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Role of combination of conventional MRI and diffusion weighted sequence in staging of rectal carcinoma assuming histopathological staging as gold standard in SMS medical college Jaipur in 2018-2019

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Abstract

Background: Colorectal cancer (CRC) is a dreadful health problem worldwide. Preoperative imaging for staging of rectal cancer has turn out to be an important aspect of recent approach to rectal cancer management as it helps to select suitable patients for neoadjuvant chemo radiotherapy and the appropriate surgical technique.

The aim of this study was to ascertain the role of combination of conventional MRI and diffusion weighted sequence in preoperative staging of rectal carcinoma and objective was to find out the efficacy of conventional MRI with diffusion weighted sequence in preoperative staging of rectal carcinoma

Methods : Biopsy proven primary rectal carcinoma patients were taken for MRI pelvis using 3 -T scanner.Axial T1, axial coronal and sagittal T2 sequenoes were taken along with fat saturated enhanced and unenhanced sequences.DWI was performed and images were obtained at *b* value of 0,500 and 1000 $mm^2/_s$ and ADC map was drawn .Findings were compared with postoperative histopathological results.

Results: Overall Sensitivity, specificity, and accuracy of diffusion weighted MRI came out to be 87.30%, 93.10% and 86.24 % in T staging and for nodal staging came out to be 87.30%, 93.65 %and 91.53 %respectively. CRM involvement was found in 25 percent of patients. Sensitivity, specificity, PPV,NPV and accuracy of diffusion weighted MRI was found to be 86.67%, 93.75%, 92.06%, 81.25% and 95.74% respectively for CRM involvement.

Conclusion: Diffusion weighted MRI along with conventional sequences is highly accurate for preoperative staging of rectal carcinoma.

Keywords: MRI, DWI, ADC,CRM.

Introduction

Colorectal cancer (CRC) is a dreadful health problem worldwide. It is the third most common

cancer in men and the second most common in women with 1.8 million new cases and almost 861000 deaths in 2018 according to the world health organization GLOBOCON database[1]

In India, the annual incidence rates (AAR) for colon cancer and rectal cancer in men are 4.4 and 4.1 per 100000, respectively. The AAR for colon cancer in women is 3.9 per 100000. In India colon cancer ranks 8th and rectal cancer ranks 9th among men, for women, rectal cancer does not figure in the top 10 cancers, whereas colon cancer ranks 9th.[2,3]

Prognosis of rectal cancer is determined by depth of invasion, number of involved lymph nodes, and involvement of circumferential resection margin. Currently, surgical resection with stage-appropriate neoadjuvant combined-modality therapy is the bastion in the treatment of rectal cancer.[3] Even with TME, however, the presence of a tumor or malignant node within 1 mm of the CRM remains an important predisposing factor for local recurrence[4]. Consequently, reliable preoperative imaging evaluation is essential to surgical planning.

DWI is increasingly incorporated into standard MRI protocol for tumor staging.DWI is the only noninvasive method which is able to detect movement of water molecules .This is important for tumor staging as areas of necrosis and inflammation have altered diffusion properties. DWI can confirm the presence of tumor which might otherwise be hard to see due to isointensity of tumor to adjacent rectal wall. When DWI is co-registered with T2W, T staging can be performed with high accuracy. Diffusion-weighted imaging may perhaps play a role in grading rectal cancer masses. Apparent diffusion coefficient (ADC) values change according to the stage of tumor cell differentiation, the degree of tumor cellularity, the presence of necrotic tissue. Poorly differentiated tumors will have have low ADC values whereas well differentiated tumors tend to have higher ADC values. .Other applications of diffusion-weighted (DW) magnetic resonance(MR) including nodal staging, treatment monitoring and early detection of treatment failure by differentiating recurrence from post-therapeutic changes. For nodal staging, DW imaging has shown promise in detecting lymph node metastases, even in small (sub-centimetre) nodes with lower ADCs as compared with normal or reactive nodes. Follow-up of early response to treatment can be correlated with an ADC increase in the primary tumor and nodal metastases; whereas non responding lesions revealed only a slight increase or even a decrease in ADC during follow-up.[5] In addition to eliminating T1 and T2 contrast effect in the images, ADC maps also help in quantifying diffusion. Further, the diffusion changes inside the tissue and the signal intensity on ADC map are directly related-if diffusion is lower in the tissue, it show as hypo-intense area on ADC maps and if diffusion is higher, then it will be shown as hyper-intense region on the map.

