Research Article

Correlation of high-resolution magnetic resonance imaging with surgico-pathological findings in rectal carcinoma patients

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Received: April 03, 2018; **Accepted:** April 18, 2018

ABSTRACT

Background: Colorectal cancer is the third most common cancer in men, and it is second most common in women worldwide. Magnetic resonance imaging (MRI) is free of ionizing radiation and imparts highest soft tissue contrast; therefore, it can provide the best assessment of evaluation of local spread. The available data show that only a few studies have been done describing the role of high-resolution MRI (HRMRI) in staging of rectal cancer in Indian population. **Objectives:** The present study attempts to find the correlation and level of agreement between HRMRI and Surgico-pathological findings in rectal carcinoma patients. **Materials and Methods:** This hospital-based prospective study was conducted on patients diagnosed with rectal cancer. MR study for pre-operative evaluation was done on 97 patients. 60 operated cases who gave the consent were included in the final study. Findings from MR study were compared with surgical and histopathological findings. **Results:** Result showed that mean tumor size was 7.43 ± 3.12, 6.88 ± 3.04, and 5.67 ± 2.50 by MRI, surgical, and histological methods ($P < 0.001$). Overall agreement between MRI and operative finding and histopathological finding was 0.95 and 0.75 respectively ($P < 0.001$), showing good absolute agreement between the methods. **Conclusions:** There was good agreement between the MR, surgical, and histopathological findings for local staging and pre-operative planning of rectal carcinoma.

KEY WORDS: High-resolution Magnetic Resonance Imaging; Surgical and Histopathological findings; Rectal Carcinoma, Local Staging

INTRODUCTION

Colorectal cancer is the third most common cancer in men, and it is second most common in women worldwide. Colorectal cancer is the second leading cause of death due to cancer after lung cancer.[1] The geographic distribution of colorectal cancer varies throughout the globe. Within Asia, the incidence rates of rectal cancer vary widely and are uniformly low as compared to western countries. Time trend studies show a rising trend in the incidence of colorectal cancer in India; this can be attributed to shift in dietary pattern from high roughage diet to a diet high in fat and red meat.[2,3] The incidence rate of colon and rectal cancer collectively among male and female population is 4.3 and 3.4/100,000. Rectal cancer has slightly male preponderance, and its incidence increases steadily after 50 years.[4] The successful tumor resection depends on the precise local staging

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Website: http://www.ijmsph.com	**Quick** Response code
DOI: 10.5455/ijmsph.2018.0410518042018	

of tumor and appropriate surgical technique. Recent trials show that evaluation of involvement of mesorectal fat and mesorectal fascia is even more important in the planning of management and subsequently its outcome.[5] Barium enema examination, endorectal ultrasonography (EUS), computed tomography scan–positron-emission tomography scan, and magnetic resonance imaging (MRI) have been used to evaluate rectal cancer.[6]

MRI is free of ionizing radiation and imparts highest soft tissue contrast; therefore, it can provide the best assessment of evaluation of local spread. Initial studies showed accuracy in T staging in the range of 58–74%.[7] Initial low sensitivity may be ascribed to poor spatial resolution due to use of whole-body coil system. With the use of endorectal coil, the MR sensitivity is increased and it has become at par with EUS.[8]

The advent of powerful gradient system and particularly the introduction of high-resolution phased array surface coil system in recent years have revolutionized the rectal cancer staging by MRI. The use of phased array system provides very high spatial resolution that allows detailed evaluation of wall layers and surrounding anatomy including mesorectal fascia.

The available data show that only a few studies have been done describing the role of high-resolution MRI (HRMRI) in staging of rectal cancer in Indian population. Of these studies, most were retrospective in nature and done at low strength (up to 1.5 Tesla) MRI system.[9]

The present study attempts to find the correlation and agreement between high-resolution 3-Tesla MRI and surgico-pathological findings and certain most important key descriptors in locoregional staging of rectal carcinoma patients.

MATERIALS AND METHODS

This hospital-based prospective study was conducted on patients diagnosed with rectal cancer in the Department of Radiodiagnosis, in collaboration with the Department of Surgical Gastroenterology and Pathology at Sanjay Gandhi Post Graduate Institute of Medical Sciences, Lucknow, India, during July 2014–December 2017.

