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SPECIAL SECTION: RECTAL CANCER

Locally recurrent rectal cancer: what the radiologist should know

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Abstract
Despite advances in surgical techniques and chemoradiation therapy, recurrent rectal cancer remains a cause of morbidity and mortality. After successful treatment of rectal cancer, patients are typically enrolled in a surveillance strategy that includes imaging as studies have shown improved prognosis when recurrent rectal cancer is detected during imaging surveillance versus based on development of symptoms. Additionally, patients who experience a complete clinical response with chemoradiation therapy may elect to enroll in a "watch-and-wait" strategy that includes imaging surveillance rather than surgical resection. Factors that increase the likelihood of recurrence, patterns of recurrence, and the imaging appearances of recurrent rectal cancer are reviewed with a focus on CT, PET CT, and MR imaging.

Keywords Rectal cancer · Magnetic resonance imaging · Recurrent rectal cancer

Introduction

The incidence of locally recurrent rectal cancer has significantly decreased following advancements made in the multidisciplinary management of primary rectal cancer, especially with the introduction of total mesorectal excision and improvements in radiation therapy [1–4]. Although the fact that the incidence of locally recurrent rectal cancer has decreased from over 30% to less than 10% is encouraging, this condition is still a cause of major clinical concern [5–7]. Patients with locally recurrent rectal cancer suffer from debilitating symptoms including localized pelvic pain, bleeding, fistula, malodorous discharge, and fungating mass. Treatment of this complex condition is difficult. Prognosis with palliative management is dismal with a 5-year survival rate of 5% [8]. However, surgery with neoadjuvant chemoradiotherapy can significantly improve prognosis, with a reported 5-year survival rate in excess of 35% [9–12]. Numerous factors impact the decision to perform potentially curative surgical resection for locally recurrent rectal cancer [13]. In particular, imaging plays a vital role in the diagnosis and decision-making process including the feasibility of surgical resection, pre-treatment planning, and follow-up.

In this article, we review the factors predisposing to local recurrence of rectal cancer, the patterns of recurrence, and the role of multi-modality imaging in the management of this condition.

Factors predisposing to local recurrence of rectal cancer

Multiple tumor-related characteristics have been associated with local recurrence of rectal cancer [14]. Advanced tumor stage, tumor location in the lower 1/3rd of the rectum, tumor located along the anterior aspect of the rectum, presence of tumor budding, poorly differentiated tumor histology, positive nodal status, perineural spread, and extramural venous invasion have been reported to be

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associated with a higher risk of local recurrence of rectal cancer [15–24]. Another key factor predisposing to high risk of local recurrence is involvement of the circumferential resection margin (CRM) by the primary tumor and/or pathologic lymph nodes. A review of over 17,500 patients confirmed that CRM involvement is a powerful predictor of local recurrence [25]. The risk of local recurrence in CRM positive patients is also influenced by other factors such as the tumor stage. The incidence of local recurrence is 12% for T1–T2 tumors with positive CRM, while this is as high as 25% for T3–T4 tumors with positive CRM [17]. A pathologic lymph node involving the CRM does not increase the risk of local recurrence [26, 27].

Treatment-related factors such as use of neoadjuvant therapy and the nature of surgical resection also significantly influence risk of local recurrence in rectal cancer. Preoperative radiotherapy is an important prognostic factor for predicting local recurrence in advanced stage rectal cancers. In a large randomized controlled trial involving 1417 patients, the 5-year local recurrence rate was 4.6% in those who received neoadjuvant radiation therapy compared to 11% in those patients who received only surgery [17]. Various other studies have also reported similar findings of significantly lower risk of local recurrence of rectal cancer in patients receiving preoperative radiotherapy or chemoradiotherapy [28–33]. Conventionally, long-course preoperative radiation therapy (45 to 50 Gy given over a period of 6 weeks) is favored in North American therapy for treatment of locally advanced rectal cancer [34]. However, numerous studies from Europe have reported achievement of improved local control in rectal cancer with short-course preoperative radiotherapy (typically a dose of 25 Gy given over 5 days) [6, 31, 35]. A recent meta-analysis involving 11 studies with 1984 patients reported that there was no significant difference in the overall survival, disease-free survival, and local recurrence rate between short-course preoperative radiotherapy compared to long-course chemoradiation in the treatment of locally advanced rectal cancer [36]. Furthermore, use of short-course preoperative radiotherapy is associated with lower incidence of acute toxicity [37]. Indeed, the 2018 NCCN Clinical Practice Guidelines in Oncology for Rectal Cancer have reported that short-course RT is an appropriate treatment option for patients with T3, N0 or T1–3, N1–2 rectal cancer [34].

The nature of surgical resection plays a vital role in the development of local recurrence in rectal cancer. An incomplete resection of the mesorectum is associated with a significantly higher risk of 5-year local recurrence compared to those with total excision of the mesorectum (25% vs. 10%, respectively) [38]. The quality of TME is important in this regard, as the risk of local and distant recurrence is significantly higher in TME resections where the plane of TME is intramesorectal or along muscularis propria, compared to those with mesorectal plane of TME [39]. Similarly, surgical removal with microscopic (R1) or macroscopic (R2) residual disease is associated with a significantly higher risk of local recurrence compared to surgeries with no residual disease (R0 resection) [40].

Some studies have evaluated if the type of surgical resection in rectal cancer (abdominoperineal resection versus low anterior resection) could influence oncological outcome [41]. While it is acknowledged that there is a significantly higher risk of local recurrence and reduced overall survival in those undergoing abdominoperineal resection, it should be noted that a direct comparison between these two surgical procedures is difficult as the indication for the two procedures is different and hence multiple tumor-related and patient-related characteristics may be influencing the outcome, rather than the procedure itself [34, 42]. The extent of surgical resection also plays a role. In 2012, the Beyond TME Collaborative made recommendations for scenarios when extended surgical resection beyond TME may be appropriate; these include high-risk rectal cancers which are extending beyond the CRM, those invading the anal sphincter complex, and those with suspected pelvic side wall nodal involvement [43]. In Japan, a more extensive resection involving the removal of the levator ani musculature and ischiorectal fat along with the dissection of lateral pelvic lymph nodes is typically performed for rectal cancer and is reported to be associated with a lower risk of local recurrence (7.4%) compared to mesorectal excision alone (12.6%) but this is achieved at the cost of higher incidence of post-surgical complications and morbidity and no increase in overall survival [44–46].

The desire to reduce morbidity and mortality with preservation of the anal sphincter has resulted in the emergence of local excision techniques for early-stage rectal cancers including transanal local excision and transanal endoscopic microsurgery (TEM) [34]. While there are obvious advantages with such localized excision techniques, there are also significant issues that require consideration. Indeed, several studies have shown that there is a much higher incidence of positive surgical margin and a much higher risk of local recurrence for local excision techniques compared to the standard radical resection [47–51]. Larger prospective studies with long-term follow-up would help provide more data on the long-term outcome for local excision techniques in rectal cancer. Currently, NCCN guidelines report that local excision may be considered for carefully selected T1, N0 early-stage rectal cancers [34].

Intraoperative tumor perforation is another key factor associated with increased risk of local recurrence. A multi-institutional national cohort study in Norway involving 2873 patients undergoing surgical resection of rectal carcinoma reported a perforation rate of 8.1% [52]. In this study, the

5-year local recurrence rate was significantly higher in those with intraoperative perforation (29%) compared to those without perforation (10%) [52]. Another study involving 273 patients from a Swedish rectal cancer registry reported a similar high rate of local recurrence (20%) in those with incidental perforation during radical rectal cancer surgery compared to those without intraoperative perforation (8%) [53]. Enlarged lateral lymph nodes (short axis ≥ 7 mm) area also associated with increased rates of lateral local recurrence after (C)RT and TME [54].