Materials and Methods

Study type: Hospital based Cross-sectional study

Study Design: Observational study

Study duration : Data collection for study was done after approval from the institutional research and review board, till sample size was achieved

Study Area: Out-patient and in-patient of Surgery, Oncology, Surgical Oncology of SMS Hospital, Jaipur, Rajasthan

Inclusion criteria

- Biopsy proven rectal carcinoma patients.
- Those who gave written informed consent.

Exclusion criteria

- Patients who had received chemoradiotherapy for rectal carcinoma.
- Patients with MRI non-compatible implants like metallic aneurysm clips, MRI non-compatible pacemakers, metallic vascular clamps and history of claustrophobia.
- Non-compliant patients.

This study included biopsy proven rectal carcinoma patients age ranging from 15-84years.

Prior to examination, written and informed consent was taken from the patient or guardian (in case of minor).

Sagittal T2 weighted image was taken to locate the tumour. On the basis of the Sagittal sequence, axial and coronal T2 weighted images were planned and they were angled to the plane perpendicular and parallel to tumour axis. Unenhanced and contrast enhanced fat saturated images were taken. The Gadolinium DTPA was used as I.V. contrast media with a dose of 0.1 mmol per kilogram of body weight to enhance tissue contrast. Slice thickness of 3 mm was taken. Diffusion weighted images were acquired in the axial plane with the patient in free breathing from the level of aortic bifurcation to the level of mid thigh in order to include inferior mesentric lymph nodes and inguinal nodes. Diffusion gradients at 3 time points (or b values) was obtained (b value 0,500,1000). An ADC map was generated using all b values on the MR console.

Results

Total 63 participants diagnosed with carcinoma rectum were included in the study. The age of the study participants ranged from 15-84 years with mean age of 55.83 years, maximum cases were from 61-70 year age group.Maximum cases were males 35 (55.5%) and 28 (44.4%) were females with M:F ratio of 1.25.Maximum patients 61.9% presented with bleeding per rectum.

Lower rectum was the most common site of rectal carcinoma in our study in 23 (36.5%) of patients..

Table 1 showing Distribution of study patients according to the site of lesion. (n=63)

S. No.	Site of lesion	Number of patients	N (%)
	Location		
i	Lower rectum	23	36.5%
ii	Middle rectum	22	34.9%
iii	High rectum	16	25.3%
iv	Whole rectum	2	3.17%

Majority of cancers in our study had moderately differentiated adenocarcinoma i.e 27(42.8%), followed by well differentiated adenocarcinoma in 21 (33.3%%) and poorly differentiated in 12 (19 %).

Table 2 Distribution of study participants according to pathological types. (n=63)

Pathological types	Number	Percentage
Well differentiate adenocarcinoma	21	33.3%
Moderately differentiated adenocarcinoma	27	42.8%
Poorly differentiated adenocarcinoma	12	19.0%
Mucinous adenocarcinoma	3	4.7%

Majority of cancers had heterogeneous enhancement 53 (84.12%) and 10 (15.87%) had homogeneous enhancement on contrasts sequences .

T staging

Tumors staged as T3 were most common comprising of 63.33 of patients followed by T2 (20.63%).No Tumor was found in stage T1.In our study out of Eleven patients diagnosed as T2, Nine were found to be of stage T2 and two were found to be in stage T3. Out of forty patients diagnosed as T3 thirty five were found to

be in stage T3 and three in stage T2 and two in stage T4 on pathology. Out of twelve patients diagnosed as stage T4 eleven were found to be in T4 and one in T3 on pathology.

Table 3 is showing correlation of T staging on DWMRI and Histopathology

DWMRI		Histopathology				
T	Number	T0	T1	T2	T3	T4
T0	0	0	0	0	0	0
T1	0	0	0	0	0	0
T2	11	0	0	9	2	0
T3	40	0	0	3	35	2
T4	12	0	0	0	1	11

Diagnostic accuracy of MRI is approx 86% in T staging of rectal carcinoma with sensitivity of 87.30% and specificity of 93.10% in our study.