Inclusion Criteria

All patients with a diagnosis of rectal cancer who were referred to the Department of Radiology, SGPGIMS, for pre-operative MRI evaluation from the Department of Surgical Gastroenterology and received surgical treatment in the same institute were included in the study.

Exclusion Criteria

The following criteria were excluded from the study:

- Individuals having contraindication for MRI.
- Individuals not giving consent for the study.
- Patient not operated after MRI.

Study Instrument

MR study was performed on a 3-Tesla MR scanner (Signa HDxt General Electric, Milwaukee, USA). 16 channel body surface phased array coils have been used for generation and acquisition of MR signal.

MRI Protocol and Sequences Used

- T2 weighted with fat axial, sagittal, coronal planes, and T2-weighted fat sat axial plane.
- Pre- and post-contrast T1-weighted and LAVA axial, sagittal, and coronal planes
- Diffusion-weighted imaging in axial plane.

After approval from the institute ethical committee and obtaining an informed consent from the patients, each patient included in the study was subjected to detailed history regarding claustrophobia and metallic implants/pacemakers before entering into imaging system.

MR examination of the pelvis has been performed in 3-Tesla longitudinal or main magnetic field. External body/cardiac coil has been used for MR signal production and detection.

The MR sequences taken are described separately. The images have been produced in axial, coronal, and sagittal plane. Images were first produced in sagittal plane, and then, axial series was planned perpendicular to the rectal wall/main axis of tumor at the level of tumor. Coronal images were planned perpendicular to the axial images and in distal tumors perpendicular to anal canal.

MR study for pre-operative evaluation was done on a total of 97 patients, but only those cases were included in study who were operated after MR examination. 60 operated cases who gave the consent to participate in the study were included in the final study as per the inclusion criteria.

Statistical Analysis

Normality of continuous data was tested and variables were considered normal when standard deviation (SD) <1/2 mean. Data were presented in terms of mean± SD and median (interquartile range) while frequency and percentage were used for categorical data. Paired samples *t*-test/repeated measures ANOVA with pairwise comparisons used for normally distributed data otherwise Friedman test for repeated observations or Wilcoxon test for paired samples were used to test the difference between two or more than two groups.

Findings from MR study were compared with surgical and histopathological findings. Pathological staging was taken as

gold standard. Agreement between the staging systems has been determined using the kappa statistics when data were categorical. In case of continuous data, intraclass correlation coefficient was calculated for the same. The Statistical Package for Social Sciences version 23 (SPSS-23, IBM Chicago USA) has been used for data analysis. A $P < 0.05$ has been considered as statistically significant.

RESULTS

Mean age of the patients was 46.9 years with the age range of 27–63 years. Of total participants, maximum 22 (36.7%) were in the age group of 40–50 years followed by 20 (33.3%) of 50–60 years, while only 4 patients were in the age group of 20–30 years. Of 60 patients of the study population, 34 (56.7%) were males, while 26 (43.3%) were females.

