Preoperative staging and planning for sphincter sparing surgery in rectal carcinoma using high resolution T2WI following endorectal gel administration

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Abstract  Purpose: To assess the accuracy of high resolution T2WI with the addition of DWI in the preoperative staging, prediction of negative circumferential resection margin and planning of surgical management of rectal carcinoma.

Patients and methods: Seventy-five patients (30 men and 45 women) with pathologically proven rectal carcinoma underwent high resolution MRI study with trans-rectal gel administration. The MRI staging was compared with the postoperative pathological staging.

Results: The MRI Sensitivity was 98.63%, Specificity 97.3% and accuracy 97.96% in evaluation of T staging. For the assessment of lymph node involvement, the sensitivity was 98.18%, specificity 85.00%, and accuracy 94.67% in correlation with histopathological study.

Conclusion: High resolution MRI is accurate for preoperative staging, prediction of negative circumferential resection margin, lymph nodes involvement and planning the feasibility of sphincter-sparing surgery.

KEYWORDS
Rectal cancer; MRI; Circumferential resection margin

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1. Introduction

Colorectal is one of the most tumors in industrialized countries (1). It accounts for over 9% of all cancer incidences (2). The evolution of surgical techniques and the shift to neoadjuvant chemotherapy–radiation therapy, along with the prognostic heterogeneity of stage T3 tumors, necessitate accurate preoperative staging—primarily in terms of tumor (T) and nodal (N) staging, depth of tumor invasion outside the muscularis propria (early versus advanced stage T3 tumors), and the relationship of the tumor to the potential CRM (3). High-resolution MR imaging has high specificity for detection of free circumferential resection margins (CRM), the extent of tumor infiltration short of the CRM, and the depth of tumor mural infiltration within the layers and beyond the muscularis propria and thus essential for assessment of candidate selection for sphincter sparing surgery (4,5).

This study aims at assessment of the role of high resolution T2WI and DWI MRI in the preoperative staging, and planning of sphincter sparing surgery of rectal carcinoma.

2. Patients and methods

2.1. Patients

Seventy-five patients with primary rectal cancer were studied in the period from June 2012 to March 2014. The age range was 20–65 years with the mean age 40 years. Female to male ratio was 3:2. All patients proven to have cancer rectum by sigmoidoscopy and biopsy and underwent surgical operation were included in this study. Patient did not underwent surgical operation are excluded.

2.2. Methods

All the patients were subjected to detailed clinical history taking, clinical examination, laboratory evaluation, real time abdominal and pelvic ultrasonography and magnetic resonance imaging. All cases were operated upon and the postoperative specimens were sent for histopathological typing and staging “according to TNM classification”. Comparison with preoperative MRI staging was done for all cases.

2.3. Magnetic resonance imaging

All the examinations were done using 1.5 closed magnet (Philips Achieva 1.5 Tesla, SE). The pelvic phased array coil was used. The patient was advised to have an enema 1–2 h prior to the examination (to reduce rectal fecal loading) and emptying the urinary bladder before the examination. 20 ml buscopan was administrated intravenously for control of peristalsis. The patient was positioned in the lateral decubitus and Foley’s catheter was inserted and luminal distention by warm gel (about 150–200 ml), and then the patient returned to the supine position on the examination couch with feet first. The upper section of the pelvic array coil was set up between the patient’s legs and centered over the lower section of the array. Both sections were aligned with the marks on both coils. When the patient was positioned comfortably, the array was secured with straps provided. In addition to holding the array sections together, these straps help minimize patient motion artifacts. Application of immobilization foam pads was used as well as ear plugs were applied for the patient after all instructions had been given.

Initial three planes localizer views covering the entire pelvis were obtained. A minimum of three pulse sequences (axial T1, T2 and coronal T1 weighted images) was performed in all patients. High-resolution T2-weighted imaging had been used in all studies, with images being obtained with a non-breathhold turbo spin-echo sequence (Table 1). We used fat-suppressed T2-weighted MR imaging to improve visualization of tumor spread into the perirectal fat. 0.1 mmol/kg contrast media (gadolinium DTPA Schering-Germany) was used. Post contrast sequences (axial oblique, coronal oblique, sagittal oblique) all parallel to the direction of the rectum were acquired. Diffusion study in different b-values (0, 400 and 800 s/mm²) and ADC map were done in all cases (Table 2).

