ORIGINAL ARTICLE

Effect of endorectal coils on staging of rectal cancers by magnetic resonance imaging

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Objective To compare the use of endorectal plus phased-array coils with use of phased-array coil alone with respect to the accuracy of magnetic resonance imaging for detecting mesorectal involvement of rectal cancer.

Design Retrospective study.

Setting A tertiary referral centre in Hong Kong.

Patients Ethnic Chinese patients with rectal adenocarcinoma who underwent staging magnetic resonance imaging during the years 2003 to 2008 in our centre were selected; those who received preoperative neoadjuvant therapy were excluded. Unless otherwise contra-indicated, endorectal coils have been used since 2006.

Main outcome measures Magnetic resonance images were retrieved and reviewed by two radiologists blinded to the pathological results. The radiological findings were then correlated with the pathological reports to determine diagnostic accuracy.

Results A total of 50 patients were studied; 13 of the examinations were in patients having an endorectal coil. The overall accuracy of magnetic resonance imaging in detecting mesorectal tumour involvement was 80%. Subgroup analysis showed higher accuracy in the group with endorectal coils than in those with phased-array coils alone. Over-detection of mesorectal involvement was noted in 12% of the cases, with lower rate being observed in patients with endorectal coils. Underdetection of mesorectal tumour involvement was only noted in the group without endorectal coils. With the use of endorectal coils, the sensitivity reached 100% and the specificity increased to 86%.

Conclusion Use of endorectal coil in staging magnetic resonance imaging of the rectum improves diagnostic accuracy. Whenever feasible, endorectal coil use is therefore recommendable to enhance diagnostic accuracy. The study results substantiate the understanding of staging by magnetic resonance imaging of rectal cancer in the local Chinese population.

Key words
Adenocarcinoma; Magnetic resonance imaging; Neoplasm staging; Rectal neoplams; Sensitivity and specificity

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Introduction

Rectal cancer is a common malignancy and causes significant morbidity. In 2006, there were 1554 newly diagnosed anorectal carcinomas in Hong Kong and the reported mortality was 538 within the same year.[1] Rectal cancer is associated with a high risk of metastases and local recurrence; local recurrence rates after surgical treatment being up to 32%.[2] An accurate local staging at the time of initial diagnosis is therefore very important. Tumour staging, especially local staging (ie T staging), determines the treatment strategy, including operation planning and the use of neoadjuvant therapy.

Various radiological modalities have been utilised for tumour staging. They include computed tomography (CT), endorectal ultrasonography (endorectal USG) and magnetic resonance imaging (MRI). Among these imaging modalities, MRI has been shown to be highly accurate for local staging. Additional benefits were that it was less operator-dependent, it enabled evaluation of anal infiltration as well as the depth of extramural invasion, and it could also be used to predict the circumferential resection margin.[3,4] Overseas studies have demonstrated encouraging results, mostly in western populations. According to the results of a study in the United States, the Chinese were 10 to 60% more

直腸表面綫圈磁力共振影像（MRI）對直腸癌分期的作用

目的 對於直腸癌患者，分別用直腸表面綫圈加上陣列綫圈及只用陣列綫圈，比較兩種方法對MRI檢測牽涉直腸系膜的準確性。

設計 回顧研究。

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患者 2003至2008年期間到本中心接受MRI直腸腺癌分期的華藉病人；術前已接受新輔助治療的病人除外。自從2006年開始，除了有禁忌症的病例外，所有病人均用直腸表面綫圈。

主要結果測量 未知道病理結果的兩名放射科醫生分別檢視MRI影像，然後將得出的放射結果與病理報告作對照來決定MRI的診斷準確性。

結果 研究了50名病人的紀錄，其中13名曾用直腸表面綫圈。MRI檢測牽涉直腸系膜的準確性為80%。分組分析顯示兩種的檢查方法，用直腸表面綫圈加上陣列綫圈的病人的準確度較高。12%的病例對於牽涉直腸系膜有過度診斷，其中又以使用直腸表面綫圈的病例有較低比率。使用直腸表面綫圈的敏感性達至100%，特異性亦上升至86%。