Nodal staging

Patients staged as N2 were majority comprising of 39.68% of patients followed by N0 (38.09%). Out of Twenty six patients diagnosed as N0, Twenty three were found to be of stage N0 and three were found to be in stage N1. Out of fourteen patients diagnosed as N1 ten were found to be in stage N1 and three in stage N2 and one in stage N0 on pathology .Out of twenty three patients diagnosed as stage N2, twenty two were found to be in N2 and one in N1 on pathology.

Table 4 showing correlation of nodal staging on DWMRI and pathology.

DWMRI N staging		Histopathological N staging		
N	Number	N0	N1	N2
N0	26	23	3	0
N1	14	1	10	3
N2	23	0	1	22

Diagnostic accuracy of MRI in our study is approx 91.53% for N staging of rectal carcinoma with sensitivity of 87.30 % and specificity of 93.65%.

CRM (circumferential resection margin)

CRM was involved in 23.80% of study patients.Sixteen patients were found to be CRM positive on MRI, thirteen were found to be CRM positive and three were found to be CRM negative. Forty seven patients were found to be CRM negative on MRI, two were found to be CRM positive and forty five were found to be negative on pathology.

Table 5 is showing correlation of CRM involvement on MRI and pathology.

CRM involvement on DWMRI		CRM involvement on pathology	
		Present	Absent
Present	16	13	3
Absent	47	2	45

Diagnostic accuracy of MRI is approx 92.06% in CRM assessment of rectal carcinoma with sensitivity of 86.67% and specificity of 93.75%

Extramural vascular invasion

Extramural vascular invasion was found in 9.52 percent of study patients.Five patients were found to be having extramural vascular invasion on MRI, four were found to be having and one was found to be negative. Fifty eight patients were found to be not having extramural vascular invasion on MRI, two were found to be having extramural vascular invasion and fifty six were found to be negative on pathology.

Table 6 is showing correlation of extramural vascular invasion on MRI and pathology

Extramural vascular invasion on DWMRI		Extramural vascular invasion on pathology	
		Present	Absent
Present	5	4	1
Absent	58	2	56

Diagnostic accuracy of MRI is approx 95.24 % in detection of extramural vascular invasion with sensitivity of 66.67% and specificity of 98.25%.

Internal sphincter was involved in 19.04 percent of our study patients.External sphincter was involved in 9.52% of cases. In our study MRI has sensitivity (75%), specificity (96.08%), accuracy (92.06 %) for internal sphincter involvement and sensitivity (66.67%), specificity (98.25%), and accuracy (95.24%) for external sphincter involvement in our study .

Discussion

Very less Indian literature is available for the diagnostic efficiency of diffusion weighted MRI for preoperative local staging of rectal carcinoma .

In our study adenocarcinoma was found in 60 (95.23%) and mucinous carcinoma was found in 3 (4.76%) patients ,this is in agreement with Veruttipong et al.[6] who reported that adenocarcinoma was the most common histopathologic type of tumors (87.0%). Majority of cancers had moderate differentiation-27(42.8%), followed by well differentiation in 21(33.33%) and poor differentiation in 12(19.0%).The accuracy of T staging with 2D T2-weighted imaging ranged between 63.3% and 66% in Kim et al.[7]study conducted on 109 patients while our study showed accuracy of T staging to be 86.24%. Our study is similar in comparison with study of Zhang et al.[8] which had specificity (100%) and accuracy (92.1%) and Mercury study group 2007[9] which had specificity of (92%). Vogl et al.[10] reported that, overstaging was the only false results found during MR staging. This could be possibly due to the considerable number of small rectal lesion evaluated in his study but in our study there was overstaging in four cases and understaging in four cases .

Identification of nodal disease is a diagnostic problem for the radiologist. Regardless of the identification of lymph nodes as small as 2-3 mm on high-spatial-resolution images, reliable detection of nodal metastasis presently is not possible. The radiologist assessment of nodal involvement generally relies on morphologic criteria such as the size, shape and signal. In our study MRI has sensitivity (87.30%), specificity (93.65%) and accuracy (91.53%) in Nodal staging while In Zhang et al.[8] study specificity, sensitivity and accuracy of lymph nodes involvement were 79.0%, 64.7% and 90.5% respectively but our study showed higher results. This difference might be due to the fact that in our study we depended mainly on morphological criteria of the lymph nodes, diffusion pattern rather than lymph nodal size alone.