2.4. Image analysis

Two independent radiologists reviewed the MR examinations. The lesions had higher signal intensity than the muscle layer on

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![](image1)

![](image2)
Fig. 1  67 years old female patient presented by bleeding per rectum. (A and B) Axial and Coronal T2 WIs and (C and D) diffusion WIs (400 and 800 b value) and (E and F) Axial T1 post contrast fat sat. and ADC map showing irregular mural wall thickening seen infiltrating the submucosa and the muscularis propria of the lower 1/3 of the rectum and anorectal junction measuring about 19 mm in its max thickness (in B) and seen breaching the mesorectal fat on the left side (arrow in a shows early extraserosal infiltration). It is seen infiltrating the internal anal sphincter and extending about 2.5 cm from the anal verge. It is seen associated with few small perirectal lymph nodes (about 4 in number) showing intense enhancement in post contrast series (arrow in E) with restricted diffusion (arrow in C, D) and low ADC value about 0.765 suggestive of metastatic nature. MRI staging: T3N2, Postoperative pathological staging: T3N2, Pathological diagnosis: Mucinous adenocarcinoma (gradII).
Fig. 2  46 years old male patient presented by bleeding per rectum. (A–C) Axial T2, T1 pre- and post contrast WIs and (D and E) Coronal T2 and pre-contrast T1 WIs and (F and G) Axial pre-contrast T1 and sagittal T2 WIs showing irregular mural wall thickening infiltrating the submucosa and the muscularis properia with extraserosal extension at the right posterolateral wall of the lower 1/3 of the rectum. An exophytic soft tissue component is seen within the right posterior mesorectal fat infiltrating and fairly inseparable from the right adjacent mesorectal fascia (D and E) and presacral fascia (G). It is also seen infiltrating the right levator sling (arrows in D and E) and extending along it to infiltrate the right sided external and internal sphincter till the anal verge (arrows in A–C). Few small perirectal lymph nodes (about 5 in number) and right internal iliac lymph node (arrow in F) are noted. MRI staging: T3N2, Postoperative pathological staging: T3N2, Pathological diagnosis: Mucinous adenocarcinoma (high grad).
T2WIs. The tumor was considered in the upper third of the rectum if it was located 12–16 cm from the anal verge. In the middle third if it is located 8–11 cm from the anal verge or on the lower rectum if it is located 4–7 cm from the anal verge. The distance between the lower margin of rectal cancer mass to the point at which the levator ani muscle is attached to the rectum was measured.

The depth of cancer invasion on MRI (T stage) was interpreted as follows: No lesion was staged as Tis or T1 (i.e. no lesion was confined to the mucosal layer of the rectal wall in our patients). The stage was considered T2 if the tumor invaded the rectal walls up to the muscularis properia without penetration of the muscularis properia or perirectal fat; T3 if tumor invaded all rectal layers into the perirectal fat; T4 if tumor invaded the perirectal fat beyond the muscularis properia.

MRI staging: T4aN2, Postoperative pathological staging: T4aN2, Pathological diagnosis: Mucinous adenocarcinoma with signet ring differentiation (high grad).

Fig. 3 38 years old male patient presented by bleeding per rectum. (A and B) Axial T1 pre- and post contrast WIs and (C and D) Axial T1 post contrast fat sat. and axial T2 WIs and (E and F) coronal and sagittal T2 WIs for known case of cancer rectum showing irregular mural wall thickening seen infiltrating the submucosa and the muscularis properia with extramural extension (arrow head at D) of the proximal half of the rectum and infiltrating the anterior mesorectal fascia (arrow in B). It is seen infiltrating the peritoneal reflection (arrow in D and F). It is seen extending about 5.9 cm from the levator insertion site at the anal canal (E) and associated with few small perirectal lymph nodes (about 5 in number) (arrow in A and C) and some of them seen in contact with mesorectal fascia (i.e. in contact with circumferential resection margin).

MRI staging: T4aN2, Postoperative pathological staging: T4aN2, Pathological diagnosis: Mucinous adenocarcinoma with signet ring differentiation (high grad).
and T4 if tumor extended to visceral peritoneum, adjacent organ, or structure.