結論 用直腸表面綫圈MRI檢測直腸癌分期可改善診斷準確度。情況許可的話，建議使用直腸表面綫圈來加強診斷準確性。本研究結果進一步加強對MRI檢測華人直腸癌分期的理解。

likely to be diagnosed with stage III or IV colorectal carcinoma than Caucasians,[5] though they had a 10 to 40% lower risk of mortality.

The objectives of this study were to determine the accuracy of MRI staging of rectal carcinoma in a Chinese population and to evaluate the effect of endorectal coils on staging accuracy.

Methods

This study entailed a retrospective correlation of MRI and histopathological findings of rectal carcinoma. Patients with histologically proven adenocarcinoma who underwent MRI in our hospital during the period of 2003 to 2008 were selected. The clinical information and the histopathological reports were retrieved from the hospital database. Patients who had received preoperative neoadjuvant therapy were excluded, as the response of the tumour after the neoadjvant therapy might alter local staging.

All MRI examinations were performed with a 1.5-Tesla (1.5T) Siemens Symphony machine (Siemens, Erlangen, Germany) with a six-channel phased-array body coil. An additional endorectal coil has been utilised in the examinations since 2006 (MRInnervu, disposable endorectal coil for 1.5T MRI of the colon by MEDRAD [Indianola, US]), except for the stenotic tumours or unless the patient could not tolerate the procedure. The balloon of the endorectal coil was not inflated. T1- and T2-weighted transaxial, as well as T2-weighted coronal and sagittal images were acquired. T2-weighted images with fat saturation sequence were acquired with imaging planes selected by reporting radiologist. Slices were 3 mm in thickness with no gap. The field of view was 20 cm x 20 cm with a 256 x 256 matrix. No intravenous contrast was administered.

All MRI images were retrieved and retrospectively reviewed by two radiologists without knowing the histopathological results. The collected data included tumour morphology (circumferential, eccentric, polypoid), length of tumour involvement, and the distance of the tumour from anus. The predicted local T staging of the tumour from MRI images was based on the following criteria: T1 tumours were those showing mild mucosal thickening (Fig 1). T2 tumours were more bulky than mucosal thickening but there was no perirectal stranding or extension of abnormal signal intensity to the mesorectal fat (Fig 2). T3 tumours were those with perirectal stranding or extension of abnormal signal intensity to the mesorectal fat (Fig 3a). For T4 tumour, there had to be evidence of extension or abnormal signal intensity to the adjacent organs, pelvic side wall or peritoneal layer (Fig 3b). The number of lymph nodes in the perirectal region and the size of the largest one were measured. The histopathological reports of the surgical specimens were also reviewed.

Statistical analyses were performed using the Statistical Package for the Social Sciences (Windows

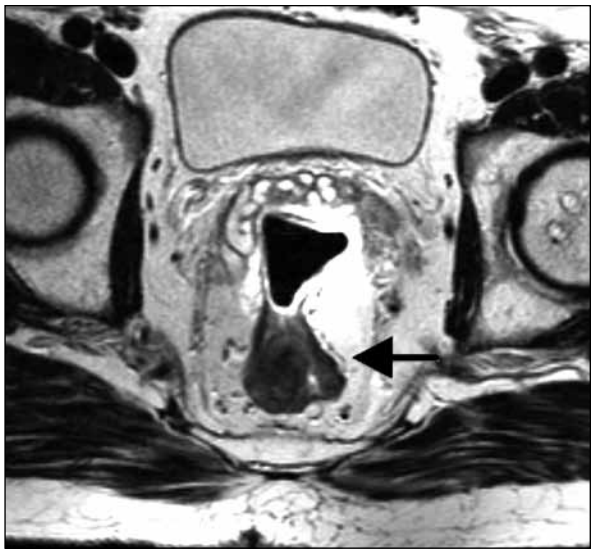

FIG 1. T2-weighted axial image of the rectum with an endorectal coil

Pathologically proven T1 tumour; tumour over the posterior rectal wall (arrow); the perirectal fat is clear