The most important predictors of local recurrence are CRM infiltration and tumor mesorectal fascia distance. The expected CRM can be described as involved if tumor invasion of the mesorectal fascia is visible or the tumor has proximity of 1 mm or less to the mesorectal fascia.In our study MRI has sensitivity (86.67%), specificity (93.75%) and accuracy (92.06%) for CRM involvement .In our study 6 (9.52 %) out of the 63 patients had extramural venous invasion. Extramural venous (or vascular) invasion (EMVI) is the presence of tumour invasion in the veins in the vicinity of the tumour. EMVI, is known to be associated with an increased risk of local and distant recurrence and an impaired overall survival. It has been shown that the presence of EMVI can be assessed on MRI based on the presence of tumoral signal intensity within vessels surrounding the rectum, or the presence of a nodular expansion or irregular vessel contour as criteria**.** In our study MRI has sensitivity (66.67%), specificity (98.25) and accuracy (95.24%) in extramural vascular invasion

of rectal cancer which is high compared to the study carried out by Sohn et al[11] in 447 patients which had a sensitivity, specificity and accuracy of 28.2%,94.0% and 80% respectively.

Conclusion

Diffusion weighted MRI is the modality of choice for the staging of rectal carcinoma. It can delineate the involvement of mesorectal fat and mesorectal fascia accurately involvement of which are considered the most important prognostic factors for local recurrence after total mesorectal excision .Extramural vascular invasion and sphincter complex involvement can be accurately asssesed by it along with T and N staging . Extramural vascular invasion is an important risk factor for recurrence and distant disease. Evaluation of sphincter involvement is important for planning of surgery and radiotherapy. So we conclude that MRI with diffusion weighted sequence is a valuable tool for T staging, perirectal spread , pelvic nodal staging, CRM assessment, vascular invasion and sphincter involvement.

The main limitation of our study was the small number of patients. The small number of patients had a negative effect on the general preoperative tumor staging purpose of the study. The number of patients who met the criteria was relatively small due to our exclusion strategy. Biases could be present in our cohort, because most of patient presenting with locally advanced rectal cancers underwent neoadjuvant therapy, limiting our study population.

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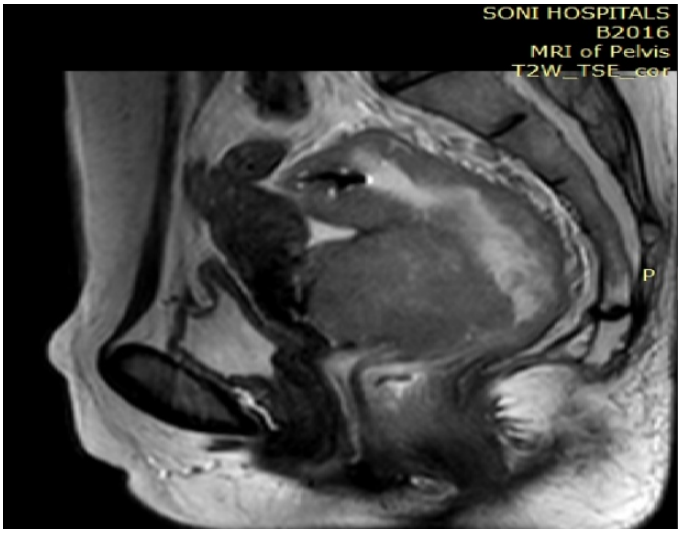
Case 1

A 50 year old female presented with complaints of deep pelvic pain and constipation. MRI revealed :circumferential mass lesion (11-5'o clock) appearing T1 hypointense,T2 hyperintense measuring approx 7*6*6.5cm, 6cm above the anal verge in the middle rectum showing diffusion restriction on DWI extending into the upper rectum involving the anterior mesorectal fascia, Cervix and upper one third of vagina with eleven enlarged lymph nodes in perirectal fat and along bilateral iliac vessels with maximum short axis diameter 6mm. Four of the lymph nodes were showing diffusion restriction and ADC fall consistent with stage T4bN2b. Pathology confirmed the findings. Note was made of left ovarian dermoid.

