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Preoperative assessment of local tumor extent in advanced rectal cancer: CT or high-resolution MRI?

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Abstract
Background: We compared high-resolution magnetic resonance imaging (MRI) with computed tomography (CT) in the assessment of tumor infiltration in surrounding structures for locally advanced primary and recurrent rectal cancer.
Methods: Twenty-six patients with operable, locally advanced rectal cancer (15 recurrent and 11 primary) were evaluated with conventional pelvic CT and 1.5-T high-resolution MRI with a quadrature phased-array coil. The images were scored for invasion of nine neighboring pelvic structures, and the results were compared with surgical and histologic findings.
Results: A total of 234 structures in 26 patients was evaluated for tumor invasion. For MRI the, sensitivity was 97% and the specificity 98%; for CT, the sensitivity was 70% and the specificity was 85%. The difference in performance was statistically significant ($p < 0.001$). The failure most frequently made on CT was the false-positive prediction of pelvic floor and piriform muscle invasion (14), whereas MRI showed only four false-positive predictions. MRI correctly predicted all four cases of sacral bone invasion, three of which were missed by CT. MRI was accurate in 20 patients (80%) and CT in only five patients (19%).
Conclusion: High-resolution MRI using a quadrature phased-array coil is highly accurate and superior to CT in predicting tumor infiltration in surrounding structures for locally advanced primary or recurrent rectal cancer and is recommended in the preoperative work-up of these tumors.

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Key words: Rectum—Recurrence—Magnetic resonance imaging—Computed tomography—Neoplasms—Gastrointestinal tract.

Ten to twenty percent of rectal tumors are locally advanced, with fixation to surrounding pelvic organs. In these cases, the patient's best chance for a local cure is a radical en bloc resection of the tumor and the surrounding invaded structures [1]. Accurate and detailed anatomic information on tumor extent is essential to plan the optimal surgical procedure and to identify those patients who may benefit from neoadjuvant radiotherapy. The same holds true for locally recurrent rectal cancer. A local recurrence after resection of a primary rectal cancer occurs in 20–30% of patients, and in more than half of these patients, the recurrence is isolated [2]. Survival rates of approximately 25% can be obtained when a radical excision of the tumor can be performed [2]. Detailed anatomic knowledge of the location of the tumor and invasion of the neighboring structures is essential for optimal treatment planning [3].

Although many studies have described the accuracy of computed tomography (CT) and magnetic resonance imaging (MRI) for predicting the depth of bowel wall and lymph node invasion [4–12], only few have addressed the problems of predicting tumor infiltration in neighboring organs for primary rectal cancer [13, 14]. For recurrent rectal cancer, most studies have focused on the detection of suspected tumor masses [15–25] and less on the invasion of adjacent structures [16, 26]. To our knowledge, there has been only one report of a comparative study

between CT and MRI that has specifically addressed this problem but with only a limited number of patients [26].

The aim of the present study was to compare high-resolution MRI (HR MRI) [27] with CT in the assessment of tumor infiltration in surrounding structures for locally advanced primary and recurrent rectal cancer.

Materials and methods

Between December 1997 and April 1999, patients with locally advanced primary or recurrent rectal cancer were evaluated for inclusion in the study. A rectal tumor was considered locally advanced when it was fixed to surrounding structures on physical examination or on a pelvic CT scan. Patients were included in the study when they were considered candidates for a curative resection. This decision was made by the surgical team on the basis of the performance status of the patient and on the basis of the physical examination and CT imaging. Patients with distant metastases at staging examination were excluded. During the study period, 26 patients met these criteria and were included. Eleven patients had biopsy-proven primary rectal cancer, and 15 patients had local recurrence of a previously resected rectal cancer. Recurrent rectal cancer was proved by biopsy in 14 of 15 patients and was highly suspected in one patient because of progressive symptoms of pain, a rising CEA level, and a progressive pelvic mass on postoperative follow-up CT. The mean interval between resection of the primary tumor and the diagnosis of the recurrence was 2 years (range = 0.5–3.5 years). The mean age of the patients was 58 years (range = 29–85 years). All patients underwent an HR MRI and had surgery. Nineteen patients underwent an HR MRI of the pelvis within 2 weeks after the CT scan, followed by immediate surgery in 12 patients and by a full 6-week course of preoperative radiotherapy in seven patients. Two to four weeks after the radiotherapy, these seven patients had a second HR MRI before surgery. Seven patients were referred to our hospital during or after preoperative radiotherapy; in these patients, only a postradiotherapy MRI could be performed, leading to an interval of 8–10 weeks between the original CT and our MRI.