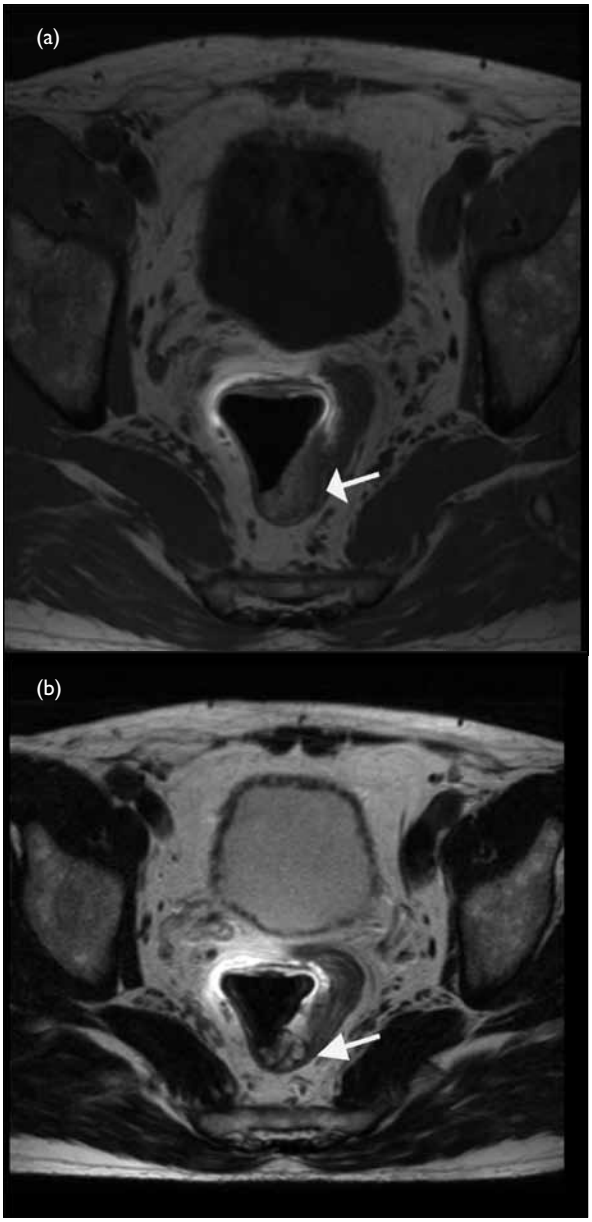

FIG 2. (a) T1-weighted and (b) T2-weighted axial images of the rectum with an endorectal coil
Pathologically proven T2 tumour; images show wall thickening of the posterior rectum (arrows); the perirectal fat is clear; this is not differentiable from T1 tumour