The significance of post-operative anastomotic leakage with regards to local recurrence of rectal cancer has long remained a topic of controversy, with conflicting reports from several studies. However, a recent meta-analysis involving 14 studies containing 11,353 patients reported that anastomotic leakage following anterior resection for rectal cancer was associated with a significantly higher risk of local recurrence [55].

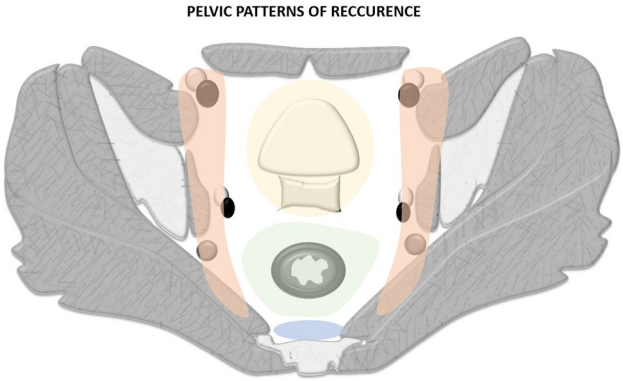

Fig. 1 Pelvic patterns of recurrence according to the Memorial Sloan Kettering classification system. Local recurrence is defined as either: axial/central (green) (anastomotic, mesorectal (residual mesorectum) or perirectal soft tissue or perineum following an abdominoperineal resection (APR)); anterior (yellow), involving the genitourinary tract; posterior (blue), involving the sacrum and presacral fascia and sacral root sheaths; or lateral (orange), involving the muscles (piriformis, elevator), soft tissue of the pelvic sidewall, lymph nodes, major iliac vessels, sacral nerve plexus, and lateral bony pelvis

Patterns of local recurrence of rectal cancer

The majority of the locally recurrent rectal cancers present within 2 years of surgical resection of the primary tumor, although late recurrences may occur [13, 56–60]. Multiple classification systems have been reported for describing the pattern of local recurrence in rectal cancer [61–63]. The Mayo Clinic classification system categorized local recurrence according to the site of fixation of the tumor in the pelvis (fixation to anterior, sacral, left, and right sides of the pelvis) [64]. This is further divided into F0 to F3 in terms of number of points of fixity (F0 referring to absence of fixity; F1, F2, and F3 corresponding to one, two, or three sites of fixation) [64]. Wanebo et al. reported a classification system based on traditional Tumor, Node, and Metastasis (TNM) and used "R" for recurrence. The grading system ranged from TR1 (referring to very limited local recurrence within the lumen) to TR5 (corresponding to advanced local recurrence with fixation to sacrum and/or pelvic side wall) [65]. The Memorial Sloan Kettering Cancer Center classification system categorizes local recurrence into 4 types, namely, axial, anterior, posterior, or lateral (Fig. 1). Axial recurrence is further subdivided into anastomotic or perineal involvement [66]. Anterior recurrence corresponds to involvement of genitourinary structures while posterior recurrence refers to involvement of sacrum. Lateral recurrence refers to the involvement of pelvic sidewall structures including pelvic bone, muscles and soft tissues, and neurovascular structures [66]. Kusters et al. used a similar classification system as above in the Dutch TME trial and classified local recurrences into 5 subgroups: presacral, anterior, anastomotic, lateral, and perineal [17]. Yamada et al. classified local recurrence into localized, sacral invasive, and lateral invasive [12]. The Leeds classification system for local recurrence of rectal cancer includes central recurrence (involvement of pelvic structures but no contact or invasion of bone), sacral (tumor abuts or invades sacrum), sidewall (involvement of lateral side wall structures), and composite (combined sacral and sidewall recurrence) [61, 67]. There is no universally accepted classification system, and the usage of each classification system may depend upon individual institutional preferences. However, these classification systems play an important role as these are predominantly based on the anatomical compartments of the pelvis, thereby helping in the surgical decision-making process and operative approach. Apart from helping decide management, the use of classification systems also has prognostic significance. Central/axial recurrences are associated with better prognosis compared to posterior or lateral recurrences [12, 61, 64, 68].

Traditionally, numerous factors were reported as contraindications for surgical resection of locally recurrent rectal cancer. These included presence of distant metastases, sacral invasion above the level of S2–S3 junction, extensive lateral pelvic sidewall involvement, hydronephrosis, encasement of external iliac vessels, involvement of anterior pubic bone, and tumor extension through the sciatic notch [13, 57]. However, significant advances and improvements in surgical techniques have resulted in a more aggressive approach for locally recurrent rectal cancers such that many of these previously considered absolute contraindications may still be considered for resection, especially in tertiary referral centers [13, 63, 69]. For example, patients presenting with locally recurrent rectal cancers along with concurrent resectable systemic oligometastases may be considered

for curative resection [70]. Similarly, surgical resections for locally advanced recurrent rectal cancers have been reported even in the presence of invasion of anterior pubic bone and high sacral involvement (at or above the S2 level) [71–73]. However, as alluded to before, such ultra-aggressive radical resections should only be considered in specialized centers with expertise in this field and further data with regard to long-term oncological outcome are warranted before these procedures can become standard of care.

Surveillance strategy

Following curative resection, societal recommendations typically include surveillance with colonoscopy, carcinoembryonic antigen (CEA) testing, history and physical exam, and CT imaging [74]. The surveillance CT imaging strategy recommended by the National Comprehensive Cancer Network varies based on disease stage [34]. For patients with Stage 1 disease (T1/2N0M0), routine imaging is not recommended, and imaging should be based on symptoms or clinical concern for recurrence [34]. Patients with Stage 2 (T3/4N0M0) or Stage 3 (T3/4 N + M0) disease should

Table 1 Diagnostic performance of different modalities for the diagnosis of recurrent rectal adenocarcinoma based on the cited literature

	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)
CT	76–93	50–100	69	67
FDG⁻PET/CT	94–98	96–98	90	97
MR	80–91	86–100	100	89
FDG-PET MR	94	94	97	90