Imaging techniques

Conventional CT scans were performed according to a pelvic protocol (Siemens Somatom Plus CT, Erlangen, Germany or Philips Tomoscan CX-S 500, Philips Medical Systems, Best, The Netherlands). Contiguous axial 8- or 10-mm sections were obtained after oral (Télébrix Gastro, Guerbet, Aulnay-Sous-Bois, France) and intravenous contrast administration (90–120 cc; Omnipaque, Nycomed Ireland LTD, Cork, Ireland; flow rate = 2 mL/s, scan delay = 40–60 s). Bone windows were obtained for evaluating bone invasion. MRI was performed at 1.5 T (Gyroscan, Powertrak 6000, NT release 6.2.1, 23.0 mT/m, rise time 0.2 ms, slew rate 105 T/m/s; Philips Medical Systems). A quadrature phased-array spine coil was used because a torso or pelvic phased-array coil was not available with our MRI system. All subjects were positioned supine, with the pelvis centered on the proximal end of the coil and feet in first position. Sequences used were a pre- and post-gadolinium contrast (0.2 mL/kg; Magnevist, Schering, Berlin, Germany)-enhanced T1-weighted, two-dimensional, turbo spin echo (T1W TSE; reptition time/echo time [TR/TE] of 612/15 ms, 5 echo train length [ETL], 3-mm slice thickness, 0.3-mm gap, eight signal averages, 383 × 512 matrix, 20-cm field of view [FOV], 0.6-mm^3 voxel size, 9.0-min acquisition time) and T2-weighted, two-dimensional, turbo spin echo (T2W TSE; TR/TE of 3427/150 ms, 25 ETL, 3-mm slice thickness, 0.3-mm gap, eight signal averages, 175 × 256 matrix, 20-cm FOV, 2.6-mm^3 voxel size, 6.5-min acquisition time). For all patients, T1W precontrast sequences were obtained in the axial plane, and T2W images were obtained in the axial and sagittal planes. For patients with advanced primary rectal cancer, T1W postcontrast images were obtained in the axial, sagittal, and coronal planes; for patients with recurrent rectal cancer, images were obtained in the axial and sagittal planes. The axial plane was always obliquely angled perpendicular to the sacral bone.

Two radiologists with experience in reading CT images and who were blinded to the MRI results analyzed all CT scans in consensus to determine the local extent of the tumor. CT criteria for tumor recurrence were based on shape, mass effect, and contrast enhancement as described in literature [15, 19, 28–30]. Tumor infiltration into an adjacent organ was defined as diffuse stranding from the tumor to the adjacent structure with loss of fat planes on contrast-enhanced CT images. The relation of the tumor to each of the adjacent structures was classified as involved or not involved. The surrounding structures evaluated were the lateral pelvic wall (obturator muscle), the presacral fascia, the sacral bone, the pelvic floor muscles, the piriform muscles, the sciatic nerves, the internal genitals (the prostate gland or seminal vesicles, the vaginal wall or the cervix), the bladder, and the anal sphincter.

Two other radiologists with experience in reading pelvic MRIs similarly analyzed all MRIs in consensus and blinded for the CT results. For the seven patients who had pre- and postradiotherapy HR MRI, both MR scans were read together. Criteria for tumor recurrence were based on shape, mass effect, presence of a high signal relative to muscle on T2W images, and contrast enhancement as described in the literature [15, 24, 26, 29]. Tumor infiltration into an adjacent organ was defined as diffuse stranding from the tumor into the adjacent structure with loss of fat planes on contrast-enhanced T1W images and areas of increased signal intensity extending into the adjacent structures on T2W images.

The signal intensities of tumor tissue relative to muscle tissue on gadolinium contrast-enhanced T1W images and T2W TSE images were subjectively recorded for each patient and classified as hypointense, isointense, or hyperintense relative to normal muscle tissue.

Surgery

The CT and MR findings were discussed with the surgeons before surgery or irradiation. On the basis of all the available information, a detailed operative plan was made, including intraoperative brachytherapy when close or involved resection margins were anticipated. At surgical exploration, three patients were found to have unsuspected, widespread peritoneal or liver metastases, and a resection was not performed. In these patients, the pelvis was surgically prepared for radiotherapy, and the relevant anatomical sites were explored for tumor invasion and biopsied when access was easy and safe. Thirteen patients with recurrent rectal cancer and 10 patients with primary advanced rectal cancer underwent a major resectional procedure, including pelvic exenteration and resection of the sacral bone when required. All the areas that were not included in the resection were verified and biopsied when invasion was suspected.

Histology

All relevant surrounding organs and structures that were included in the en bloc resection were histologically evaluated for invasion. The margins of the resected specimen were thoroughly evaluated, and when the margin in the direction of a nonresected organ or structure was free of tumor at histology, the structure was considered as noninvaded. When the resection margin was close to a structure and showed tumor involvement, the structure was considered as invaded. The histologic results of the guided biopsies were self-evident. When a tumor response to radiotherapy was noted, the area of obvious tumor necrosis and fibrosis was considered as the former tumor extent.