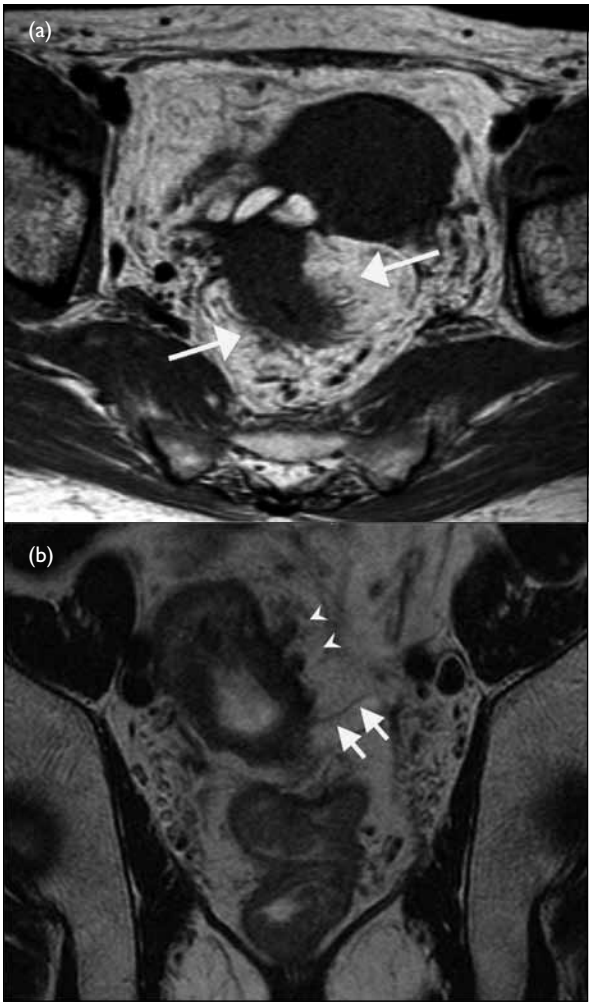

FIG 3. (a) T1-weighted axial image showing spiculation and stranding in perirectal fat, suggesting subserosal invasion (arrows); pathologically proven T3 tumour. (b) Coronal T2-weighted image showing a large rectal tumour involving the rectosigmoid junction. The arrows indicate the mesorectal fascia. Invasion into the peritoneal cavity (arrowheads) is evident; pathological examination showed a T4 tumour

version 15.0; SPSS Inc, Chicago [IL], US). The Pearson Chi squared test was used in the analysis of contingency tables, and Fisher's exact test for small samples. The Spearman correlation was used for correlation studies. Non-parametric tests (such as the Mann-Whitney test) were performed in the analysis between different cohorts. Confidence intervals and P values were calculated. A P value of less than 0.05 (2-tail) was considered to be statistically significant. Other parameters including sensitivity, specificity, and positive and negative predictive values were also calculated.

Results

Fifty patients were included in the study (M:F=30:20; mean age, 68 years). The commonest clinical presentation was per-rectal bleeding (76%, n=38).

Preoperative MRI examination was performed for all patients and an additional endorectal coil was used in 13 of them (26%); 16 of these examinations were performed after year 2006, at which time use of an endorectal coil had become a routine. There was failure of coil insertion in three patients, corresponding to a failure rate of 19% (3/16). No serious complication was reported from placement of endorectal coils.

All patients subsequently underwent operation. The mean time lag between the MRI study and operation was 23.2 days.

TABLE 1. Correlation of magnetic resonance imaging–predicted staging versus actual pathological staging (based on all cases irrespective of endorectal coil use), subdivided into three groups

Magnetic resonance imaging	Pathology			
	T1	T2	T3	T4
All cases included				
T1	0	0	0	0
T2	2	7	4	0
T3	0	6	27	1
T4	0	0	0	1
Total	**2**	**13**	**31**	**2**
With endorectal coil				
T1	0	0	0	0
T2	1	5	0	0
T3	0	1	5	0
T4	0	0	0	0
Total	**1**	**6**	**5**	**0**
Without endorectal coil				
T1	0	0	0	0
T2	1	2	4	0
T3	0	5	22	1
T4	0	0	0	1
Total	**1**	**7**	**26**	**2**

TABLE 2. Improved sensitivity, specificity, positive and negative predictive values for magnetic resonance imaging examination of the rectum with endorectal coils

	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Overall	88%	60%	83%	69%
With endorectal coil	100%	86%	83%	100%