The number and distribution of lymph nodes in the MRI of each patient were detected, the criteria for lymph node metastasis including size, indistinct border, irregular margins, mixed SI and restricted diffusion with low ADC value. The ADC value for each lymph node was calculated by placing the region of interest “ROI” well in the confines of the LN. The cutoff value of ADC for lymph node infiltration was considered 1.007.

3. Results

This study included 75 patients: 30(40%) men, 45(60%) women. In two cases (2.7%) the tumor was located in the upper third of the rectum; in 14 cases (18.7%), the lesion was located in the middle third; in 29 cases (38.7%), it was located at the lower 1/3 of the rectum and in 26 cases (34.7%) it was seen involving the whole rectal length as well as in 4 cases (5.3%) involving the anal canal alone. Contrast enhancement was noted in all cases presenting different patterns ranging between homogenous and heterogeneous enhancement. The tumor tissues were enhanced more profound than the rectal wall muscle layers yet less than the mucosal layer.

No lesion was staged as T1 either by MRI or by histopathology. 20 cases staged as T2 by histopathology, and MRI detected 19 of them (95%). Forty-one lesions diagnosed as T3 (Fig. 2) by MRI and this was confirmed by histopathological assessment in 39 cases (95.1%) while one lesion (2.4%) was proved to have infiltration of the peritoneal fold (T4a) and the last case (2.4%) was confined to the muscularis propria (T2) with no evidence of perirectal fat infiltration. Fifteen lesions were diagnosed as T4 (Fig. 3) by MRI (one case showed seminal vesicles, urinary bladder as well as peritoneal fold invasion, 2 cases showed posterior vaginal wall invasion and 12 cases showed peritoneal fold infiltration), and this was confirmed by histopathological assessment in 14 cases (93.3%). The other lesion (6.7%) was staged as T3 instead of T4a. For the T staging, the overall true diagnosis was 96%, false + ve in 2.7% and false –ve in 1.3% of all cases. The overall Sensitivity was 98.63%, specificity was 97.3% and accuracy was 97.96% compared to histopathological examination.

23 of our patients underwent sphincter sparing surgery and MRI proved to have accuracy of 100% in the assessment of the distance between the lower border of the tumor to the levator insertion site. The other 52 cases underwent abdominoperineal resection. 29/75 patients showed involvement of the mesorectal fascia with MRI sensitivity and specificity of 100% in correlation with pathological results. Three cases of the examined patients showed levator ani sling infiltration and this was confirmed by the histopathological examination (100%).

Regional lymph node involvement was detected in 57 patients, and twelve of them showed enlarged internal iliac lymph nodes beside the mesorectal lymph nodes involvement. This was confirmed in 54 cases (94.7%). Only one case (1.8%) proved to have positive metastatic regional perirectal lymph node involvement while negative by the MRI assessment. Three cases (5.3%) with suspected perirectal lymph node infiltration by MRI were negative by histopathological examination.

The smallest detected lymph node measured about 4 mm in its maximal dimensions while the largest one measured about 3.8 cm in its maximal dimensions. Twelve cases only showed enlarged internal iliac lymph nodes with morphological and signal criteria suggestive of metastatic nature and this was confirmed by histopathological results in all positive cases.

MRI assessment of pelvic lymph nodes was done in comparison with histopathological results. The overall sensitivity of the detection of lymph nodes involvement was 98.18% with 85% specificity. Positive predictive value was 94.7% and negative predictive value was 94.4% as well as the accuracy reached to about 94.67%.

The diffusion sequence showed important role in detection of the lymph nodes and helping in differentiation between benign and malignant lymph nodes. The metastatic lymph nodes showed restricted diffusion with low ADC values (Fig. 1). Our cutoff value for nodal infiltration was 1.007, and the sensitivity and specificity were 100%.

4. Discussion

The prognosis of patients with colorectal cancer is largely dependant on the preoperative TNM stage of the disease and is directly related to the extent of spread into the mesorectum as well as the success to achieve surgical clearance at the circumferential resection margins (4,6).

Zhang et al. (5) found the percentage of mucinous adenocarcinoma to be 43.6%, In our study we found the mucinous adenocarcinoma was the histopathological results in 46 patients out of 75 (61.3%).