Table 1. Magnetic resonance imaging (MRI) and computed tomographic (CT) findings compared with final surgical and histological diagnosis of tumor infiltration in the pelvic structures

	MRI				CT			
	True+	True−	False+	False−	True+	True−	False+	False−
Pelvic sidewall	7	19	0	0	4	17	2	3
Pelvic floor	15	8	3	0	13	4	7	2
Presacral fascia	14	11	0	1	11	10	1	4
Sacral bone	4	22	0	0	1	20	2	3
Piriform muscle	6	19	1	0	5	13	7	1
Internal genitals	11	15	0	0	7	12	3	4
Bladder	1	24	0	1	1	23	1	1
Sciatic nerve	1	25	0	0	1	25	0	0
Anal sphincter	2	24	0	0	1	21	3	1
Total	61	167	4	2	44	145	26	19

Analysis and statistics

The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for both CT and MRI in predicting infiltration of the surrounding pelvic structures by using the combination of histologic and surgical findings as the gold standard. These figures were again calculated by using only the histologic findings as the gold standard to evaluate the hypothesis that the surgical findings were not as correct as the histologic findings. To exclude the possibility of a confounding effect of comparing the preradiotherapy CT images with the postradiotherapy MR images, the figures were again calculated on the basis of the data of the 19 patients who had CT and MRI performed at the same time.

The sensitivity and specificity for HR MRI and CT were compared with the McNemar test, using the software package SPSS for Windows release 8.0 (SPSS, Chicago, IL, USA). A p value of less than 0.05 was considered significant.

Table 2. Paired 2 × 2 table of magnetic resonance imaging (MRI) and computed tomographic (CT) findings for all invaded and noninvaded structures

	CT−	CT+	Total
Invaded structures			
MRI−	2	0	2
MRI+	17	44	61
Total	19	44	63
Noninvaded structures			
MRI−	144	23	167
MRI+	1	3	4
Total	145	26	171

The difference in performance between CT and MRI was statistically significant. $p < 0.001$

Results

The correlation of the MR and CT findings with the surgical and histologic findings of tumor infiltration in the surrounding pelvic structures is presented in Table 1. A total of 234 structures was evaluated for tumor invasion in 26 patients. Two hundred ten of these 234 structures (90%) were correlated with histology; the remaining 24 were correlated with the surgical findings (10%). CT produced 26 false-positive findings, with the most common failure being a false prediction of muscle invasion (pelvic floor: seven, piriform muscle: seven). MRI was more successful than CT in predicting muscle infiltration, with only three false-positive cases of pelvic floor infiltration and one false-positive case of piriform muscle invasion. Only two false-negative findings were recorded with MRI, whereas 19 false-negative findings were recorded with CT.

The sensitivity of HR MRI for the prediction of invasion was 97%, specificity was 98%, PPV was 94%, and NPV was 99%. CT had a sensitivity of 70%, specificity of 85%, PPV of 63%, and NPV of 88%. The difference in performance between MRI and CT for predicting tumor invasion was statistically significant ($p < 0.001$). The 2 × 2 tables on the basis of which this was calculated are shown in Table 2. MRI never missed an invasion that was detected by CT. For the false-positive prediction, MRI performed better than CT 23 times, whereas CT performed better than MRI only once.

The sensitivities and specificities of CT and HR MRI did not change significantly when only histologic proof was used as the gold standard, and there was no difference when the seven patients with only a postradiation MRI were excluded from statistical analysis.

The MRI findings were accurate in 20 of 26 patients (80%), whereas the CT was accurate in only five of 26 patients (19%).

The MR signal intensity of tumor tissue relative to normal muscle tissue and the histologic correlation are shown in Table 3. In five patients with recurrent rectal cancer and two patients with primary advanced rectal

Table 3. Magnetic resonance signal intensities for mucinous, nonmucinous, and irradiated tumors relative to muscle tissue

n	Histology	T2W TSE	Contrast-enhanced T1W TSE
7	Mucinous adenocarcinoma	Strongly hyperintense	Heterogeneous, hyperintense
5	Nonmucinous adenocarcinoma	Hyperintense	Homogeneous, hyperintense
14	Irradiated adenocarcinoma	Iso- to hypointense	Homogeneous, hyperintense