The most common tumour morphology on MRI was eccentric wall thickening (48%, n=24), followed by circumferential thickening (44%, n=22) and polypoid growth (6%, n=3). The length of the tumours ranged from 1.4 to 10.8 cm (mean, 4.5 cm) and their distance from anus ranged from 1.5 to 12.0 cm (mean, 6.5 cm). Regarding the local tumour staging (T-staging), the histopathological results showed that there were 2 (4%) T1 tumours, 14 (28%) T2 tumours, 31 (62%) T3 tumours, and 2 (4%) T4 tumours. A positive correlation was demonstrated between the MRI-predicted T-staging and histopathological T-staging (P<0.01). One tumour which was not well identified by MRI (ie MRI-predicted T-staging as T1), but subsequently shown to be a T2. Another postoperative surgical specimen with MRI prediction of a T2 tumour yielded no residual pathological lesion, which was very likely related to the prior endoscopic polypectomy before the operation. In this study, the overall accuracy of MRI-predicted T-staging was 72% (n=36) [Table 1]. The accuracy with the endorectal coil was 77% (11/13) and without an endorectal coil it was 68% (25/37).

The overall accuracy in detecting mesorectal involvement (ie T3 and T4 diseases) was 80% (n=40). Correlational study demonstrated a positive correlation between the MRI-predicted mesorectal tumour involvement and actual histopathological findings (P<0.001). In predicting mesorectal involvement of rectal carcinoma, subgroup analysis revealed higher accuracy in examinations involving endorectal coils (92%, 12/13) than those without such involvement (76%, 28/37). However, the difference in accuracies did not achieve statistical significance (P=0.202). Over-detection of mesorectal involvement was noted in 12% of cases (n=6), but lower in the group in whom endorectal coil was used (8%, 1/13) compared with those in whom endorectal coil was not used (14%, 5/37). Under-detection of mesorectal involvement was not seen when the endorectal coil was used. The under-detection rate in those without using endorectal coil was 11% (4/37).

The sensitivity, specificity, positive and negative predictive values were improved in those for whom the endorectal coil was used (Table 2). With the use of endorectal coils, the sensitivity reached 100% and the specificity increased to 86%. The positive predictive

value was 83% and the negative predictive value was 100%.

The correlation between histopathological N-staging and with the number of perirectal lymph nodes or the size of the largest perirectal lymph node was poor (Table 3). Despite an apparently positive correlation, they were not significant (P=0.069 and 0.074, respectively).

TABLE 3. Correlation of number or visualised perirectal lymph nodes, and the size of the largest perirectal lymph node, with pathological N-staging

Pathological staging	N0	N1	N2
No. of lymph nodes			
0-4	11	2	2
5-9	13	6	5
>9	3	1	7
Size of largest lymph node (cm)			
0-0.5	11	3	0
0.6-1.0	14	5	10
≥1.1	2	1	4
Total	**27**	**9**	**14**

Discussion

Staging for rectal carcinoma based on MRI was used as early as late 1980s.[6] Earlier studies with pelvic phased-array coils quoted an accuracy of 55%.[7] Following further improvements in equipment, experience and techniques, the quoted accuracy in recent studies varies from 86 to 100%.[8,9] Most, however, usually entailed small samples and different methods of classification (Duke staging instead of TNM staging). Variations in technique have also been advocated, including the use of endorectal coils, rectal distension, and the administration of intravenous contrast. Although it is a perception that endorectal coils offer higher signal-to-noise ratios than external coils, their effect in improving staging accuracy remains very controversial. Some have reported satisfactory results with the endorectal coil,[10-12] but others discerned no additional improvement in diagnostic accuracy compared to phased-array coil alone.[13,14] Inaccurate staging of early tumours (T1) with endorectal coils was also reported.[15] However, the statistical analysis (if any) and conclusions were usually based on small sample sizes. Regarding the use of intravenous gadolinium, some studies demonstrated that it did not improve staging accuracy.[16]

Most studies in the available literature are based on western populations. Our study showed that MRI is also useful in local staging of rectal carcinoma in a Chinese population, as reflected by comparable accuracy with other major overseas studies.[8,9] Our sample allowed us to compare two cohorts (ie those in whom an endorectal coil was and was not used). This demonstrated that its use conferred higher accuracy in predicting mesorectal invasion of rectal carcinoma with high sensitivity and specificity. Although the ability of MRI to differentiate T1 from T2 tumours is not optimal, it is our opinion that the differentiation of mesorectal tumour invasion is more practical and has significant clinical implication as neoadjuvant therapy can then be offered to patients with locally advanced tumour (T3 disease or above).