Images 1 : sagittal T2,2: coronal T2,3: axial T2,4: axial T1, 5: axial DWI ,6: ADC



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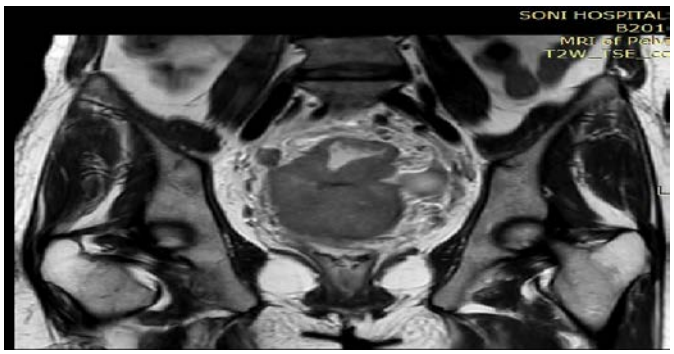

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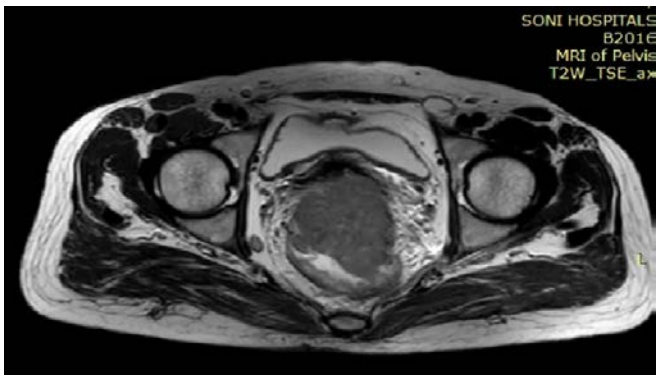

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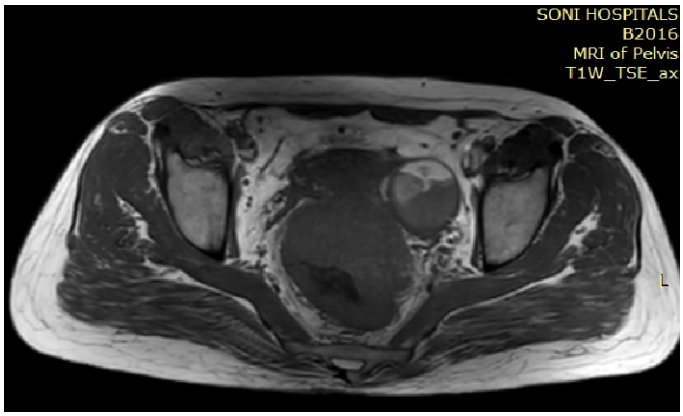

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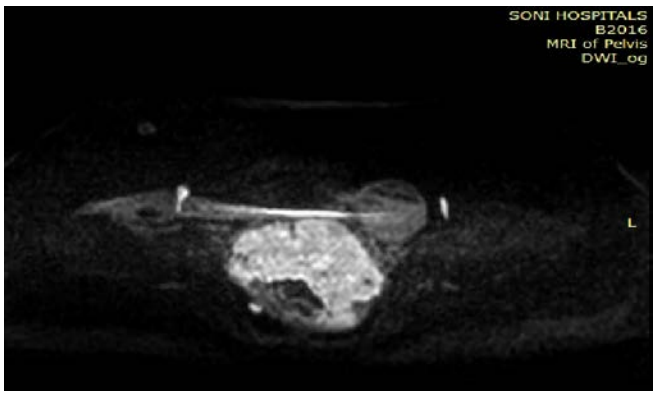

