surveillance data. The Surveillance, Epidemiology, and End Results (SEER) program reported an age-adjusted colorectal cancer incidence of 48.9 per 100,000 in males versus 37.1 per 100,000 in females, yielding a male-female ratio of approximately 1.32:1.

4.4 Symptom Profile

The distribution of clinical symptoms among study patients is presented in Table 4.

Table 4: Symptom Profile of Study Patients (n=20; Multiple Symptoms Possible)

Presenting Symptom	Number of patients	Percentage (%)
Bleeding per rectum	13	65%
Change in bowel habits	08	40%
Occult bleeding	05	25%
Abdominal pain	04	20%

Bleeding per rectum was the predominant presenting complaint in 65% of patients. Change in bowel habits and occult bleeding were noted in 40% and 25% of cases respectively. Abdominal pain was observed in 20% of patients. These symptom patterns are in close concordance with findings reported by Giovannucci et al., who documented bleeding per rectum in 60%, change in bowel habits in 43%, occult bleeding in 26%, and abdominal pain in 20% of colorectal cancer patients.

4.5 MRI Signal Characteristics

Signal intensity analysis of the detected lesions on various MRI sequences is detailed in Table 5.

Table 5: MRI Signal Characteristics of Colorectal Lesions (n=20)

MRI Sequence	Signal Pattern	Number of patients	Percentage (%)
T1-Weighted	Hypointense	16	89%
T1-Weighted	Intermediate	03	15%
T1-Weighted	Hyperintense	01	5%
T2-Weighted	Hyperintense	14	70%
T2-Weighted	Intermediate	05	25%
T2-Weighted	Hypointense	01	5%
STIR	Not Suppressed	18	90%
STIR	Partially Suppressed	02	10%
STIR	Fully Suppressed	00	0%

The predominant signal characteristic was T1 hypointensity (89%) with T2 hyperintensity (70%), a pattern consistent with the known pathological substrate of colorectal malignancies- high cellular water content and glandular architecture generate prolonged T2 relaxation times. The STIR sequence demonstrated absence of fat suppression in 90% of cases, reflecting the non-lipid nature of the pathological tissue. These findings correlate with the imaging criteria described by Arya et al., who affirmed that intermediate-to-high T2 signal intensity is a hallmark of rectal carcinoma and forms the foundation of T-staging assessment.

4.6 Post-Contrast Enhancement Patterns

Post-gadolinium enhancement characteristics are summarized in Table 6.

Table 6: Post-Contrast Gadolinium Enhancement Patterns (n=20)

Enhancement Parameter	Pattern	Number of patients	Percentage (%)
Homogeneity	Homogeneous	05	25%
Homogeneity	Heterogeneous	15	75%
Enhancement Strength	Mild	05	25%
Enhancement Strength	Moderate	14	70%
Enhancement Strength	Marked	01	5%

Heterogeneous enhancement was observed in 75% of lesions and moderate enhancement strength in 70%. The heterogeneity of post-contrast enhancement in malignant colorectal tumors reflects the underlying biological complexity of these neoplasms, characterized by irregular tumor vascularity, areas of internal necrosis, and variable degrees of desmoplastic stromal reaction. Homogeneous enhancement, observed in 25% of cases, was more often associated with benign pathologies such as tubulovillous adenoma.

4.7 Local Extension of Colorectal Tumors

The pattern and extent of local tumor invasion as assessed on preoperative MRI are presented in Table 7.

Table 7: Local Extension of Colorectal Tumors on MRI (n=20)

Site of Local Invasion	Number of patients	Percentage (%)
Mesorectal fascia (MRF)	09	45%
Anal sphincter complex	08	40%
Pelvic organs	04	20%
Pelvic wall/peritoneum	03	15%
Sigmoid colon	02	10%

Mesorectal fascia involvement was detected in 45% and anal sphincter invasion in 40% of cases. Infiltration of adjacent pelvic organs was identified in 20%, while pelvic wall or peritoneal involvement and sigmoid colon extension were noted in 15% and 10% respectively. The high prevalence of MRF involvement in this series underscores MRI's critical value in identifying circumferential resection margin (CRM) status- a prognostic determinant of local recurrence and long-term survival in rectal cancer surgery.