Apart from MRI, CT and USG are also used to stage rectal carcinomas. Whilst CT is widely available and can readily detect distant metastasis, its usefulness in local staging is limited by intrinsically poor contrast resolution, such that visualisation of different layers of the rectal wall is poor. Endorectal USG allows excellent depiction of the layers of rectal wall and immediate perirectal tissue, but is very operator-dependent. In addition, the inability of USG beams to penetrate deep structures renders the evaluation of bulky tumours and mesorectal fascia difficult.[17]

In our study, six patients with T2 tumour are overstaged as T3; four were proven to have N0 disease, whilst one had N1 and two had N2 disease. A theoretical over-selection of patients for neoadjuvant therapy thus exists. Overstaging has been a known problem with rectal MRI. Further modifications of MRI techniques and sequences are needed to minimise staging error, as discussed below.

Over-detection of mesorectal involvement is a common problem with MRI in the assessment of rectal carcinomas that also occurred in our study, irrespective of whether endorectal coils were used. For tumours showing direct extension to mesorectal fat, the detection of mesorectal invasion is usually not a problem. Diagnostic problems usually arise when the MRI shows only suspicious spiculation or stranding in mesorectal fat, which can either be from invasive malignant tumour or benign causes (such as desmoplastic reaction). For these cases, accurate diagnosis appears to depend on microscopy. Efforts have been made to differentiate malignant tumour extension from benign tissue reactions, using dynamic contrast injections with T1 scans.[18] Further studies including advances in techniques are required to address this problem.

N-staging is one of the considerations for administration of neoadjuvant therapy. However, the correlation between either the number or the size of the largest perirectal lymph nodes with actual pathological staging is poor. In our experience, assignment of N-staging to MRI findings is difficult. Higher N-stage disease tends to have larger and more numerous perirectal lymph nodes. It is difficult, however, to predict which particular lymph nodes are involved by disease and which are only large in

size without disease involvement. Research on how to improve N-staging accuracy is still ongoing. One approach is to give iron oxide injections to identify pathologically involved lymph nodes, irrespective of size.[19]

There were several limitations to our study. Although the size and characteristics of the sample enabled inter-group analysis, a larger sample was desirable and may have facilitated statistical analysis of some numerical difference between the two groups. Selection bias may have arisen, as all patients who had received neoadjuvant therapy before operation were excluded. Exclusion of these subjects, however, enabled us to perform the study on a cohort with more homogeneous characteristics, which in turn enhanced the internal validity of our study. Bias may also be induced in those patients who failed to have an endorectal coil inserted for practical reasons. As can be seen in Table 1, the group with endorectal coil placement had a smaller proportion with higher T stage tumours as compared with the group without placement of such a coil.

Conclusion

Our study has demonstrated that MRI can be used to predict local staging and mesorectal involvement of rectal carcinoma, there being a positive statistically significant correlation with histopathological findings. It can therefore be concluded that MRI is reasonably accurate for the local staging of rectal carcinoma in the Chinese population, there being high sensitivity and specificity for such testing. Moreover, MRI should be the investigation of choice in local staging of rectal carcinomas. That use of endorectal coils improves diagnostic accuracy is encouraging, although further studies with larger samples are necessary to facilitate statistical significance. Nevertheless, whenever feasible, use of endorectal coils is recommended so as to enhance diagnostic accuracy.

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