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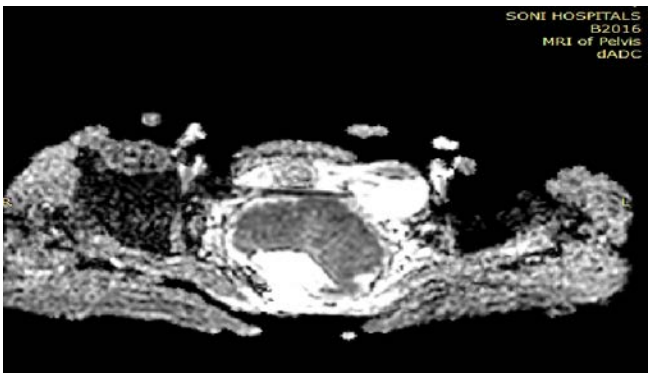
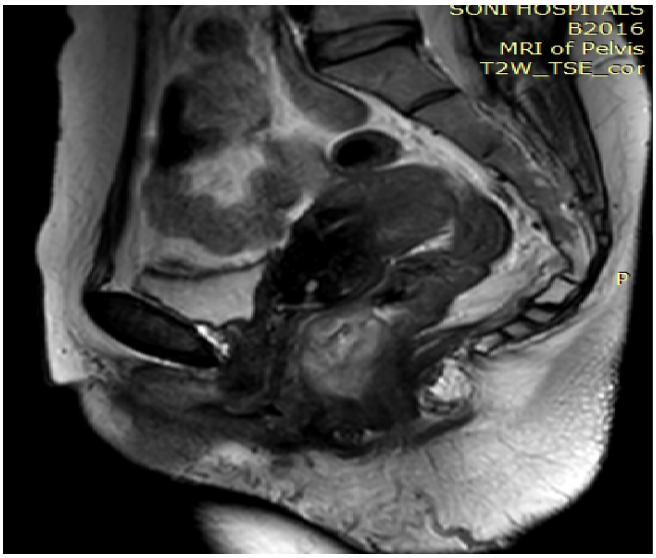


Image 6

Case 2

A 44 year old female presented with complaints of pelvic pain. MRI revealed Heterogeneously enhancing circumferential mass lesion measuring approx 7cm in length and 2.6 cm away from the anal verge in lower rectum showing restricted diffusion and infiltrating into the mesorectal fat with involvement of internal sphincter and external sphincter with no extramural vascular invasion with no extrarectal spread with enlarged lymph nodes (3 in mesorectum and 1 along iliac vessels) largest measuring approx 7mm consistent with Stage T3N2a. Pathology confirmed the findings.

Images 1 : sagittal T2, 2: axial T2, 3: coronal T2, 4: DWI ,5: ADC



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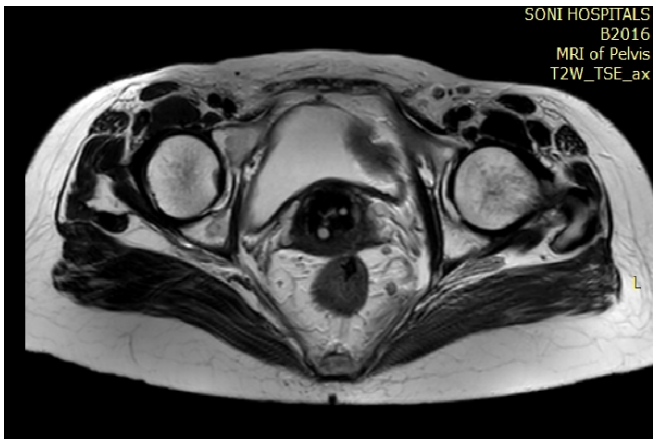

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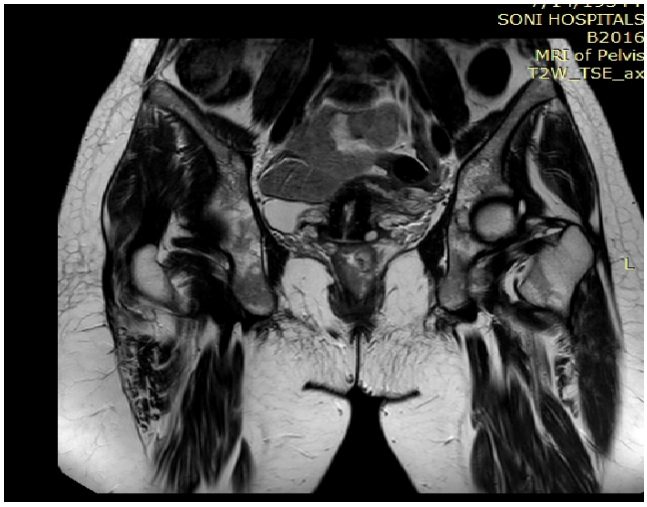