T1W TSE, T1-weighted turbo spin echo; T2W TSE, T2-weighted turbo spin echo

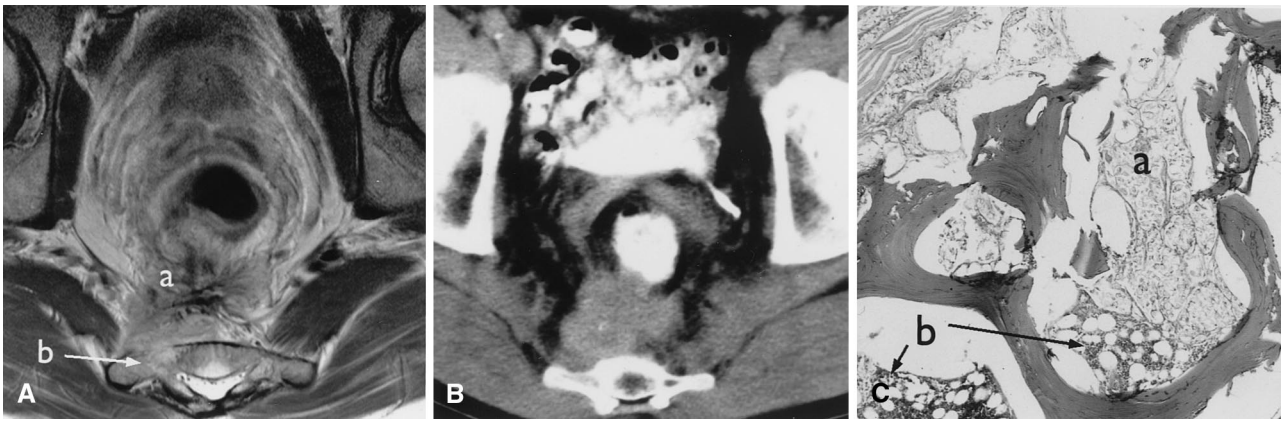


Fig. 1. A 48-year-old male with recurrent rectal cancer in the presacral region. **A** Axial T2W TSE MRI shows the tumor (*a*) invading the bone marrow (*b*). **B** Axial CT at the level of the tumor fails to show bone invasion. The axial CT section may appear to be at a different level because of the slightly different angulation of the MR axial section (perpendicular to the sacral bone). **C** Histology confirms the tumor (*a*) invading the bone marrow (*b*). The trabecular bone is intact.

cancer, histology demonstrated an adenocarcinoma of the mucinous type. All tumors with a substantial mucinous component showed a very strong hyperintense signal intensity on T2W TSE and a characteristic heterogenous enhancement pattern on contrast-enhanced T1W MR images.

Discussion

Patients with a locally advanced primary or recurrent rectal cancer benefit from accurate information on the local extent of the tumor [3, 31]. With the exact knowledge of where the tumor comes close to or actually invades the surrounding structures, a detailed operative plan can be made for an en bloc resection with wide margins around the tumor. This maximizes the chances for a complete resection and thus the chances for survival [1, 2]. Some patients may be selected for neoadjuvant chemo- or radiotherapy to obtain tumor shrinkage and wider resection margins. When close or involved resection margins are anticipated preoperatively, one should consider the use of intraoperative radiotherapy, which requires planning from the radiotherapy department.

Our study shows that HR MRI using a quadrature phased-array coil is highly accurate and superior to conventional pelvic CT in predicting the local tumor extent for advanced primary and recurrent rectal cancer. HR MRI had a sensitivity of 97% and a specificity of 98%, whereas CT had a sensitivity of 70% and a specificity of 85%.

The sensitivities and specificities of CT in our series are in agreement with data from other investigators [12, 31, 32]. CT is unable to differentiate fibrosis, normal tissue, and tumor recurrence [15, 20, 21, 29, 31, 33–36]. In the present study, this resulted in a low specificity for the prediction of muscle invasion, mainly due to false-positive invasion of the pelvic floor and piriform muscle, a finding also seen by Clark et al. [31]. The low sensitivity of CT in our study was due mainly to missed invasion of the pelvic sidewall, the presacral fascia, and the sacral bone (Fig. 1). This confirms the difficulties in detecting a subtle sacral bone invasion described by others [15, 28].

The slice thickness of the conventional pelvic CT protocol in our study was 8 or 10 mm. CT scanning with thinner slices could theoretically produce more detailed images. However, Skriver et al. did not find any difference in outcome between thin- and thick-slice CT tech-

niques in a small study with nine patients with locally advanced rectal cancer [37]. Newer-generation spiral pelvic CT with optimal bolus timing and reconstructions in multiple planes may perform much better than conventional pelvic CT, but it has not been fully investigated in advanced rectal cancer [38, 39]. Although spiral CT techniques may improve imaging results as compared with conventional CT, the inherent lack of soft tissue contrast remains a disadvantage when compared with MRI.