Tumor size in the patients was measured in all three planes and longest plane was described as tumor size. Result revealed that mean tumor size was found 7.43 ± 3.12, 6.88 ± 3.04, and 5.67 ± 2.50 by MRI, surgical, and histological methods. Repeated measures ANOVA test revealed that the variation in size reported by three methods was statistically significant ($P < 0.001$) [Table 1 and Figure 1]. Intraclass correlation coefficient between MRI and operative finding and histopathological finding was 0.95 and 0.75, respectively ($P < 0.001$), showing good absolute agreement between the methods and also indicating high accuracy of MRI in predicting tumor size. Distance of lower tumor margin from anocutaneous junction forms the basis of the location of tumor in terms of high/medium/low [Figure 2]. This variable was determined surgically coupled with findings of digital rectal examination and rectosigmoidoscopy. Weighted Kappa indicated that there was a strong absolute agreement between MRI and surgical findings (1.00, $P < 0.001$). The distance of lower tumor margin from anocutaneous junction in the patients was measured. Result revealed that mean distance was found 4.45 ± 2.80 and 4.30 ± 2.75 by MRI and surgical methods, respectively. The variation in size reported by two methods was not statistically significant ($P > 0.05$) and there was a strong correlation (0.98, $P < 0.001$) between two methods. Similarly, the length of involved segment measured by MRI and surgery was statistically significant ($P < 0.001$) with very good correlation (0.96, $P < 0.001$). The distance of tumor from mesorectal fascia between MRI and surgical findings was statistically significant with good correlation between two measurements (0.81, $P < 0.001$). A total number of suspicious locoregional lymph nodes on MRI, surgical, and histopathological finding were noted which difference was statistically significant as well as good agreement between MRI and surgical (0.80, $P < 0.001$) and MRI histopathology (0.73, $P < 0.001$) [Table 1 and Figure 1]. As an effort to develop a synoptic report format for convenience of operating surgeon, the status of mesorectal fascia involvement was recorded by MRI and surgical findings in yes or no form. There was a very good agreement between two findings (Kappa coefficient =0.81, $P < 0.001$). Circumferential resection margin (CRM) is a surgical term; however, in general, mesorectal fascia is the plane limiting resection in TME, and therefore, it is considered as the potential CRM on imaging, depending on plane of surgical dissection. CRM is applicable to tumors which lie below the peritoneal reflection of rectum. CRM was assessed by measuring shortest possible distance between peripheral edge of tumor and mesorectal fascia. The CRM/radial resection margin was determined on histopathology wherever possible by staining the radial margins of resected tumor for conspicuity and measuring shortest possible distance between tumor and radial margin. Distance of CRM between MRI and surgical findings was statistically insignificant and there was a weak correlation between MRI and surgical findings (0.46, $P < 0.001$) [Table 1 and Figure 3].

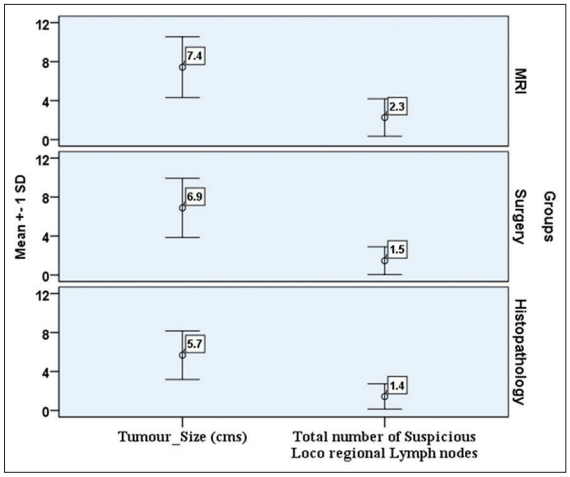

Figure 1: Error bar graph showing comparisons of mean measurements between magnetic resonance imaging, surgery, and histopathology

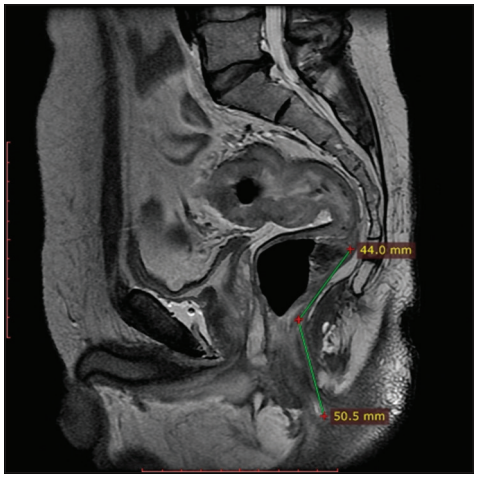

Figure 2: Mid-sagittal T2WI FSE image showing mid rectal tumor. Distance of lower most tumor margins (arrow) from anocutaneous junction (anal verge on DRE) divides the tumor into low/mid and high (0–6 cm), mid (6–12 cm), and high (12–16 cm) groups

Table 1: Description of tumor and its variation in methods (n=60)