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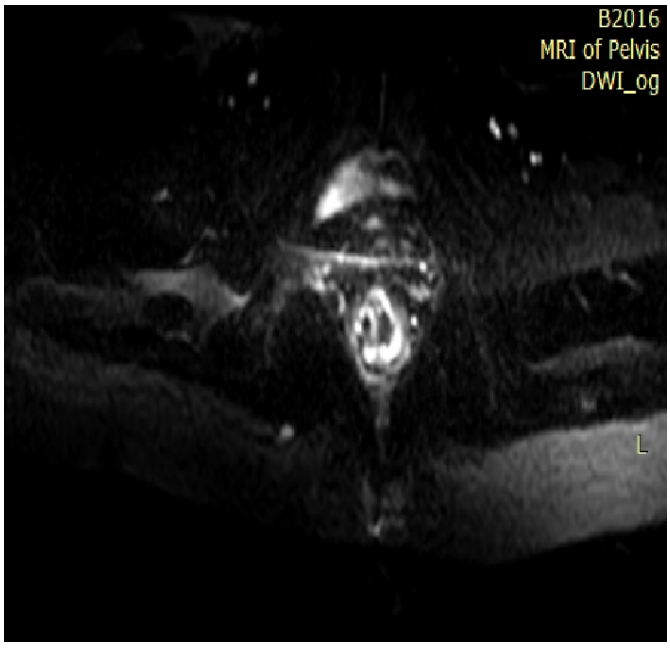

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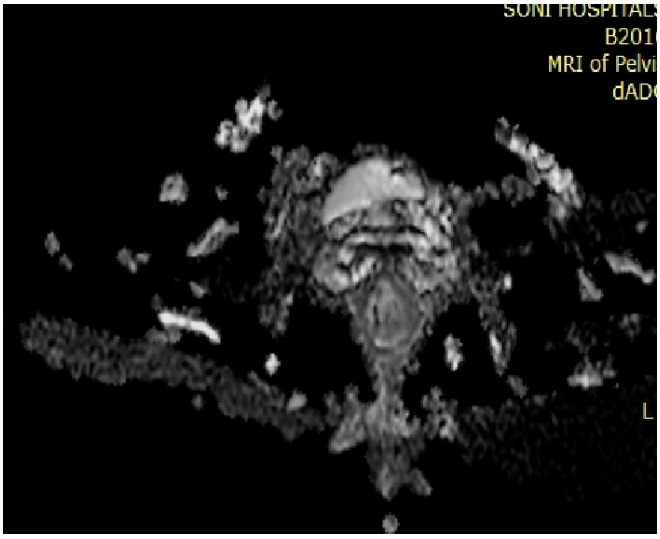
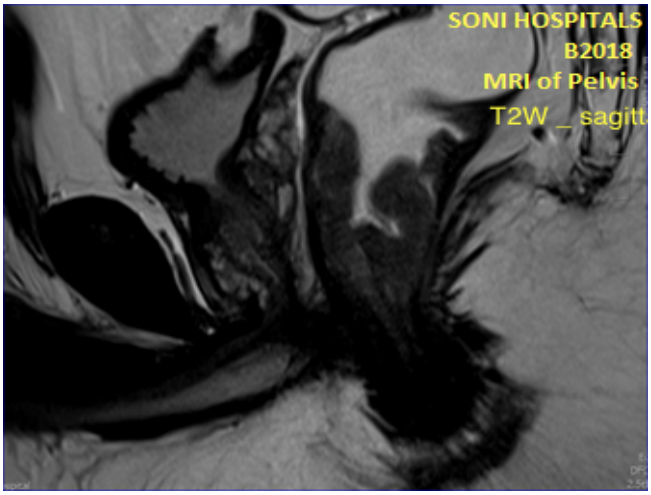


Image 5

Case 3

48 year old male patient presented with bleeding per rectum.MRI revealed circumferential mucosal thickening involving the lower rectum showing restricted diffusion and post contrast enhancement without any evidence of transserosal spread consistent with T2 disease. Histopathology revealed T2N0.

Images 1: sagittal T2W, 2: coronal T2W 3:ADC



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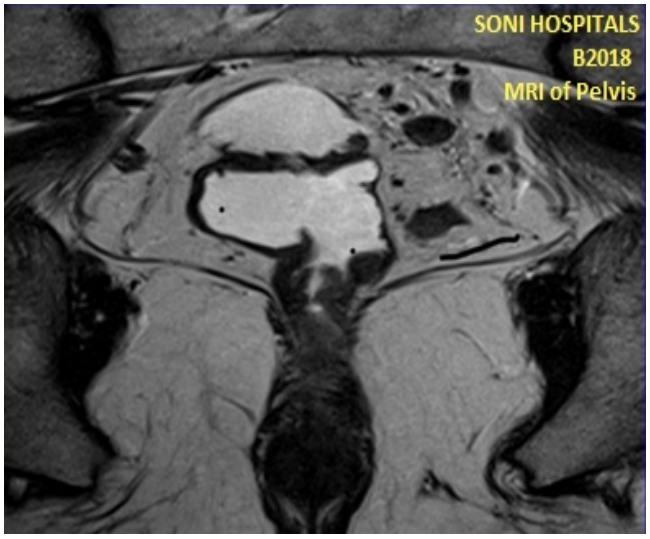