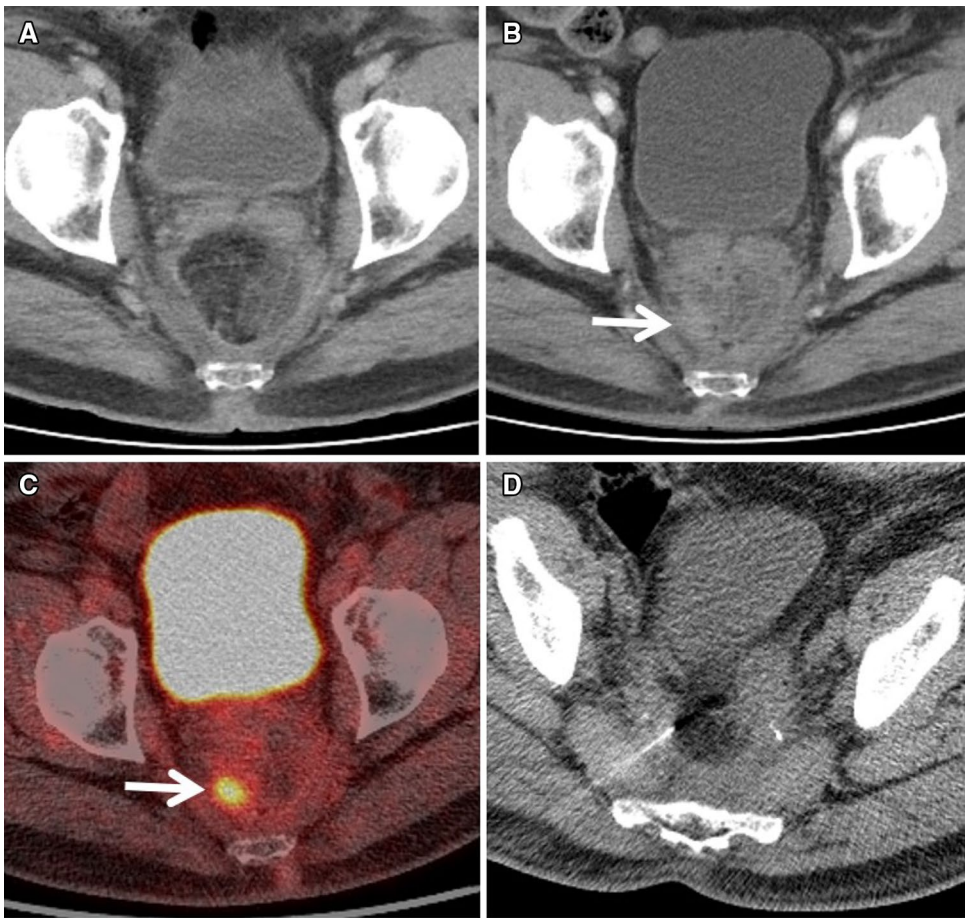

Fig. 2 A 52-year-old male with recurrent rectal adenocarcinoma. The patient underwent abdominoperineal resection with omental pedicle flap, and a perforated mucinous rectal adenocarcinoma was found intraoperatively. **a** Axial image from initial post-operative baseline surveillance CT demonstrates post-operative changes. **b** Axial CT image from surveillance CT scan 6 months later demonstrates nodular component (arrow). **c** The patient underwent ^{18}F-FDG PET/CT imaging which demonstrated hypermetabolic activity in this location (arrow). **d** Image from percutaneous CT-guided biopsy which established a diagnosis of recurrent rectal adenocarcinoma

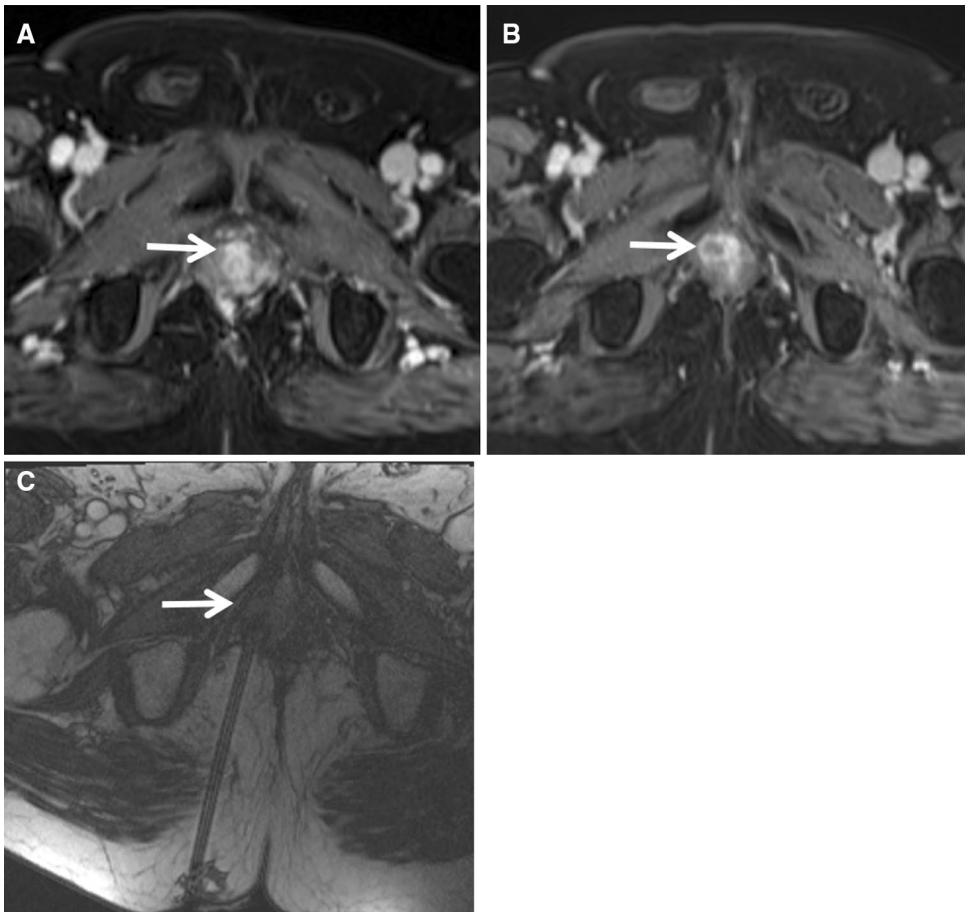

Fig. 3 Anterior compartment recurrence. A 77-year-old male with history of rectal adenocarcinoma status post-abdominoperineal resection. **a** Surveillance MRI shows normal prostatic enhancement (arrow). **b** Surveillance MRI 3 years later demonstrates an enhancing nodule. This nodule was biopsied with MR-guidance (**c**), and the pathologic diagnosis was rectal adenocarcinoma

undergo CT surveillance every 6–12 months for a total of 5 years [34]. As recurrent tumor most commonly occurs locally or in the liver or lungs, CT imaging of the chest, abdomen, and pelvis is recommended. The NCCN recommends that patients who have undergone transanal local excision should undergo MRI or EUS of the rectum every 3–6 months for 2 years then every 6 months for a total of 5 years [34].

CT surveillance is recommended as a survival benefit is seen in patients with recurrence detected by imaging [74, 75]. In a study of 259 patients with colorectal cancer enrolled in intensive surveillance which included imaging or simple surveillance which did not include imaging, 80% of patients with recurrent rectal cancer had resectable disease in the intensive surveillance group as compared to 20% in the simple surveillance group [76]. In a study of 530 patients with median follow-up of 5.6 years, patients whose recurrences were detected with CT imaging had better survival from the time of relapse as compared to individuals whose recurrences were detected based on development of symptoms [77]. However, some studies have not found a survival benefit with intensive surveillance. A Cochrane Database systematic review of 15 randomized clinical trials found that more patients with tumor recurrence undergoing intensive surveillance underwent resection with curative intent, though an overall survival benefit was not observed as compared to patients enrolled in simple surveillance [78].

Adherence to post-resection surveillance strategies is suboptimal with an adherence rate of 10.3% at 3 years for CT imaging reported in a study of 314 participants who had undergone resection for rectal cancer [79]. In a study of 241 colorectal cancer patients treated at National Cancer Institute-designated Comprehensive Cancer Centers, overall adherence to recommended surveillance regimens was 23% with adherence to recommended CT imaging of < 50% [80]. As stringent surveillance strategies have not been shown to improve overall survival in some series, it has been suggested that a more personalized approach to post-resection surveillance based on an individual's particular prognostic factors may be more efficacious as compared to the current one-size-fits all strategy [78, 81–83]. Diagnostic performance of CT, FDG^{18} PET CT, MR, and FDG^{18} PET MR, for the detection of recurrent rectal cancer are reported in Table 1 and described below.

