ORIGINAL ARTICLE

DIAGNOSTIC ACCURACY OF CONTRAST ENHANCED MRI IN STAGING OF RECTAL CARCINOMA BY TAKING HISTOPATHOLOGY AS GOLD STANDARD

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ABSTRACT

OBJECTIVES: To determine the diagnostic accuracy of contrast enhanced MRI in staging of rectal carcinoma by taking histopathological findings as gold standard. **STUDY DESIGN:** Cross-sectional validation study. **SETTING:** Department of Radiology, Combined Military Hospital, Rawalpindi from 15-03-2022 to 14-09-2022. **METHODOLOGY:** A total of 100 patients were included with suspected CA rectum of either gender aged 20 to 50 years. Patients with claustrophobia, cardiac pacemakers/ metal implants, allergic to contrast agent or not willing to participate in study were excluded. Magnetic resonance imaging was performed on a 1.5 T MR system (Siemens) centered on pelvis which was covered with body-matrix coil. Findings of MRI were evaluated by the researcher which were supervised by a consultant radiologist. Staging was done according to the TNM classification system. Histopathological reports were evaluated at histopathology department of hospital. **RESULTS:** Diagnostic accuracy of contrast enhanced MRI in T2 staging of rectal carcinoma showed sensitivity 87.5%, specificity 83.7%, PPV 31.8%, NPV 98.7%, diagnostic accuracy 84%. T3 staging demonstrate sensitivity, Specificity, PPV, NPV and diagnostic accuracy of 73.2%, 77.2%, 80.3%, 69.3% and 75% respectively. T4 staging showed sensitivity 75%, specificity 100%, PPV 100%, NPV 87.6%, diagnostic accuracy 91%. Diagnostic accuracy of MRI in nodes showed sensitivity 85.9%, specificity 72.7%, PPV 91.8%, NPV 59.2%, diagnostic accuracy 83%. Diagnostic accuracy of MRI in CRM revealed sensitivity 72.8%, specificity 89.4%, PPV 96.7%, NPV 43.5%, diagnostic accuracy 76%. **CONCLUSION:** In conclusion, contrast enhanced MRI is a non-invasive technique with high degree of sensitivity and accuracy in the diagnosis of staging of rectal carcinoma.

Key words: Rectal carcinoma, diagnostic accuracy, contrast enhanced MRI, histopathology.

Introduction

Colorectal cancer is the second most common cancer in women and being the third most common in men.[1] It is the second most common cause of cancer related deaths in Europe.[2] It is known to be the third most common cause of new cancers in both genders in United States. Its prevalence is increasing in age group of less than 50 years and the death rate has increased by 1% every year.[2] The prognosis of this cancer is not good with direct relation to the progressive stage of the disease.[2] This reflects the need of increased screening and improvement in staging of colorectal cancer.[3] The introduction of MRI in rectal cancers has led to significant improvements in control of the disease at early stages. Surgical resection is still considered the curative treatment for most of the rectal cancers which depend on MRI for the local staging.[4] Patients with early rectal

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cancer can be offered the correct treatment if they are identified and accurately staged before resection. Organ preservation avoids the extra mortality and morbidity such as permanent stoma, sexual dysfunction and a prolonged hospital stay.[5] In context of staging the primary tumor, rectal MRI is crucial for evaluating tumor morphology and its TNM stage with significant impact on therapeutic decisions. The features that help with this include tumor location, depth of invasion, lymph node involvement, circumferential resection margin (CRM) status and extramural venous invasion.[5-8] United Kingdom by Balyasnikova et al condected a study[7] demonstrating that MRI was 91% sensitive, 85% specific with an overall diagnostic accuracy of 89% accuracy (95% CI), 93% PPV and 81% NPV in differentiating tumor stages when compared with histopathological data. However, there is paucity of data on staging based on MRI in Pakistan. The objective of this study is to determine the diagnostic accuracy of contrast enhanced MRI in staging of rectal carcinoma in our hospital setup which will guide the appropriate treatment planning and surgical management by facilitating the surgeon in accurate assessment of mesorectal fascia and the sphincter complex as well as obtaining a negative resection margin.