We found that, the administration of endorectal warm gel to distend the involved rectal lumen and the intravenous injection of spasmolytic material just prior to the examination had important role in decreasing motion artifacts and improving image quality. Those findings agreed with Kaur et al. (4).

Kim et al. (7) in agreement with our study that, High-resolution T2-weighted imaging is the single most sensitive and reliable sequence in the assessment and staging of rectal neoplasm. The high resolution layer definition allows accurate detection of rectal tumor depth invasion, the exact layers involved and whether it has breached the muscularis propria or the serosal coverings and in the assessment of perirectal reflection infiltration, helping in differentiating stage T3 from T4 lesions.

We also found the axial T2 FSE was the best sequence used for evaluation of involvement of the rectal layers, while the coronal T1 WIs were better delineating the levator ani affection. T1 and T2WIs and fat saturation techniques are all necessary for assessment of pelvic organ infiltration.

In agreement with Brown et al. (8), we found that Coronal straight high-resolution T2-weighted images of the pelvis are the best, most sensitive sequences for assessment of the anal sphincter and detection of tumor infiltration. It allows superior illustration of the anal sphincter anatomy, tumor size, layers infiltration, pelvic lateral walls, peritoneal reflections and adjacent structures invasion as well as the marginal extension in relationship with the sphincter.

The Mercury groups in their studies done on 2006 (9) and on 2007 (10) as well as Beets et al. (11) agreed with our study on the sensitivity of high-resolution MR imaging in accurate assessment of the depth of tumor invasion of the muscularis
prochia and tumor marginal extension within or beyond the CRM.

In our study the overall specificity, sensitivity and accuracy were about 97.3%, 98.1%, and 97.9% respectively which show no significant changes in comparison with mercury study group 2007 (specificity 92%) and the Zhang et al. (5) (specificity 100% and accuracy 92.1). Ichiro et al. (12) reported that, the sensitivity, specificity, and accuracy were 98%, 96%, and 97%, respectively. Our study also was in agreement with Giusti et al. (13) in that Preoperative MR prediction of histologically involved MRF is very accurate (sensitivity 100%; specificity 100%).

Accurate detection of the extent of tumor lymph nodal involvement allows for accurate staging and improving the prognosis of patients with adjuvant chemo-radiotherapy (12). The cutoff value size criteria used for distinguishing malignant from non-malignant nodes (5 mm) have a sensitivity of 68% and a specificity of about 78% according to Merkel et al. (14). Another study by Brown et al. (15) stated that about 30-50% of rectal cancer nodal metastases are less than 5 mm. Using high resolution MRI imaging criteria relies on other features beside the size as nodal margins and internal nodal characteristics, heterogeneous signal intensity and restricted diffusion pattern being more reliable and sensitive for nodal infiltration (16).

In our study specificity, sensitivity and accuracy of lymph nodes involvement were 85%, 98.2%, and 94.6% respectively but the Zhang et al's (5) results were lower than our study (specificity, sensitivity and accuracy 79.0%, 64.7%, 90.5%) and this difference might be due to the fact that, in our study we depend mainly on morphological criteria of the lymph nodes, diffusion pattern and its ADC value and considering the lymph node size significant even it measures less than 5 mm.

All infiltrated lymph nodes or tumor margins involving or nearby (within 1 mm from) the mesorectal fascia should be reported pre-operatively so as to have clear tumor margins. Extra-mesorectal fascia lymph nodes should be reported so as to modify the treatment plan to add preoperative adjuvant chemo- or radiotherapy to avoid recurrence in untreated nodes. Involved intra-mesorectal fascia lymph nodes are resected within the total mesorectal excision (TME). And these nodes should be assessed in terms of their involvement (i.e., benign or malignant) and the relationship of clearly malignant nodes to the mesorectal fascia (7).

The limitation of our study: no cases were diagnosed as stage Tis or T1 either by MRI or by histopathology. The second limitation was the diffusion protocols were applied only for lymph node detection.

5. Conclusion

Well-tailed high-resolution MR imaging following endorectal gel administration is a sensitive highly specific technique for staging of rectal neoplasms, predicting of negative CRM and involvement of the perirectal and pelvic lymph nodes as well as planning of the sphincter sparing surgery.

Conflict of interest

We have no conflict of interest to declare.

References