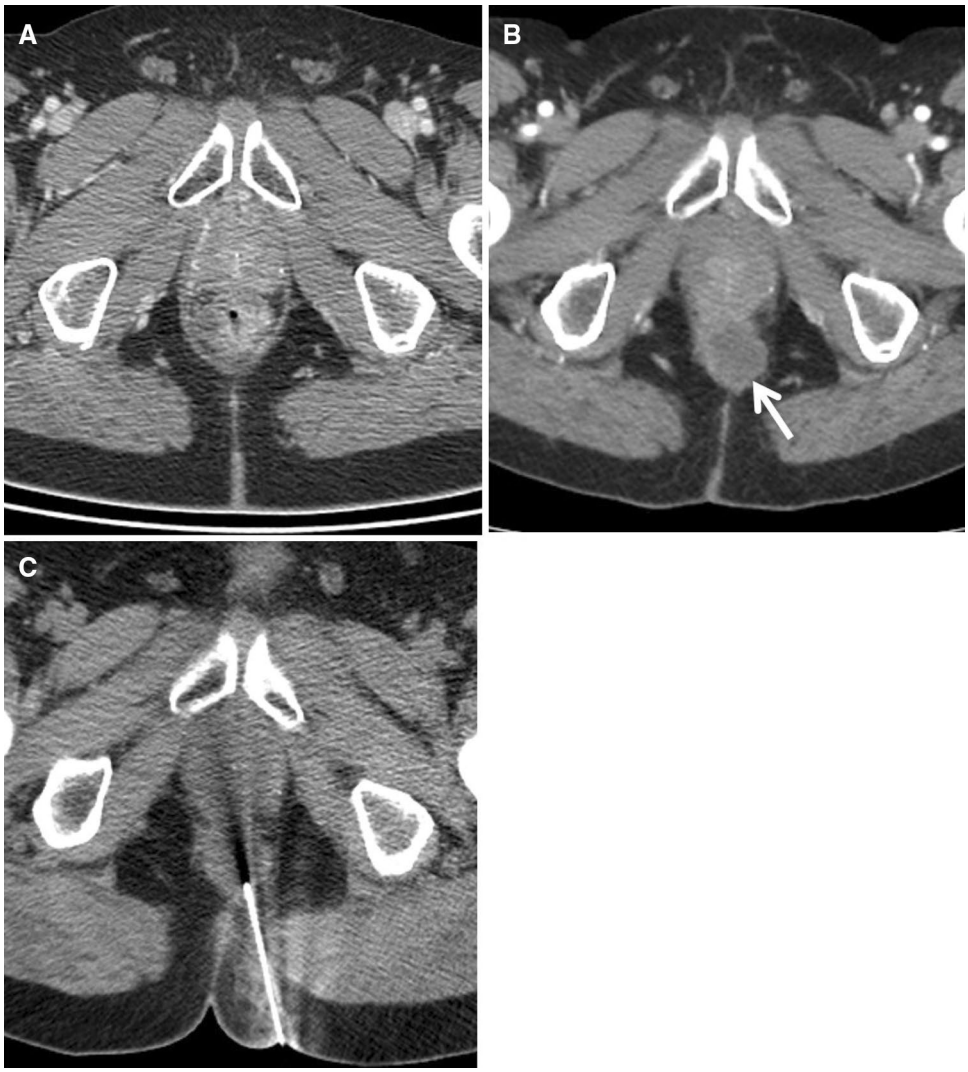

Fig. 4 Recurrent tumor, central/axial compartment. A 59-year-old male status post-low anterior resection for rectal cancer. **a** Axial contrast-enhanced CT image from initial surveillance scan demonstrates no recurrent tumor. **b** Three years later, axial intravenous contrast-enhanced CT demonstrates a perirectal mass (arrow). **c** CT-guided percutaneous biopsy was performed and demonstrated recurrent adenocarcinoma

CT surveillance

The initial post-operative surveillance CT exam serves as the baseline exam. Patients often demonstrate post-operative changes including areas of fluid and scarring in the presacral region (Fig. 2). These post-operative changes are typically stable or decrease over time. New or enlarging areas of soft tissue are concerning for recurrent tumor (Fig. 2). Anterior compartment recurrences involve the genitourinary organs (e.g., prostate gland or uterus) (Fig. 3). Central or axial compartment recurrences involve the remnant rectum or perineum (Fig. 4). Posterior compartment recurrences involve the sacrum or presacral region (Fig. 5). Lateral compartment recurrences involve the pelvic sidewalls (Fig. 6).

In two older studies from the 1990s, the sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of CT for the diagnosis of recurrent rectal cancer were 76–82%, 505, 695, 675, and 68%, respectively [84, 85]. Technical advancements have resulted in improved CT performance. For example, multiplanar reformations have been shown to improve the performance of CT imaging for the diagnosis of locally recurrent rectal cancer. In an investigation of 40 patients with resected rectal cancer, CT imaging with multiplanar reconstructions showed sensitivity, specificity, and accuracy of 88%, 100%, and 97%, respectively, for the diagnosis of locally recurrent rectal adenocarcinoma as compared to axial images which showed sensitivity, specificity, and accuracy of 86%, 96%, and 93%, respectively [86].

Patients with new imaging findings concerning for recurrence typically next undergo tissue sampling via either endoscopy for accessible lesions or percutaneous biopsy for sites not reachable by endoscopy (Figs. 2, 3, 4, 5). PET/CT, MR, or more recently PET/MR may also be used for problem solving in challenging cases (Figs. 2,5).

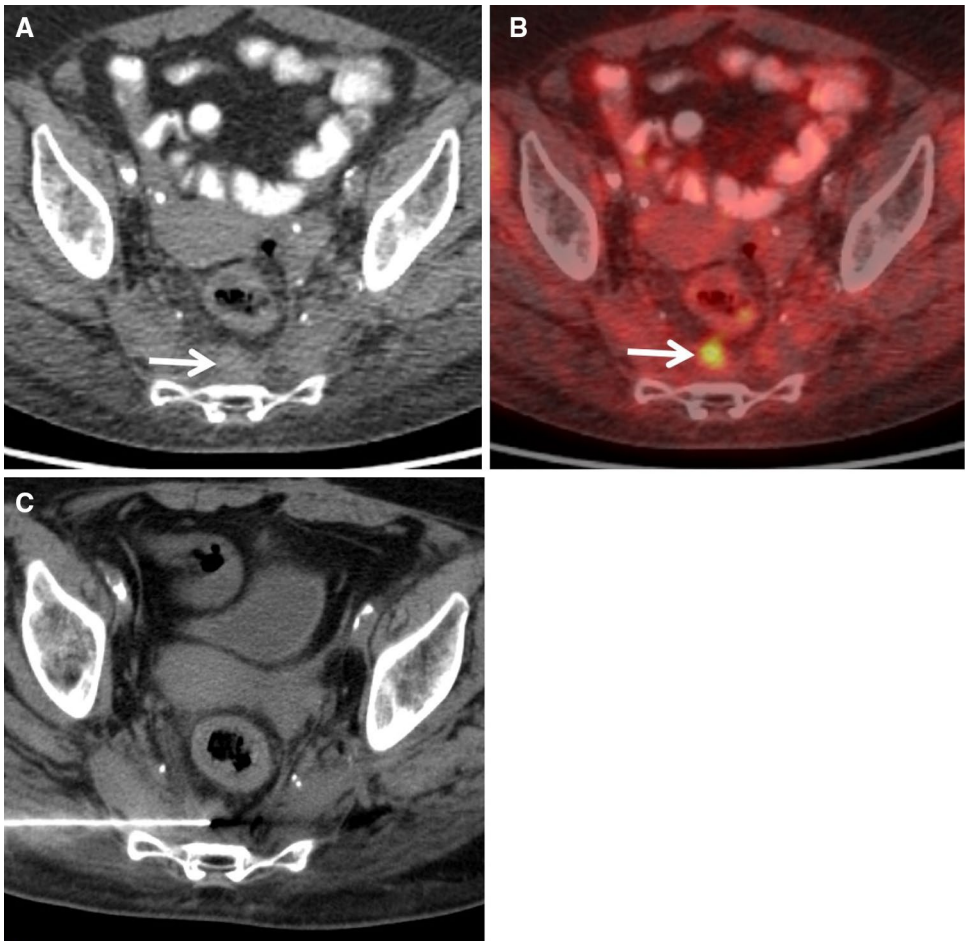

Fig. 5 Posterior compartment recurrence. A 62-year-old woman with history of rectal cancer status post prior low anterior resection. **a** Axial non-contrast CT image demonstrates a presacral soft tissue nodule (arrow). **b** Fused axial ^{18}F-FDG PET/CT image demonstrates hypermetabolic activity within the nodule (arrow). **c** Percutaneous biopsy resulted in a diagnosis of recurrent adenocarcinoma