Methodology

The study was conducted at Department of Radiology, Combined Military Hospital, Rawalpindi over a period of six months from 15-03-2022 to 14-09-2022. Approval was taken from hospital ethical committee. Sample size was calculated using sensitivity specificity calculator, sensitivity is 91% and specificity is 85%. Prevalence is 50% with confidence interval of 95%. Absolute Precision=10%. 100 patients with mean age of 41.06 ± 8.62 years (20 to 50 years) presenting to radiology department of Combined Military Hospital, Rawalpindi fulfilling the inclusion criteria were selected by non-probability sampling technique. Informed consent was taken from each patient. Then MR examinations were performed on a 1.5 T MR system (Siemens) with a body-matrix coil centred over the pelvis. High-resolution T2W turbo spin echo (TSE) scans were acquired in coronal and sagittal planes, followed by oblique-axial scans (perpendicular to the long axis of the rectum with 250 mm field of view (FOV), 3 mm slice thickness). After T2W sequences intravenous gadolinium-based contrast agent (0.2 mL/kg) and contrast-enhanced fat suppressed T1-weighted images were obtained. Findings of MRI were evaluated by the researcher which were supervised by a consultant radiologist. TNM classification was use to classify the results. Histopathological reports were evaluated at histopathology department of hospital. Data was entered on structured proforma (annexure A).

Inclusion Criteria

All clinically suspected patients of rectal carcinoma. Either gender, aged 20 to 50 years.

Exclusion Criteria

Patients with claustrophobia, cardiac pacemakers/ metal implants.
Patients allergic to contrast agent.
Patients not willing to participate in study.
Collected data was analyzed through computer software SPSS version 22.0. Quantitative variables like age were measured on mean standard deviation. Qualitative variables like gender, true positive, true negative was measured on frequency and percentage.

MRI staging of rectal cancer

MRI staging of rectal cancer based upon tumor location, relationship to mesorectal fascia and sphincters, size, extent of extramural spread, peritoneal reflection, lymph nodes, and bony metastasis. The distance for lower end of tumor to anal verge is measured for localization. A rectal tumor is characterized as low (when its most caudal border is less than 5 cm from the anal verge), middle (5-10 cm from the anal verge), or high (more than 10 cm from the anal verge).

T Stage

Differentiation of T1 from T2 tumors on MRI is usually not reliable without an endorectal coil, and tumors should be generally staged as “T1/T2.” A tumor is staged as T3 when it invades the mesorectal fat. Spiculation of the mesorectal fat can be caused by either a benign desmoplastic reaction, seen as low signal intensity on T2-weighted images (T2 tumor), Early T3 tumor extension is demonstrated as intermediate signal intensity on T2-weighted images, and may not be easily differentiated from one another on MRI. For T3 tumors, the shortest distance between the most penetrating parts of the tumor and the mesorectal fascia (MRF) should be measured. The MRF is best visualized on T2-weighted images as a hypointense line surrounding the mesorectal fat especially at the proximal and posterior portions of the rectum where fat tissue is more abundant. If satellite nodules are seen, shortest distance between the nodules and mesorerctal fascia is also reported. The invasion / extension of tumor beyond the muscularis propria is used for risk assesmnet. The American Joint Committee on Cancer suggested an optional stratification of T3 tumors based on the extramural depth of invasion: less than 5 mm, T3a; 5-10 mm, T3b; and more than 10 mm, T3c. An extramural depth of invasion of less than 5 mm confers a significantly higher survival rate, and these early T3 tumors may be adequately managed with surgery alone and have a prognosis comparable to that of tumors characterized as “T1/T2”.

N Stage

In the TNM system, disease involving only the regional nodes, including the mesorectal and internal iliac nodes, accounts for the N stage; involvement of other nodes is regarded as metastasis. Extramesorectal nodes are generally involved in locally advanced cancers. Inguinal nodal metastases, which are more typical of anal cancer than of rectal cancer, are uncommon even in low rectal cancers and imply poor prognosis.