Many reports have described the value of MRI for preoperative staging of colorectal cancer [4, 6–8, 12, 16, 26, 40]. However, most of these studies have not focused on the invasion of surrounding organs, but rather have assessed the prediction of the depth of bowel wall invasion and lymph node invasion and have included only a limited number of patients with locally advanced rectal cancer. The body coil MRI technique that was used in most studies has demonstrated little advantage over CT because of the inherent low resolution obtained with the body coil. Most MRI studies on recurrent rectal cancer have focused on the detection of suspected tumor masses [15–25]. Only a few investigators have addressed the important problem of predicting organ invasion in advanced rectal cancer with MRI [13, 16, 26]. De Lange et al. concluded from a study with 11 patients that MRI with a body coil was reasonably useful for the evaluation of tumor extent [16]. Blomquist et al. evaluated an MRI technique with a pelvic phased-array coil in patients with recurrent rectal cancer and found a better prediction for organ invasion with MRI (six of nine) than with CT (three of nine) [26]. In these two studies, sensitivities and specificities were not presented, but MRI seemed to perform better than CT. Popovich et al. evaluated the accuracy of a body coil MRI technique in 22 patients with a variety of pelvic tumors requiring a pelvic exenteration [13]. They reported a sensitivity of 100% and a specificity of 76% for predicting involvement of the pelvic side wall muscles. Although the high sensitivity corresponds with our figures, the specificity is substantially lower. This is attributed to the false-positive interpretations of pelvic wall invasion in patients who had undergone radiotherapy. In our study, the sensitivity and specificity remained equally high whether or not patients with an MRI after radiotherapy were included.

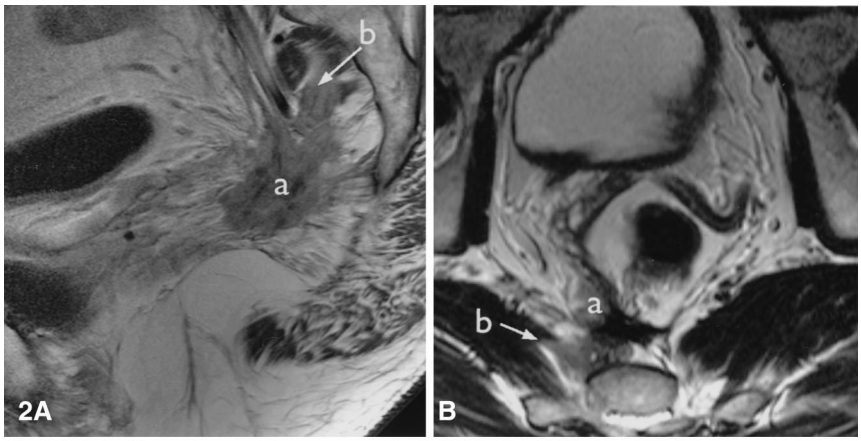
The excellent performance of MRI in advanced rectal cancer in the present study can be largely attributed to the use of a quadrature phased-array coil. The multiple coil arrangement in a phased-array coil increases the signal-to-noise ratio and provides images with smaller voxel sizes and a higher resolution than with a body or surface coil [27, 41]. In our study, a quadrature phased-array spine coil was used. This was more a necessity than a choice because at the time of the study a torso or pelvic phased-array coil was not available for our Philips MR machine. In this phased-array spine coil, the coil components are arranged in quadrature in contrast to the linear arrangement of a torso or pelvic phased-array coil. This quadrature arrangement further improves the signal-to-noise ratio, and even smaller voxel sizes can be obtained. The use of ultra small voxel sizes (0.6 mm^3) in our T1W sequence resulted in very detailed images of the pelvic structures and contributed to the high sensitivity and specificity results.

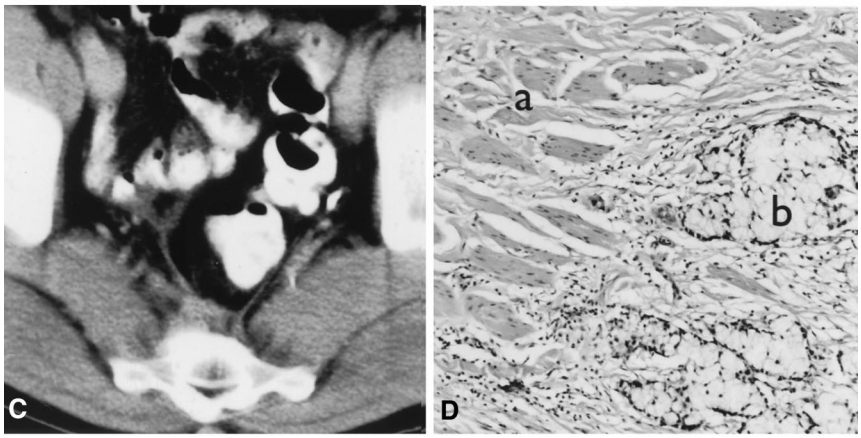
Another factor that contributes to the superiority of MRI over CT in assessing organ invasion is the inherent high soft tissue contrast resolution [15]. The differentiation between normal tissue, scar tissue, and tumor is easier with MRI because of the difference in signal intensities (Fig. 2). Tumor tissue has a relatively high water content and thus a high signal intensity on T2W images in contrast to the low water content and low signal intensity of scar tissue (Fig. 3) and the intermediate water content and signal intensity of normal muscle tissue [15, 42]. The differentiation between tumor tissue and muscle is further improved by the more pronounced enhancement of tumor on T1W images after administration of gadolinium (Fig. 2) [24].