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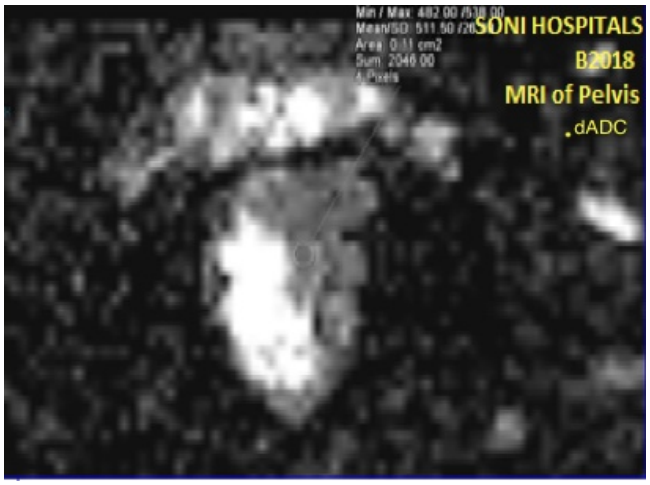
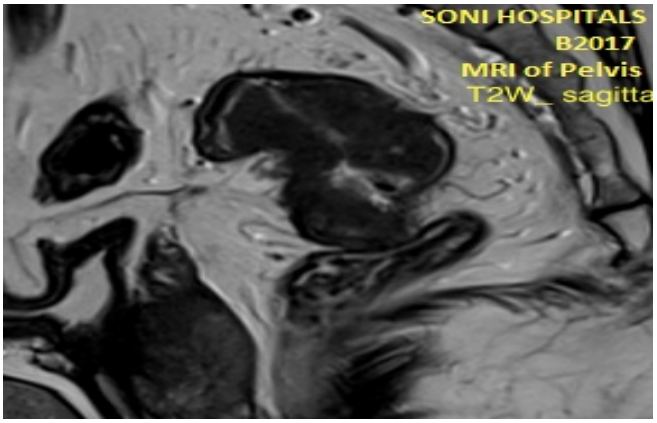


Image 3

CASE 4

38 year old male patient with biopsy proven well differentiated adenocarcinoma presented with bleed per rectum .MRI revealed transerosal circumferential heterogeneously hyperintense wall thickening involving the upper rectum showing restricted diffusion. No evidence of any invasion into adjacent fat/organs noted suggestive of T3N0. Pathology revealed T3N0.

Images : 1: sagittal T2W, 2: axial T2W



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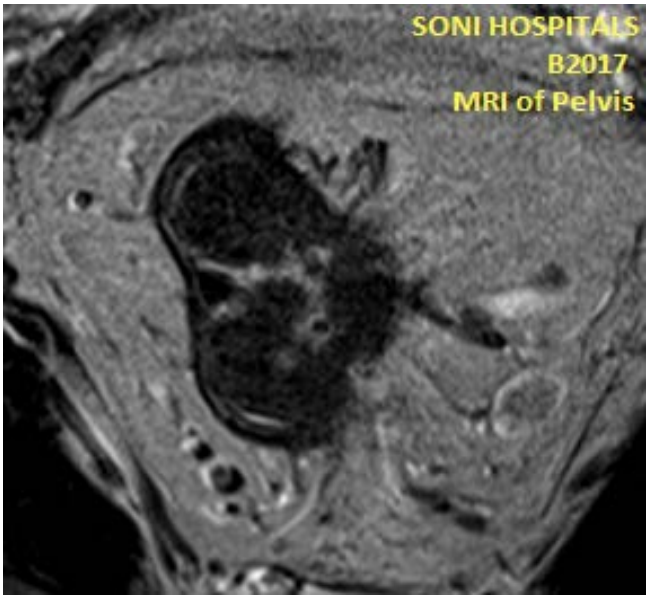

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