Currently, size (i.e., short axis) and morphologic criteria are used with variable sensitivities (56-94%) and specificities (67-83%) for the differentiation of benign from malignant nodes.[11] The most commonly advocated size cutoffs for the diagnosis of malignancy are in the range of 5-8 mm; however, adding morphologic features, such as irregular contour and mixed signal intensity may increases the diagnostic accuracy.

Extramural Vascular Invasion

EMVI refers to the extension of rectal tumor into the veins beyond the muscularis propria .MRI canvisualized it by moderate sensitivity and high specificity by noting the vessels close to the tumor are obviously irregular or distended by tumoral signals. EMVI is associated with a higher incidence of metastasis, local recurrence, poorer response to preoperative CRT, and overall lower survival rate.

CA rectum staging on histopathology

The extent of local tumor spread in each histopathologic slice was assessed according to the TNM staging. If the tumor is seen extending to 1 mm of the circumferential excision marginthen the margins are considered to be involved.

2 x 2 contingency table was used to measure specificity, sensitivity, positive predictive value, negative predictive value and diagnostic accuracy of contrast enhanced MRI scan in staging rectal carcinoma, taking histopathology as gold standard.

Results

Mean age of the patients was 41.06 ± 8.62 years. There were 68 males (68%) and 32 females (32%). Out of 100 subjects, 53 (53%) were living in Urban areas while 47 (47%) belonged to rural setup. Diagnostic accuracy of contrast enhanced MRI in T2 staging of rectal carcinoma

Rectal carcinoma on MRI	Rectal Carcinoma on Histopathology (Gold Standard)		Total
	Positive	Negative	
Positive	41 (TP)	10 (FP)	51
Negative	15 (FN)	34 (TN)	49
Total	56	44	100

Table 1: Diagnostic accuracy of contrast enhanced MRI in T3 staging of rectal carcinoma by taking histopathological findings as gold standard.

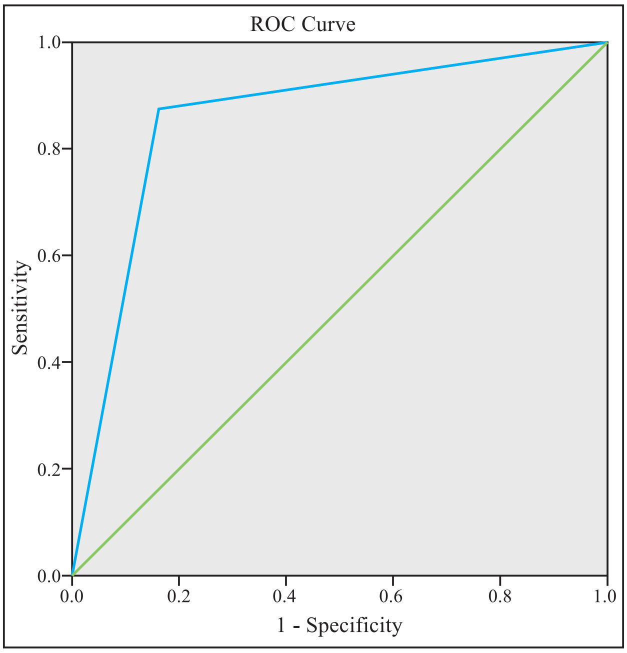

Figure 1: ROC curve for T3 staging of rectal carcinoma.

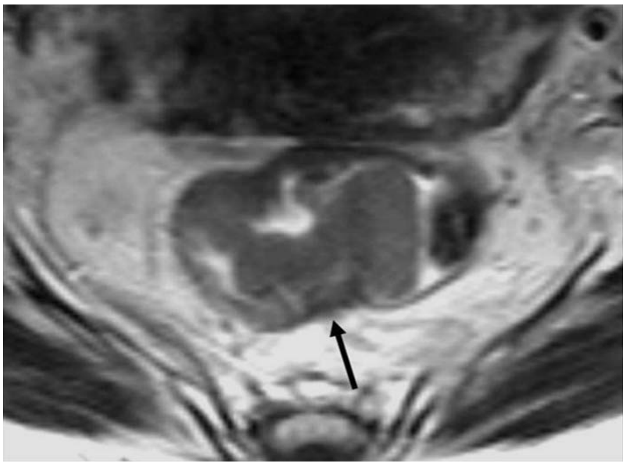

Figure 2: Axial T2W MR image shows a typical T2-stage lesion infiltrating muscularis propria but limited to the bowel wall, which is identified as the black line around the tumour.