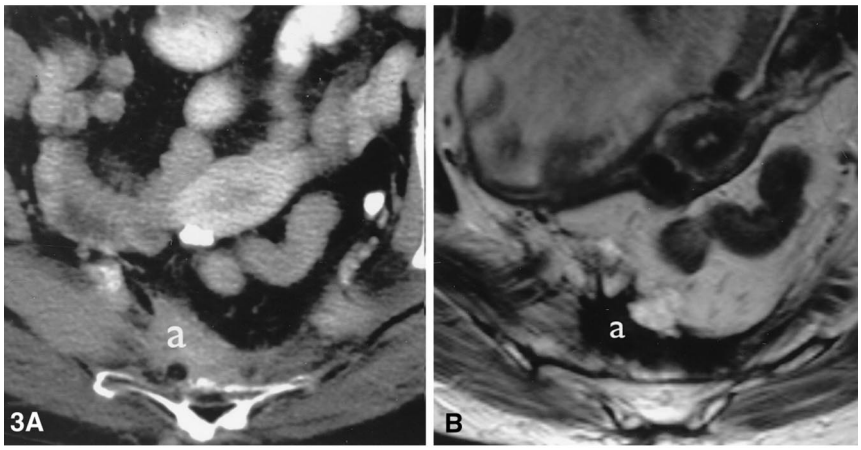
Our findings show a characteristic MR pattern for mucinous tumors. The strong hyperintense signal intensity on T2W images reflects the high water content of mucin and mucin-producing tumor cells. The characteristic heterogenous enhancement pattern on T1W images after gadolinium contrast administration is explained by the numerous lakes of mucin found within the tumor (Fig. 4). These MR characteristics have also been described by Hussain et al. [43]. The lower water content in nonmucinous tumors and even more so in irradiated tumors is reflected in decreasing signal intensities on T2W TSE (Table 3).

There are some pitfalls in MRI of rectal cancer. Masses that are hypointense on T2W images generally represent fibrosis but, in some cases, can contain tumor. This can occur in tumors that have been irradiated. When the tumor responds to the radiotherapy, it is partly or completely replaced by fibrosis, but these fibrotic areas can still contain viable tumor cells. MRI cannot reliably distinguish between fibrosis with and fibrosis without tumor [16, 44, 45]. To ensure that no viable tumor is left behind at surgery, the complete area of the original tumor needs to be resected, including the parts of the tumor that have been replaced by fibrosis. Because patients with locally advanced rectal cancer are now frequently treated with a full course of radiotherapy before surgery, the assessment of tumor invasion should be made on a baseline MRI before radiotherapy. Some of the difficulties with radiation fibrosis are shown in Figures 5–7.

The same problem of differentiation between tumor and fibrosis can occur in patients without prior radiotherapy. Some malignant tumors provoke a desmoplastic reaction, a host reaction in which fibrous tissue is formed in and around the tumor [15, 16, 18]. As with radiotherapy