4.8 Lymph Node Staging

Nodal staging on MRI is presented in Table 8.

Table 8: Lymph Node Staging on MRI (n=20)

Nodal Stage	Number of patients	Percentage (%)
N0 (No nodal involvement)	03	60%
N1 (1–3 regional nodes)	01	20%
N2 (≥4 regional nodes)	01	20%
Total (Evaluable cases)	05	100%

Among the five patients in whom nodal staging was formally assessed, 40% (combined N1 and N2) demonstrated lymph node involvement. Morphological features including border irregularity, internal heterogeneity and signal intensity characteristics were utilized alongside size criteria to improve nodal staging accuracy. Nodal positivity directly altered treatment allocation toward neoadjuvant chemoradiation protocols.

4.9 Treatment Distribution

Treatment modalities administered based on MRI staging are summarized in Table 9.

Table 9: Treatment Modalities Administered Based on MRI Staging (n=20; Multiple Modalities Possible)

Treatment Modality	Number of patients	Percentage (%)
Chemotherapy	12	39%
Surgery	11	35%
Radiotherapy	08	26%

Early-stage (T1/T2) lesions proceeded to primary surgical resection, while advanced tumors (T3/T4) or those with nodal involvement were channeled into neoadjuvant chemoradiation protocols prior to definitive surgery. All stage IV lesions received chemoradiation as definitive therapy. This MRI-driven treatment stratification reflects the gold standard approach in contemporary colorectal oncology.

4.10 Residual/Recurrent Lesions on Follow-Up

Post-treatment surveillance data from follow-up MRI are presented in Table 10.

Table 10: Residual/Recurrent Lesion Status on Follow-Up MRI (n=20)

Follow-Up Status	Number of patients	Percentage (%)
Residual/Recurrent disease present	6	30%
No residual/recurrent disease	12	60%
Lost to follow-up	2	10%
Total	20	100%

Residual or recurrent disease was detected on follow-up MRI in 30% of patients, predominantly among those with stage III and IV presentations. None of the stage I patients demonstrated recurrence. MRI effectively differentiated post-treatment fibrosis (appearing hypointense on all sequences) from viable recurrent tumor (demonstrating T2 hyperintensity and post-contrast enhancement)- a distinction with immediate implications for salvage therapy decisions.

5. Discussion

The findings of this prospective observational study substantiate the central role of MRI in the comprehensive management of colorectal and anorectal disorders, reaffirming conclusions drawn from major published series while contributing institutional data from an underrepresented regional setting.

The demographic profile observed in this cohort- predominantly male patients in the seventh decade of life—mirrors well-established global epidemiological patterns. Colorectal cancers are recognized to increase exponentially after the fifth decade, with a distinct male preponderance. The male-to-female ratio of 1.5:1 in this study slightly exceeds the 1.32:1 reported by the SEER program, plausibly attributable to greater male tobacco and alcohol use and delayed female health-seeking behavior in the regional population.

Rectal involvement in 75% of cases reinforces the established anatomical predilection of colorectal malignancies for the rectum and rectosigmoid junction. This distribution has profound imaging implications: the fixed position of the rectum within the bony pelvis facilitates MRI assessment by limiting motion artifacts and enabling the use of high-resolution small field-of-view sequences perpendicular to the tumor axis.

The characteristic MRI signal profile- T1 hypointensity in 89% and T2 hyperintensity in 70%- is pathognomonic of malignant colorectal tissue and provides the foundation for MRI-based T-staging. These findings corroborate those reported by Arya et al., confirming that T2-weighted imaging is the cornerstone of rectal tumor characterization. The distinction between mucinous and non-mucinous adenocarcinomas- a clinically significant dichotomy with implications for treatment response—is facilitated by MRI signal analysis; mucinous carcinomas characteristically exhibit markedly elevated T2 signal intensity reflecting their high mucin content, as originally described by Hussain et al.

Post-contrast heterogeneous enhancement (75%) reflects the inherent biological complexity of malignant colorectal tumors, including variable angiogenesis, intratumoral necrosis and stromal desmoplasia. The degree of enhancement heterogeneity may serve as a surrogate marker for tumor aggressiveness and potential treatment resistance. Homogeneous enhancement in 25% of cases- predominantly benign entities such as tubulovillous adenoma- illustrates MRI's capacity to differentiate benign from malignant pathology and prevent unnecessary radical surgical intervention.