showed sensitivity 87.5%, specificity 83.7%, PPV 31.8%, NPV 98.7%, diagnostic accuracy 84%. T3 staging showed sensitivity 73.2%, specificity 77.2%, PPV 80.3%, NPV 69.3%, diagnostic accuracy 75% (Tab.1). T4 staging showed sensitivity 75%, specificity 100%, PPV 100%, NPV 87.6%, diagnostic accuracy 91%. Diagnostic accuracy of contrast enhanced MRI in nodes showed sensitivity 85.9%, specificity 72.7%, PPV 91.8%, NPV 59.2%, diagnostic accuracy 83% (Tab.2). Diagnostic accuracy of contrast enhanced MRI in CRM revealed sensitivity 72.8%, specificity 89.4%, PPV 96.7%, NPV 43.5%, diagnostic accuracy 76% (Tab.3). Stratification for age, gender and residence was also carried out.

Nodes on MRI	Nodes on Histopathology (Gold Standard)		Total
	Positive	Negative	
Positive	67 (TP)	6 (FP)	73
Negative	11 (FN)	16 (TN)	27
Total	78	22	100

Table 2: Diagnostic accuracy of contrast enhanced MRI in nodes by taking histopathological findings as gold standard.

CRM on MRI	CRM on Histopathology (Gold Standard)		Total
	Positive	Negative	
Positive	59 (TP)	2 (FP)	61
Negative	22 (FN)	17 (TN)	39
Total	81	19	100

Table 3: Diagnostic accuracy of contrast enhanced MRI in CRM (circumferential margin of resection) by taking histopathological findings as gold standard.

Discussion

One of the most common gastrointestinal malignancies worldwide is rectal carcinoma with high mortality rates due to increased risk of local recurrence and distant metastasis.[25,26] About 98% of the rectal tumors are adenocarcinoma on histopathology and they predominantly affect the elderly population (> 50 years) with a slight male predominance.[26] Patients with rectal tumors usually present with symptoms of painful defecation, lower gastrointestinal and rectal bleeding as well as altered bowel habits.[27] Imaging plays a vital role in the staging of rectal malignancy and aids in the assessment of other important prognostic features like extramural tumor invasion, extramural tumor vascular invasion (EMVI).[22] Tumor staging plays a vital role in patient management and evaluating the prognosis of the disease. In order to decide the appropiatemanage mentits very important to do rectal tumor staging. Magnetic Resonance Imaging (MRI) is increasingly being performed for the local tumor staging of rectal tumors as it can accurately depict the extent of the tumor and outline any local organ involvement as well as involvement of the neurovascular bundles.[29] MRI is the modality of choice for staging rectal tumors along with computed tomography of the chest, abdomen and pelvis to screen for distant metastasis. This is then followed by surgery with or without prior chemoradiotherapy depending on the stage of disease and the extent of tumor infiltration. The higher-grade tumors are subjected to pre-operative chemoradiotherapy to down size the tumor. Hence, accurate pre-operative staging is very vital as it would allow the surgeons to decide suitable management plan.[26] MRI staging of rectal tumors evaluated the tumor location, depth of invasion and its relationship with adjacent viscera, neurovascular bundles, peritoneal reflection, internal sphincter, nodal involvement and osseous metastasis. MRI is very helpful and have high specificity in detecting extramural vascular invasion and extramural invasion into mesorectal fat.[30] In current study, contrast enhanced MRI in staging of rectal carcinoma T2 stage showed sensitivity 87.5%, specificity 83.7%, accuracy 84%, T3 stage showed sensitivity 72.2%, specificity 77.2%, accuracy 75% while T4 stage showed sensitivity 75%, specificity 100%, accuracy 91%. Nodal staging showed sensitivity 85.9%, specificity 72.7%, accuracy 83%. Our findings are comparable with a study carried out by Balyansikova et al.[7]

Conclusion

In conclusion, contrast enhanced MRI is a non-invasive technique with high degree of sensitivity and accuracy in the diagnosis of staging of rectal carcinoma.
MRI is the modality of choice for staging rectal cancer to assist surgeons in obtaining negative resection margins. MRI facilitates the accurate assessment of mesorectal fascia and the sphincter complex for surgical planning.