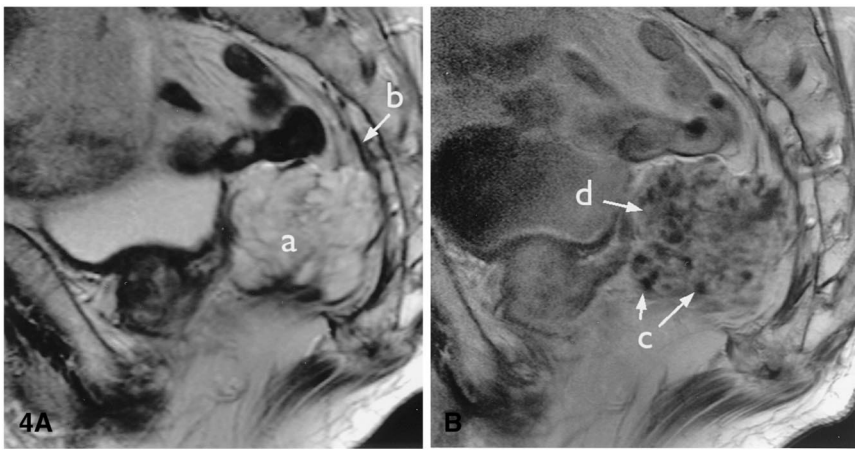


Fig. 2. A 55-year-old male with recurrent rectal cancer in the presacral region. **A** Sagittal contrast-enhanced T1W TSE MRI accurately shows the tumor (*a*) invading the right piriform muscle (*b*). **B** Axial T2W TSE MRI also clearly visualizes the tumor (*a*) invading the presacral space and the right piriform muscle (*b*). (The axial plane was angled perpendicular to the sacral bone.) **C** CT shows the tumor mass but fails to show piriform muscle invasion. **D** Corresponding histologic section through the right piriform muscle shows tumor (*b*) infiltrating the muscle fibers (*a*).

Fig. 3. An 81-year-old female with recurrent rectal cancer in the perineal region. **A** CT section above the recurrence shows an enhancing mass in the presacral region (*a*), which could be either tumor or fibrosis. **B** Corresponding axial T2W TSE MRI shows a homogeneous hypointense signal intensity of the mass (*a*), suggesting fibrosis only, which was confirmed at histology.

Fig. 4. An 83-year-old male with mucin-producing recurrent rectal cancer in the presacral region. **A** Sagittal T2W TSE MRI shows a strong hyperintense well-defined tumor mass (*a*) in the presacral region, adherent to the presacral fascia (*b*). **B** On the corresponding sagittal contrast-enhanced T1W TSE MRI, the tumor is seen with a characteristic heterogeneous enhancement pattern, caused by numerous nonenhancing lakes of mucin (*c*) surrounded by enhancing tumor cells (*d*).

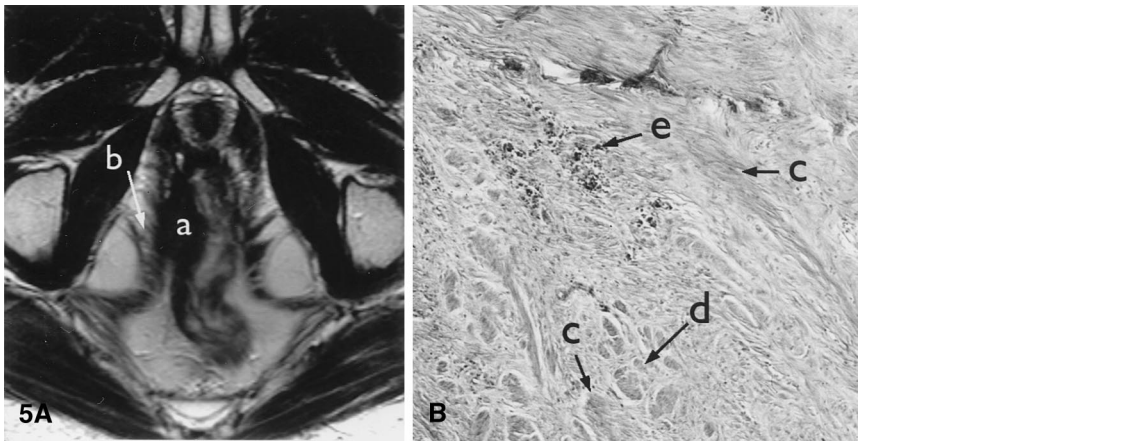


Fig. 5. A 67-year-old male with rectal cancer involving the pelvic floor, after a full dose of preoperative radiotherapy. **A** Axial postirradiation T2W TSE MRI shows a hypointense thickening of the right lateroventral rectal wall (*a*) extending into the right pelvic floor (*b*), suggesting fibrosis. **B** Corresponding histology shows fibrosis (*c*) between the muscle fibers (*d*). No tumor cells were visualized. Apparently, the tumor has responded well to radiotherapy and has been completely replaced by fibrosis. *e* = inflammatory response.