Positron emission tomography (PET) and PET/CT

^{18}F-fluorodeoxyglucose (FDG) positron emission tomography (PET) and PET/CT are generally used for problem solving in patients undergoing surveillance. For example, with CT imaging differentiating post-treatment change from locally recurrent tumor can be difficult without prior imaging studies for comparison. In this scenario ^{18}F-FDG PET/CT is helpful for differentiating post-treatment change from recurrent tumor (Figs. 5,7). PET/CT has a reported sensitivity, specificity, positive predictive value, negative predictive value, and accuracy for differentiating malignant from benign ^{18}F-FDG uptake of 98, 96, 90, 97, and 93%, respectively [87]. PET and PET/CT generally outperform CT in the detection of locally recurrent disease [88]. In a meta-analysis of fourteen observational studies evaluating imaging with PET, PET/CT, and CT, PET/CT performed better than CT alone [88]. The AUC of CT for locally recurrent or metastatic colorectal cancer was 0.83 (0.72–0.90) as compared to 0.94 for PET and PET/CT [88]. In another study, ^{18}F-FDG PET was found to have a 94% sensitivity and 98% specificity for the diagnosis of local recurrence [89]. Combined PET/CT demonstrated a sensitivity of 98% and specificity of 96% for local recurrence of rectal cancer [89]. In a study of one hundred seventy patients previously treated for colorectal cancer with suspected recurrence, PET/CT including contrast-enhanced CT (sensitivity 93%, specificity 96%, accuracy 95%) performed better than PET/CT with non-contrast CT (sensitivity 89%, specificity 95%, accuracy 92%) [90].

PET/CT has limitations in detecting small lesions, and false positives may occur due to infectious or inflammatory pathology [91]. False negatives may occur in patients with mucinous tumors with low cellularity and abundant mucin [92]. MR and PET/MR outperform PET imaging for detection of liver metastases [93].

Magnetic resonance imaging

MRI is recommended for primary surveillance imaging in patients who have undergone transanal resection of rectal adenocarcinoma [32]. By comparison, for patients who have undergone total mesorectal excision, CT is the primary surveillance modality and MR is utilized as a problem-solving

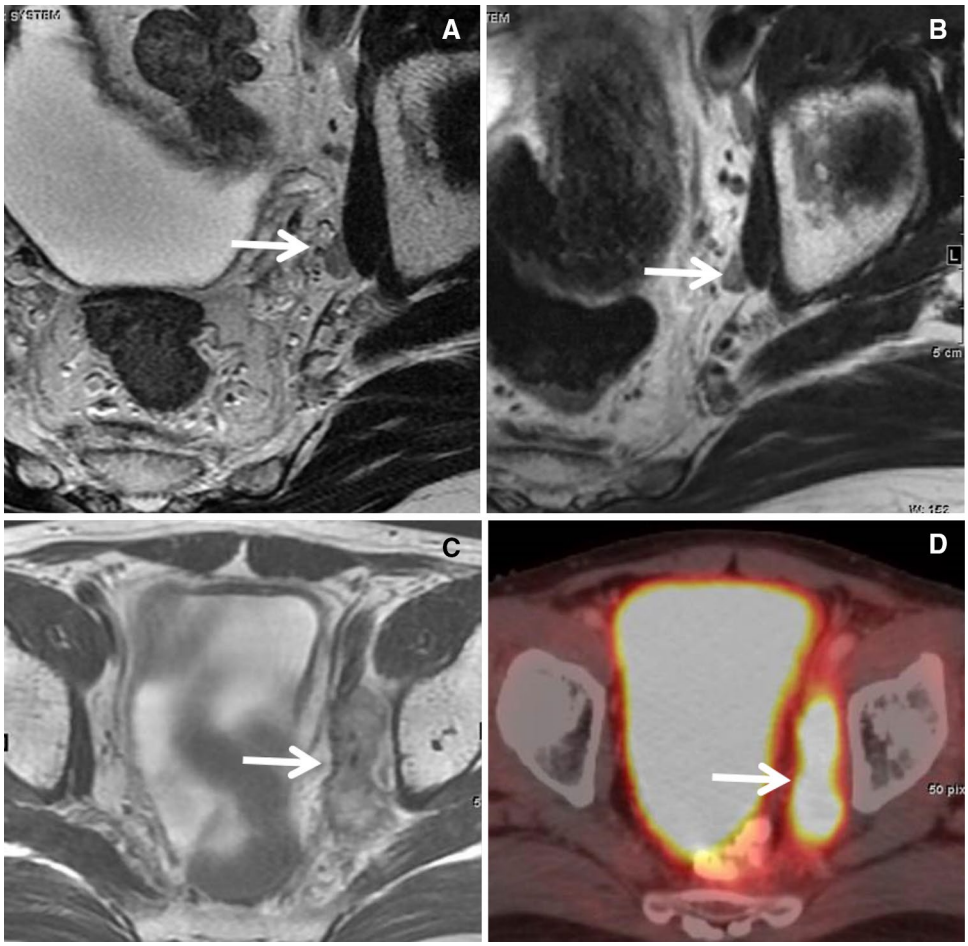

Fig. 6 Lateral compartment recurrence. **a** Axial T2WI from initial staging MRI demonstrates a suspicious pelvic sidewall lymph node (arrow). **b** Axial T2WI from restaging MRI following chemoradiation demonstrates similar appearance of the suspicious lymph node (arrow). Despite being read as a suspicious lymph node on staging and restaging scans, the patient underwent total mesorectal excision without a pelvic sidewall resection. **c** Axial T2WI performed 9 months later demonstrates tumor along the pelvic sidewall (arrow) which was hypermetabolic on PET CT (**d**, arrow). Images courtesy of Marc J. Gollub, MD

tool. MRI is also recommended for primary imaging surveillance in patients who have undergone chemoradiation therapy, are thought to have had a complete clinical response (e.g., no tumor detectable at restaging MRI, endoscopy, or on biopsy), and opt for enrollment in a "watch-and-wait" strategy rather than resection.

Transanal resection may be performed for carefully selected tumors (e.g., small, T1 tumors with favorable histologic features) and generally results in less morbidity as compared to total mesorectal excision [94]. Transanal resection includes removal of the tumor along with a small surrounding cuff of normal rectum and perirectal tissue. Stable linear signal abnormality at the resection site typically reflects post-operative change (Fig. 8). By comparison, enlarging rounded intermediate signal intensity structures are suggestive of recurrent tumor (Fig. 9).