CONFLICT OF INTEREST: None

References

1. Iqbal Memon A, Naz S, Jalees U, Masroor Bhatti A, Khan R, Zeb M. Diagnostic accuracy of MRI for detecting the preoperative tumor staging of colorectal carcinoma: MRI for the preoperative tumor staging of colorectal carcinoma. PJHS-Lahore [Internet]. 2022 Dec 31, cited May 2025; **3(07):** 176-80.

2. Naz N, Azmatullah U, Ali A, Majid M, Ahmed A. To determine the diagnostic accuracy of magnetic resonance imaging in detecting rectal cancer, keeping histopathology as a gold standard. Int J Endors Health Sci Res. 2021; **9(3):** 365-70.

3. Saeed S, Muhammad A, Khan N, Adil Z, Majid A. Diagnostic accuracy of MRI in mesorectal fascial involvement. J Rehman Med Inst. Apr-Jun 2022; **8(2):** 19-22.

4. Çelik H, Barlik F, Sökmen S. Diagnostic performance of magnetic resonance imaging in preoperative local staging of rectal cancer after neoadjuvant chemoradiotherapy. DiagnIntervRadiol. 2023; **29(2):** 219-27.

5. Krdzalic J, Beets-Tan RGH, Engelen SME, Bahadoer RR, Maaskant-Braat AJG, Martijn H, et al. MRI predicts increased eligibility for sphincter preservation after CRT in low rectal cancer. Radiother Oncol. 2020;**145:** 223-8.

6. Horvat N, Carlos Tavares Rocha C, Clemente Oliveira B, Petkovska I, Gollub MJ. MRI of rectal cancer: Tumor staging, imaging techniques, and management. Radiographics. 2019; **39(2):** 367-87.

7. Brenner H, Bouvier AM, Foschi R, Hackl M, Larsen IK, Lemmens V, et al. EUROCARE Working Group. Progress in colorectal cancer survival in Europe from the late 1980s to the early 21st century: the EUROCARE study. International Journal of Cancer. Oct 2012; **131(7):** 1649-58.

8. Jemal A, Ward EM, Johnson CJ, Cronin KA, Ma J, Ryerson AB, et al. Annual report to the nation on the status of cancer, 1975-2014, featuring survival. JNCI. Sep 2017; **109(9)**.

9. Santiago I, Figueiredo N, Parés O, Matos C. MRI of rectal cancer-relevant anatomy and staging key points. Insights Imaging. 2020; **11:** 100.

10. Amin MB, Greene FL, Edge SB, Compton CC, Gershenwald JE, Brookland RK, et al. The eighth edition AJCC cancer staging manual: continuing to build a bridge from a population-based to a more “personalized” approach to cancer staging. CA: a cancer journal for clinicians. Mar 2017; **67(2):** 93-9.

11. Balyasnikova S, Read J, Wotherspoon A, Rasheed S, Tekkis P, Tait D, et al. Diagnostic accuracy of high-resolution MRI as a method to predict potentially safe endoscopic and surgical planes in patients with early rectal cancer. BMJ Open Gastro. 2017; **4:**1-9.

12. Tamandl D, Mang T, Ba-Ssalamah A. Imaging of colorectal cancer - the clue to individualized treatment. Innov Surg Sci. 2018; **3(1):** 3-15.

13. Al-Sukhni E, Milot L, Fruitman M, Beyene J, Victor JC, Schmocker S, et al. Diagnostic accuracy of MRI for assessment of T category, lymph node metastases, and circumferential resection margin involvement in patients with rectal cancer: a systematic review and meta-analysis. Ann Surg Oncol 2012; **19:** 2212-23.