Study parameters	Mean±SD	Median (IQR)	Min-max	*P* value	**Absolute agreement	*P* value
#Tumor size						
MRI	7.43±3.14	6.80 (5.00–8.33)	4–15	<0.001*	-	-
Surgery	6.88±3.06	6.00 (5.00–8.00)	3–15		0.95	<0.001
Histopathology (gross)	5.67±2.51	5.00 (4.00–7.00)	3–13		0.75	<0.001
Distance of lower tumor margin from anocutaneous junction						
MRI	4.45±2.80	3.75 (2.78–4.88)	0–14	0.145	-	-
Surgery	4.30±2.75	4.00 (3.00–5.00)	0–14		0.98	<0.001
Length of involved segment on						
MRI	9.10±3.50	8.70 (5.65–11.25)	5–16	<0.001	-	-
Surgery	8.42±3.50	8.00 (5.00–11.00)	4–16		0.96	<0.001
$*total number of suspicious locoregional lymph nodes on						
MRI	2.27±1.92	2.00 (0.75–4.00)	0–7	<0.001	-	-
Surgical dissection	1.47±1.43	1.00 (0.00–2.25)	0–5		0.80	<0.001
Histopathology	1.43±1.30	1.00 (0.00–2.00)	0–4		0.73	<0.001
Distance of tumor from mesorectal fascia						
MRI	4.25±4.69	2.90 (0.00–8.05)	4–14.6	<0.001	-	-
Surgery	2.70±3.29	1.00 (0.00–5.00)	0–10		0.81	<0.001
CRM						
MRI	4.18±4.57	2.90 (0.00–8.00)	0–14.6	0.063		-
Surgery	5.07±3.89	5.00 (2.00–5.00)	2–20		0.46	<0.001

Repeated measures ANOVA with pairwise comparisons or paired *t*-test used. Friedman test/Wilcoxon signed-rank test used. Pairwise difference was statistically significant, #Between all three pairs, $Between MRI and surgical, *MRI and Histopathology, **absolute agreement between the methods using intraclass correlation/Kappa statistics, CRM: Circumferential resection margin, MRI: Magnetic resonance imaging

DISCUSSION

We evaluated our experience with a high-resolution 3-Tesla MRI in 60 patients using primarily T2-weighted FSE sequences and compared the results with operative and histopathological findings for certain parameters. The study showed that tumor size by MRI, operative findings, and histopathological findings was statistically significant difference ($P < 0.05$), and agreement between the MRI and operative findings and histopathological findings was 0.95 and 0.75, quite good, and showing high accuracy of MRI in predicting tumor size. The total length of involved segment showed a very good agreement between MRI and surgical findings (0.96, $P < 0.001$). MRI was able to predict mesorectal fat and fascia involvement with high accuracy.

Our results were comparable in a study conducted by Brown *et al*. in 1999 and have been supported from time to time.[10] Recently, Giusti *et al*. in 2016 conducted a study on 1.5-Tesla MR systems to assess the role of MRI in predicting overall stage and mesorectal fascia evaluation. Authors reported a good agreement between MRI and histopathological findings

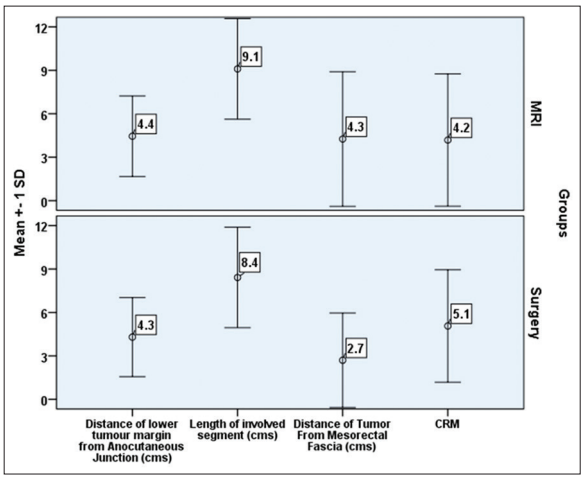

Figure 3: Error bar graph showing comparisons of mean measurements between magnetic resonance imaging and surgery

(kappa coefficient =0.78) which was almost the same with our study (kappa coefficient =0.81) to predict overall locoregional stage. A higher kappa coefficient in our study indicates the high accuracy of 3-Tesla MRI in predicting locoregional stage.[11]