In an evaluation of 81 patients who underwent transanal endoscopic microsurgery (TEM), 18 patients developed a local recurrence (22%) [95]. The AUC for T2-weighted imaging was 0.72–0.80 for local recurrence, and 0.70–0.89 for DWI [95]. In this study, presence or absence of local recurrence was graded on a 5-point confidence scale. Findings of definite local recurrence were massive intermediate signal in the rectal wall or mesorectal tissues and marked high signal intensity in b1000 images [95]. Findings of probable local recurrence were mixed signal intensity but predominantly intermediate signal intensity in the rectal wall and a small area of high signal in the surgical site in b1000 images. Intermediate presence of recurrence was defined as a defect in the rectal wall with mesorectal spiculation, heterogeneous signal in the scar, or massive fibrosis at the surgical site along with small foci of high signal in scar in b1000 images [95]. Minimal fibrotic wall thickening and

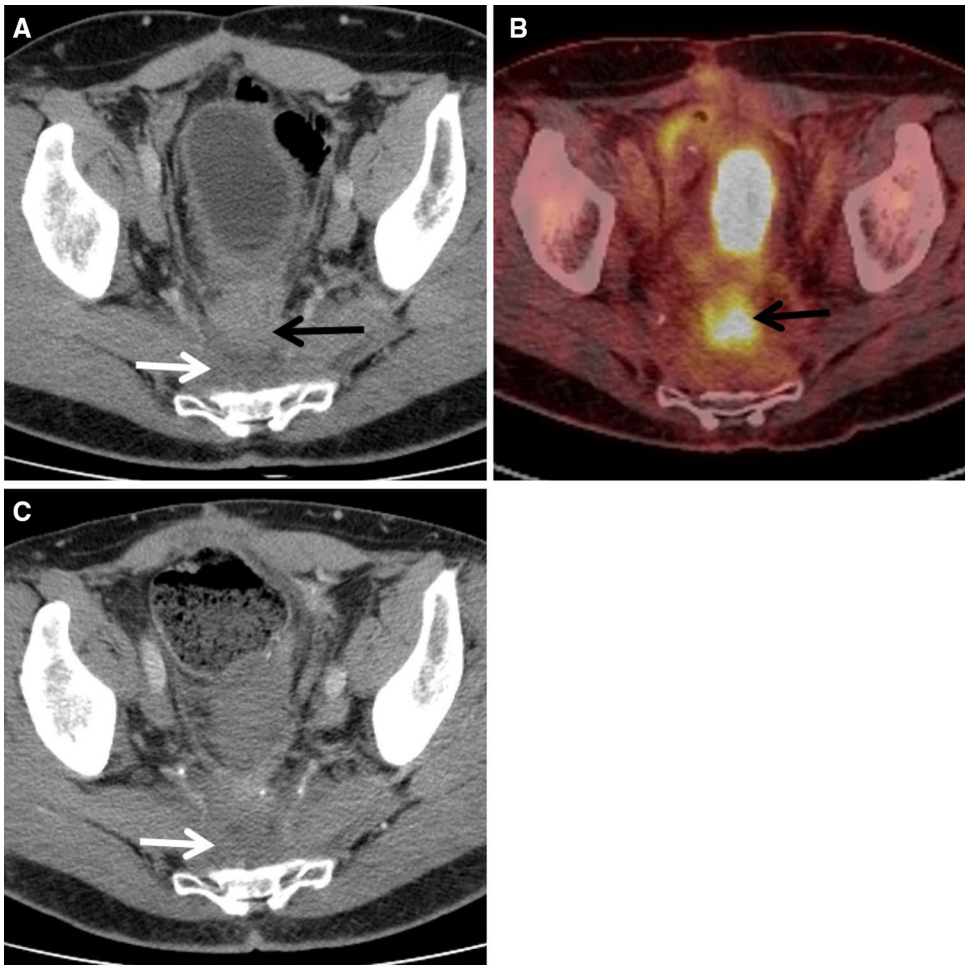

Fig. 7 Post-operative change. A 61-year-old man status post-abdominoperineal resection for rectal adenocarcinoma, previously treated at outside institution. **a** Initial surveillance scan at our institution demonstrates increased attenuation in the presacral region (white arrow) with small bowel located more anteriorly (black arrow). **b** Axial F18FDG PET-CT image demonstrates no hypermetabolic activity in the presacral region. Physiologic F18FDG uptake is visible in small intestine (arrow) indicating that the presacral material was post-operative change. **c** Follow-up surveillance scan 3 years later demonstrates unchanged post-operative change (arrow) in the presacral region

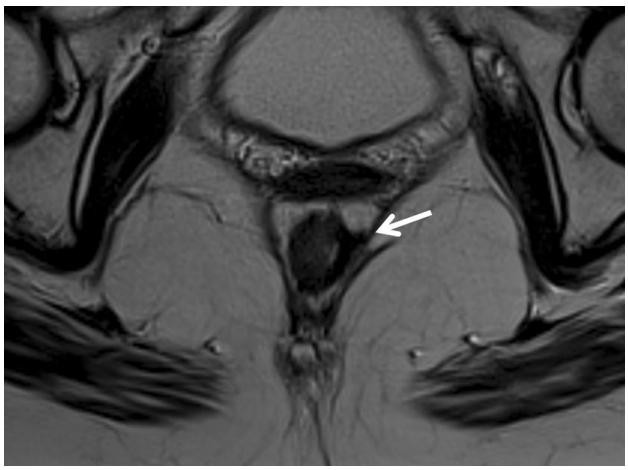

Fig. 8 Normal appearance after transanal resection. A 67-year-old woman status post-TAMIS. Axial T2-weighted image demonstrates linear low T2 signal along the resection site which was unchanged on follow-up MR and is compatible with scar tissue

no high signal intensity in the surgical site in b1000 images was defined as probably no recurrence [95]. Post-operative changes can be difficult to interpret in the initial post-operative MR, but reader confidence improved with further follow-up imaging [95].

For patients who have undergone total mesorectal excision, CT is the recommended initial surveillance modality and pelvic MRI is primarily a problem-solving tool in the assessment of possible locally recurrent rectal tumor. New areas of nodular signal abnormality with restricted diffusion are concerning for recurrent tumor (Figs. 10,11). The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of MR for the diagnosis of recurrent rectal cancer are 91%, 100%, 100%, 89%, and 95%, respectively [85]. In a study of thirty-six patients suspected of having locally recurrent rectal cancer who underwent MRI with T2-weighted and contrast-enhanced T1-weighted imaging including calculation of percentage enhancement in

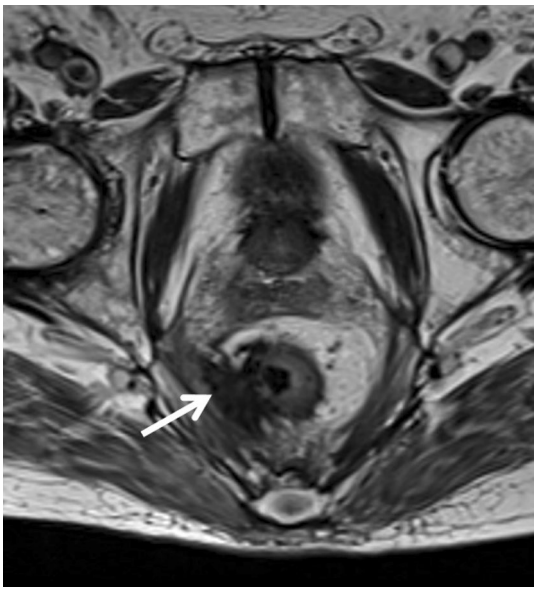

Fig. 9 Recurrent tumor after TAMIS. A 72-year-old man. Axial T2-weighted image demonstrates an irregular mass (arrow) arising from the right posterolateral wall of the rectum 1-year following TAMIS. The mass demonstrates areas of low and intermediate signal intensity. Endoscopic biopsy confirmed a diagnosis of recurrent adenocarcinoma

the post-contrast images, unenhanced MRI had 80% sensitivity and 86% specificity for diagnosis of local recurrence while analysis of percentage of enhancement showed 87% sensitivity and 100% specificity [96]. In a more recent analysis of forty-two patients with clinical suspicion of recurrent tumor who underwent 1.5 T MRI with 3 plane T2-weighted FSE imaging and axial diffusion-weighted imaging (DWI) (b0,500,100), the addition of DWI increased specificity and interobserver agreement [97]. In a study of fifty-two patients with suspected pelvic recurrence from colorectal cancer, gadolinium-enhanced MRI and DWI both significantly increased diagnostic performance for diagnosis of pelvic recurrence for radiology residents [98]. In a study of forty-three patients with suspected locally recurrent rectal cancer, the addition of gadolinium-enhanced T1-weighted images and DWI improved diagnostic performance as compared to T2-weighted imaging alone [99]. In an evaluation of 30 patients who underwent resection for colorectal cancer and had a mass detected by CT or MR, median apparent diffusion coefficient values were lower for patients with recurrent tumor as compared to patients with benign fibrosis/granulation tissue [100]. False-negative diagnoses were seen in patients with mucinous adenocarcinomas [100]. MRI is also accurate for assessing disease extent and invasion of