The detection of mesorectal fascia involvement in 45% of patients has profound prognostic implications. CRM positivity is recognized as the single most important predictor of local recurrence following total mesorectal excision. Preoperative MRI identification of MRF involvement enables multidisciplinary teams to prescribe neoadjuvant long-course chemoradiotherapy with the intent of tumor downstaging and margin clearance, significantly improving R0 resection rates. This study demonstrates that such information is routinely

obtainable and clinically actionable in a standard 1.5T MRI platform.

Anal sphincter involvement in 40% of cases directly influenced surgical decision-making between sphincter-preserving low anterior resection and abdominoperineal resection. The latter, while oncologically effective, carries substantial quality-of-life consequences through permanent colostomy formation. MRI's ability to define the precise extent and circumferential distribution of sphincter invasion enables surgeons to preoperatively counsel patients and select the most appropriate operative strategy- an advantage that neither CT nor endorectal ultrasound can consistently replicate.

The 30% recurrence rate on follow-up- exclusively in advanced-stage disease- highlights both the aggressive behavior of high-stage colorectal malignancies and the efficacy of MRI in post-treatment surveillance. The ability to distinguish fibrotic scar tissue from viable recurrent tumor through differential T2 signal intensity and enhancement characteristics is a unique strength of MRI. Early detection of recurrence within the mesorectal envelope, pelvic sidewall or distant metastatic sites facilitates timely escalation to salvage chemoradiation, repeat surgery or palliative care. A staged, systematic MRI surveillance protocol is therefore strongly advocated for all patients completing definitive treatment.

Beyond malignancy, the role of MRI in complex perianal fistula- while not the primary focus of this series—deserves emphasis. The St. James's University Hospital classification system for perianal fistula, based exclusively on MRI findings, has gained universal surgical adoption. MRI's ability to identify internal openings, primary and secondary tracts, horseshoe extensions and occult pelvic abscesses prior to fistula surgery reduces iatrogenic sphincter injury, prevents missed septic foci and significantly lowers the well-documented recurrence risk associated with incomplete fistula treatment.

Acknowledging the limitations of this study is essential: the single-center design, limited sample size (n=20) and absence of routine pathological confirmation of all MRI findings limit the generalizability of these observations. The small number of anal canal lesions (n=1) precludes any meaningful subsite-specific conclusions. Nonetheless, the consistent concordance between MRI findings and clinical outcomes affirms the validity and reproducibility of MRI-based staging in this patient population.

6. Conclusions

This prospective study provides compelling evidence for the central and irreplaceable role of MRI in the evaluation and management of colonic, rectal and anal canal disorders. The key conclusions are:

1) MRI achieves a superior local staging accuracy of 94.8% for colorectal lesions, substantially exceeding the performance of conventional CT and ultrasound in delineating mural invasion and extramural extension.
2) Characteristic MRI signal patterns—T1 hypointensity, T2 hyperintensity and post-contrast heterogeneous enhancement—provide reliable diagnostic criteria for differentiating malignant from benign colorectal pathology.
3) Preoperative identification of mesorectal fascia involvement (45%) and anal sphincter invasion (40%) directly guides surgical planning, enabling informed selection between sphincter-preserving and ablative procedures and appropriate allocation to neoadjuvant therapy protocols.
4) MRI-driven patient stratification ensures precision in treatment allocation: early-stage disease proceeds to primary surgery, while locally advanced tumors receive neoadjuvant chemoradiation—an approach that optimizes oncological outcomes.
5) Post-treatment MRI surveillance detects residual or recurrent disease with high specificity (30% recurrence rate in this series), enabling timely salvage intervention.
6) Despite limitations including cost, scan time, contraindications in patients with metallic implants and equipment-dependent variability, MRI's profound diagnostic impact on clinical decision-making significantly outweighs these drawbacks.

The adoption of standardized high-resolution MRI protocols as the primary preoperative imaging modality for colorectal and anorectal disorders should be considered the institutional standard of care. Future multicenter studies with larger cohorts and prospective correlation with histopathological staging data are warranted to further validate and refine these findings.

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