Imaging plays a crucial role in pre-operative evaluation of carcinoma of rectum. Initially, high post-operative recurrence was a major concern in the treatment of rectal cancer.[12] The main reason for high recurrence was incomplete removal which in turn was due to inadequate pre-operative information regarding tumor extent and resection plane.[13] Introduction of total mesorectal excision has resulted in significant decrease in post-operative recurrence.[14] Total mesorectal excision (TME) is a common procedure used in the treatment of colorectal cancer in which a significant length of the bowel around the tumor is removed. Certain studies have shown that in addition to TME, pre-operative long course CT-RT has lower 5-year local recurrence rates as compared to post-operative long course CT-RT in T3, T4, and lymph node-positive cancers.[15]

CRM is a surgical term and refers to surgically dissected surface of non-peritonealized surfaces of rectum. Mesorectal fascia constitutes the surgical plane which limits resection. Based on the plane of surgical dissection, the CRM can be both inside and outside the mesorectal fascia. In the present study, potential CRM was measured as the shortest possible distance between outermost tumor margins and mesorectal fascia, and a fair correlation was obtained between MRI and Surgery.

Mesorectal fat infiltration appears as relatively hypointense tumor signal in hyperintense fat, thereby imparting innate contrast obviating need of contrast. The topographic relation of tumor margins to mesorectal fascia and clock face depiction of mesorectal fat infiltration is very important in planning resection and selecting plane of dissection [Figure 4a-d]. We noticed a good agreement between MRI and histopathological findings in the evaluation of mesorectal fat infiltration by tumor.

The number of suspicious for malignancy/positive lymph nodes is more important in staging as small mesorectal lymph nodes can also be positive. A single criterion of lymph node positivity is not sufficient. In our experience, a triad of criteria, namely, the lymph node size ≥8 mm, heterogeneous internal signal, and irregular shape showed a good prediction of lymph node positivity. Mesorectal lymph nodes are resected *en bloc* in TME, and for mesorectal lymph nodal evaluation, the number and clock face position of node as well as distance of node from mesorectal fascia was also noted to be useful for surgeons because lymph nodes lying very close (<1 mm) to mesorectal fascia should be resected. Thus, the results of the present study are encouraging to determine exact accuracy of high-resolution 3-Tesla MRI in the pre-operative evaluation of rectal cancer.

Strength and Limitations of this Study

The present study is included in very few studies in which this kind of research has been done. Smaller sample size is a limitation of this study. Interesting observations seen in the present study opens the scope for a larger population-based study with larger sample size.

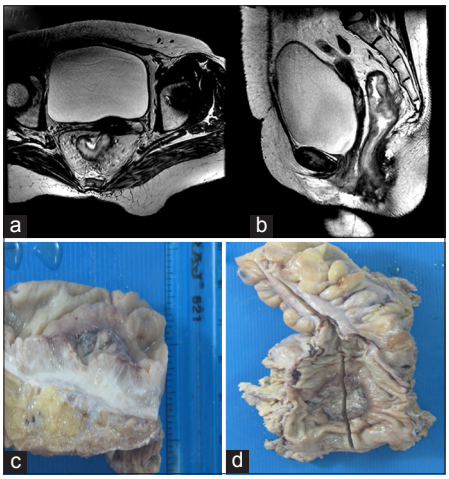

Figure 4: T staging-(a), axial T2W FSE showing tumor margins involving mesorectal fascia posteriorly (b). Sagittal T2W FSE images clearly showing extension of tumor posteriorly to involve MRF. (c and d) Corresponding gross resected specimen showing growth extending into mesorectal fat and toward luminal side

CONCLUSION

HRMRI, therefore, is a promising imaging modality for local staging and pre-operative planning of cases of rectal cancer. Despite few limitations, this modality has definitely good ability to address issues related to evaluation of primary tumor and pre-operative planning with high accuracy. Thus, the present study concludes that non-contrast high-resolution 3-Tesla MRI in T2-weighted FSE sequences are alone sufficient to appropriately assess preoperatively and stage accurately. The MRI can also be used in case of renal dysfunction and in pregnant status.

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How to cite this article: Kumar S, Singh US, Mishra P, Lal H, Kumari N, Prakash A, Gupta A. Correlation of high-resolution magnetic resonance imaging with surgico-pathological findings in rectal carcinoma patients. Int J Med Sci Public Health 2018;7:580-585.

Source of Support: Nil,**Conflict of Interest:** None declared.