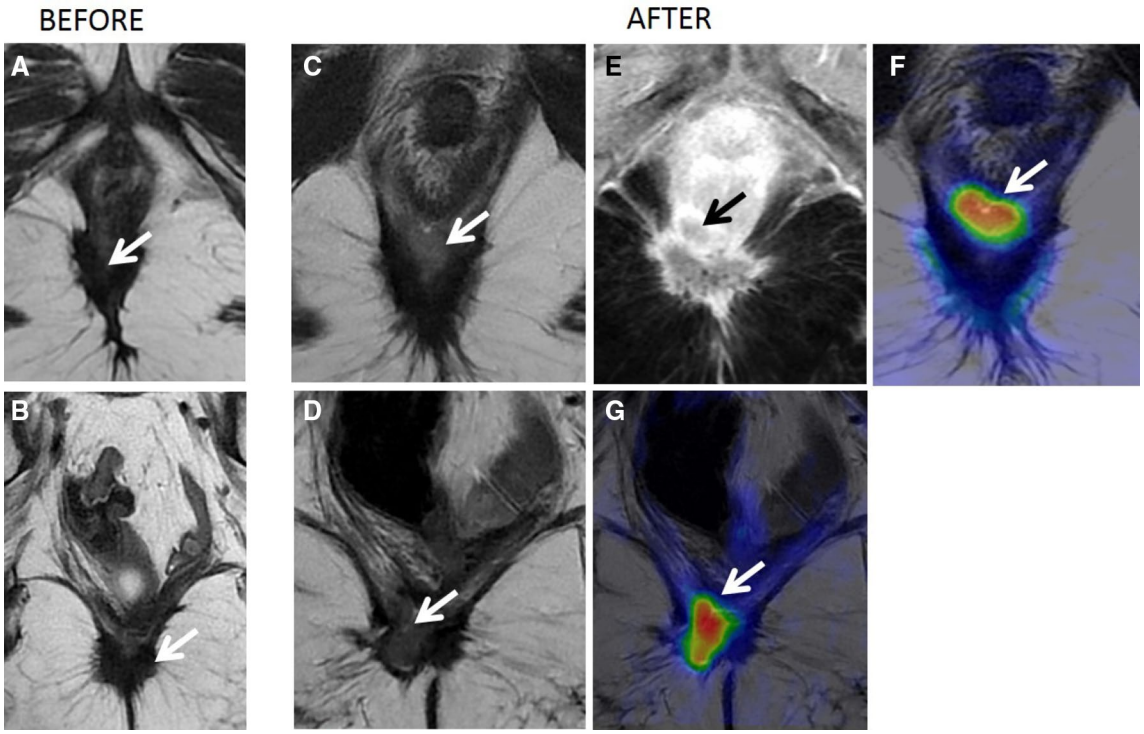

Fig. 10 Patient status post-abdominoperineal resection (APR) for a pT3 N0 M0 low rectal cancer with intersphincteric involvement. Axial (**a**) and coronal (**b**) T2WI show perineal scarring in keeping with normal post-APR changes (arrows). Follow-up imaging 9 months later shows a T2 intermediate soft tissue mass (arrow) (**c**, axial T2WI) within the perineum and the right ischioanal fossa (arrow) (**d** coronal T2WI). This soft tissue mass is enhancing on T1FS post-contrast images (**e**, arrow) and demonstrates restricted diffusion on fused T2 + DWI axial (**f**) and coronal (**g**) images (arrows) in keeping with tumor recurrence

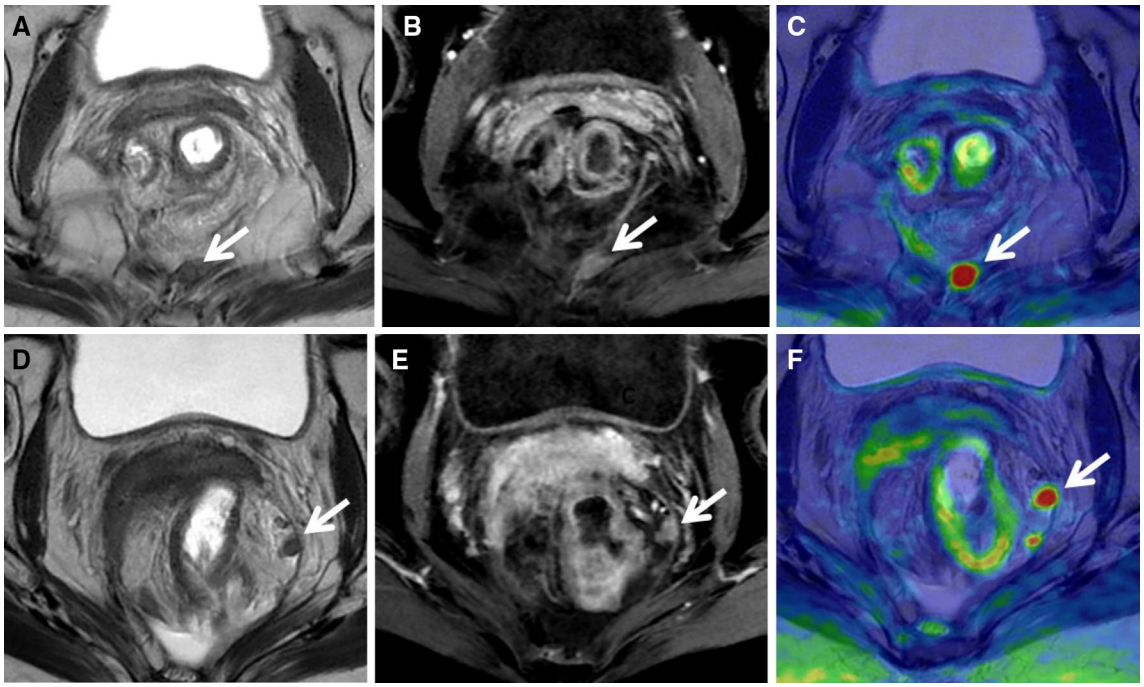

Fig. 11 Patient status post-proctectomy for a pT3N1M0 rectal cancer treated initially with neoadjuvant chemoradiation therapy. Axial oblique (**a**) T2WI shows an intermediate soft tissue mass (arrow) within the iliococcygeal muscle. This soft tissue mass is enhancing on T1FS post-contrast images (**b**, arrow) and demonstrates restricted diffusion on fused T2 + DWI axial oblique images (**c**, arrow) in keeping with posterior tumor recurrence. Axial oblique (**d**) T2WI further up within the pelvis shows another intermediate soft tissue mass (arrow) within the mesocolon. This soft tissue mass is enhancing on T1FS post-contrast images (**e**, arrow) and demonstrates restricted diffusion on fused T2 + DWI axial oblique images (**f**, arrow) in keeping with central tumor recurrence

local structures [101]. However, it can be challenging to differentiate post-surgical and post-radiotherapy changes from residual tumor along the pelvic sidewalls [102]. MR is more accurate in identifying recurrence in the anterior and central compartments and less accurate at assessing pelvic sidewall involvement [103]. For patients with a primary mucinous lesion, increased fluid attenuation material that appears lobular versus free could indicate recurrent mucinous disease (Fig. 12). MR is accurate in the prediction of tumor invasion into structures with a negative predictive value of 93–100% [104]. Positive predictive value is lower (53–100%) in part because differentiating recurrent tumor from fibrosis is challenging [104].