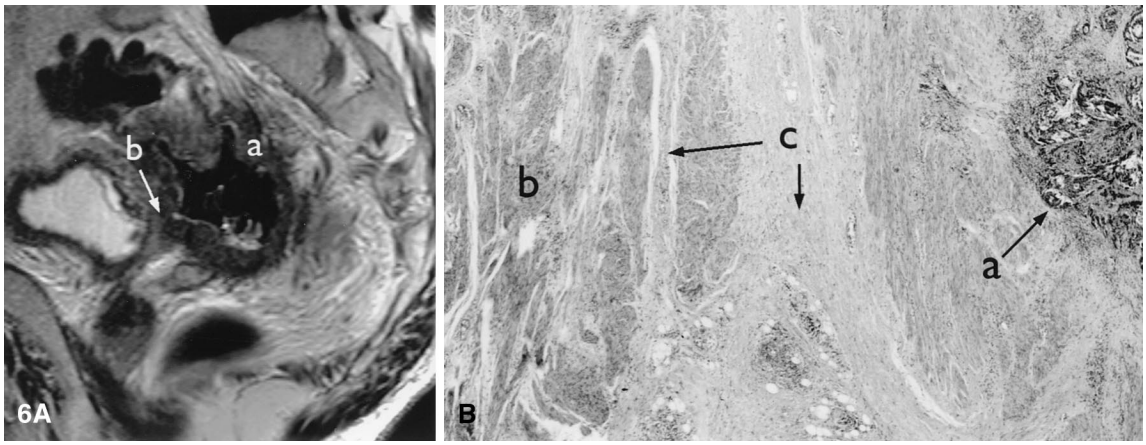


Fig. 6. A 62-year-old male with primary rectal cancer involving the bladder, after a full dose of radiotherapy. **A** Sagittal T2W TSE MRI shows a hypointense thickening of the rectal wall (*a*) invading the dorsal bladder wall (*b*), suggesting fibrosis. **B** At histology there is still viable tumor in the rectal wall (*a*), surrounded by extensive fibrosis (*c*), that is invading the muscular bladder wall (*b*). This fibrosis may be tumor that has responded to radiotherapy. MRI was not able to distinguish between fibrosis and the tumor.

fibrosis, it is difficult to predict on MRI the presence or absence of tumor cells interspersed between the fibrotic tissue. When a desmoplastic reaction is suspected, it should be resected with the tumor, even if this involves resection of surrounding structures.

Another pitfall can occur in the early postoperative phase. In the first year after surgery, the scar tissue can still be in the inflammatory phase and can show MR characteristics suggestive of tumor tissue. Therefore, one should be cautious during this period in diagnosing a pelvic mass that is hyperintense on T2W and homogeneously enhancing on T1W as a recurrence [24].

Endorectal MRI provides detailed high-resolution images of the prostate, the anal sphincter, and the rectal wall [25]. Therefore, endorectal MRI would seem useful for the assessment of the local extent of advanced rectal cancer, but the limited FOV due to a significant signal drop-off at a short distance from the coil [46–49] is a disadvantage in this clinical setting. Other practical problems are that the technique is not applicable in patients who have had an abdominoperineal resection of the rectum and it can be painful in patients with a stenosing tumor [25, 50].

In conclusion, HR MRI with a phased-array spine coil is highly accurate and superior to CT in predicting tumor infiltration in surrounding structures for locally advanced primary and recurrent rectal cancer and is recommended in the preoperative work-up of patients with these tumors. The assessment of tumor invasion should be made on MRI before preoperative radiotherapy because it remains difficult to accurately distinguish tumor from postradiation fibrosis.

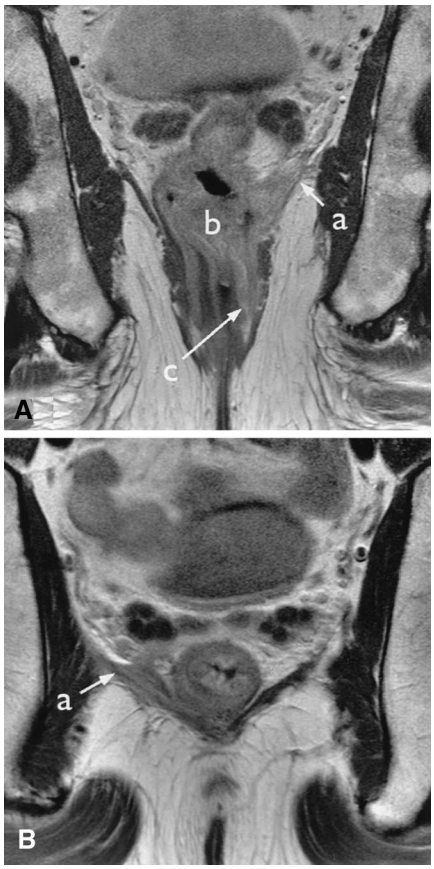


Fig. 7. A A 65-year-old male with distal rectal cancer involving the pelvic floor. Coronal contrast-enhanced T1W TSE MRI shows enhancement of the left pelvic floor muscles (*a*), suggesting tumor extension from the distal rectal cancer (*b*), confirmed at histology. Also note how the tumor invades the left anal sphincter muscles (*c*). **B** A 67-year-old male with rectal cancer involving the pelvic floor, after irradiation. Coronal contrast enhanced T1W TSE MRI shows unilateral enhancement of the pelvic floor muscles (*a*), similar to that shown in A. However, only fibrosis without tumor cells was seen at histology. This fibrosis must be tumor that has responded to radiotherapy. A symmetrical bilateral pelvic floor enhancement would be more suggestive for fibrotic changes in normal tissue secondary to irradiation.

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