14. Beets-Tan RGH, Lambregts DMJ, Maas M, Bipat S, Barbaro B, Curvo-Semedo L, et al. Magnetic reso-

nance imaging for clinical management of rectal cancer: Updated recommendations from the 2016 European Society of Gastrointestinal and Abdominal Radiology (ESGAR) consensus meeting. EurRadiol. 2018; **28(4):** 1465-75.

15. Kim DJ, Kim JH, Ryu YH, Jeon TJ, Yu JS, Chung JJ. Nodal staging of rectal cancer: high-resolution pelvic MRI versus ^{18}F-FDGPET/CT. J Comput Assist Tomogr2011; **35:** 531-4.

16. Taylor FG, Quirke P, Heald RJ, Moran B, Blomqvist L, Swift I, et al. Preoperative high-resolution magnetic resonance imaging can identify good prognosis stage I, II, and III rectal cancer best managed by surgery alone: a prospective, multicenter, European Study that recruited consecutive patients with rectal cancer. Ann Surg. 2011; **253:** 711-9.

17. Shihab OC, Taylor F, Bees N, Blake H, Jeyadevan N, Bleehen R, et al. Relevance of magnetic resonance imaging-detected pelvic sidewall lymph node involvement in rectal cancer. Br J Surg 2011; **98:** 1798-804.

18. Siegel R, Desantis C, Jemal A. Colorectal cancer statistics, 2014. CA: a cancer journal for clinicians. 2014; **64(2):** 104-17.

19. GLOBOCAN. Estimated Cancer Incidence, Mortality and Prevalence Worldwide in 2012: International Agency for research on Cancer. World Health Organization; 2014 [cited 2022 August 11]. Available from: http://globocan.iarc.fr/Pages/fact_ sheets_ cancer.aspx.

20. Siegel R, Ma J, Zou Z, Jemal A. Cancer statistics, 2014. CA. 2014; **64(1):** 9-29.

21. Maas M, Lambregts DM, Lahaye MJ et al (2012) T-staging of rectal cancer: accuracy of 3.0 tesla MRI compared with 1.5 tesla. Abdom Imaging 2012; **37(3):** 475-81.

22. Bruening W, Sullivan N, Paulson EC. Imaging tests for the staging of colorectal cancer. Agency for Healthcare Research and Quality (US), Rockville, 2014.

23. Kaur H, Choi H, You YN. MR imaging for preoperative evaluation of primary rectal cancer: practical considerations. Radiographics 2012; **32(2):** 389-409.

24. Lambregts DMJ, van Heeswijk MM, Delli Pizzi A, van Elderen SGC, Andrade L, Peters NHGM, et al. Diffusion-weighted MRI to assess response to chemoradiotherapy in rectal cancer: main interpretation pitfalls and their use for teaching. EurRadiol. 2017; **27(10):** 4445-54.

25. Furey E, Jhaveri KS. Magnetic resonance imaging in rectal cancer. Magn Reson Imaging Clin N Am 2014; **22:** 165-90.

26. Sohn B, Lim JS, Kim H, Myoung S, Choi J, Kim NK, Kim MJ. MRI-detected extramural vascular invasion is an independent prognostic factor for synchronous metastasis in patients with rectal cancer. EurRadiol. 2015; **25:** 1347-55.

27. Bugg WG, Andreou AK, Biswas D, Toms AP, Williams SM. The prognostic significance of MRI-detected extramural venous invasion in rectal carcinoma. Clin Radiol2014; **69:** 619-23.

28. Pedersen BG, Moran B, Brown G, Blomqvist L, Fenger-Grøn M, Laurberg S. Reproducibility of depth of extramural tumor spread and distance to circumferential resection margin at rectal MRI: enhancement of clinical guidelines for neoadjuvant therapy. AJR Am J Roentgenol2011; **197:** 1360-6.

29. Iafrate F, Laghi A, Paolantonio P, Rengo M, Mercantini P, Ferri M, et al. Preoperative staging of rectal cancer with MR Imaging: correlation with surgical and histopathologic findings. Radiographics. 2006; **26(3):** 701-14.