"Watch and wait," tumor regrowth

Patients thought to have a complete clinical response to chemoradiation (e.g., no residual tumor visible on imaging and endoscopy, and negative biopsies) may opt to enroll in a "watch-and-wait" strategy rather than undergo surgical resection. In a landmark 2004 study by Habr-Gama et al., 5-year overall and disease-free survival rates were 88% and 83% in the resection group and 100% and 92% in the non-operative management group [105].

Patients enrolled in "watch and wait" typically undergo digital rectal exam, endoscopy with biopsy, and often MRI at scheduled intervals [106]. The ideal surveillance interval is not universally agreed upon. A proposed "watch-and-wait" surveillance strategy is follow-up visits at 1–2 month intervals during the first year, 3-month intervals for the second year, and 6-month intervals for the remaining years of follow-up [107]. Digital rectal exam and endoscopy are recommended during each visit with MR imaging at least every 6 months for the first 2 years and yearly thereafter with PET/CT imaging reserved for equivocal cases [107].

Limited information is available in literature regarding imaging findings during "watch and wait." In an observational study of 19 carefully selected patients who underwent surveillance with clinical exam, endoscopy with biopsies, and rectal MRI every 3–6 months, patients were observed to have either fibrosis (74%) or a normalized rectal wall (26%) [108]. Of patients with fibrosis, three patterns of fibrosis were observed (full thickness, minimal, or spicular) [108]. Edematous wall thickening that gradually decreased over time was observed in 26% of patients [108]. Tumor regrowth may occur within fibrosis or within the mesorectum [Fig. 13]. Enlarging, rounded intermediate signal intensity material is concerning for tumor regrowth (Figs. 14,15).

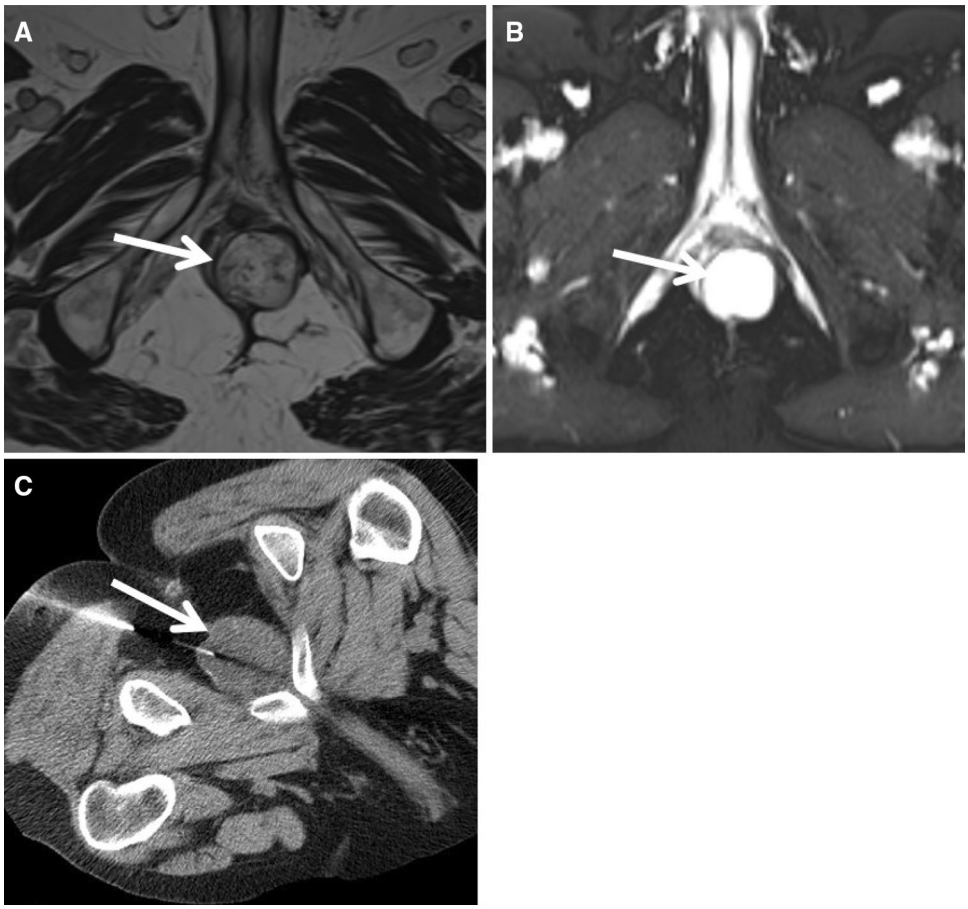

Fig. 12 Recurrent mucinous adenocarcinoma. A 50-year-old male status post-abdominoperineal resection with end ostomy. **a** Axial T2-weighted MR image demonstrates a high T2 signal round structure (arrow) with internal areas of irregular low T2 signal in the former location of the anus. **b** Axial T2-weighted image obtained with fat saturation demonstrates persistent high T2 signal in this location (arrow) compatible with fluid or mucinous material. **c** Image from CT-guided biopsy which resulted in a diagnosis of atypical cells compatible with mucinous adenocarcinoma

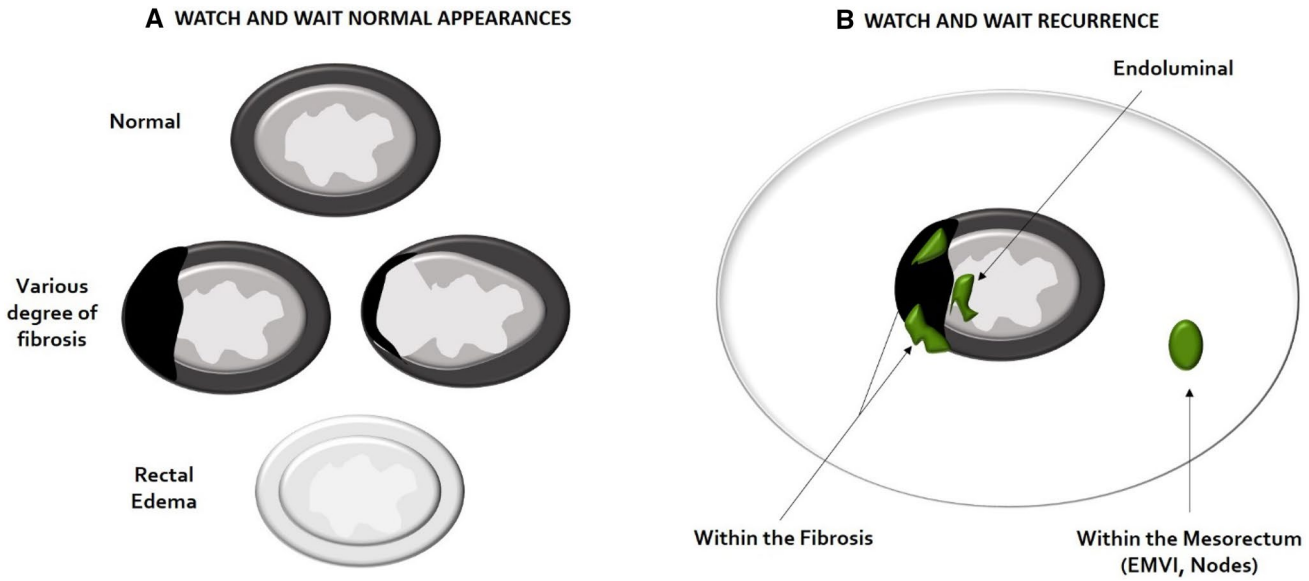

Fig. 13 **a** Drawing illustrating the range of expected normal appearances in patients enrolled in watch and wait after chemoradiation therapy. **b** Drawing illustrating patterns of regrowth in patients enrolled in watch and wait

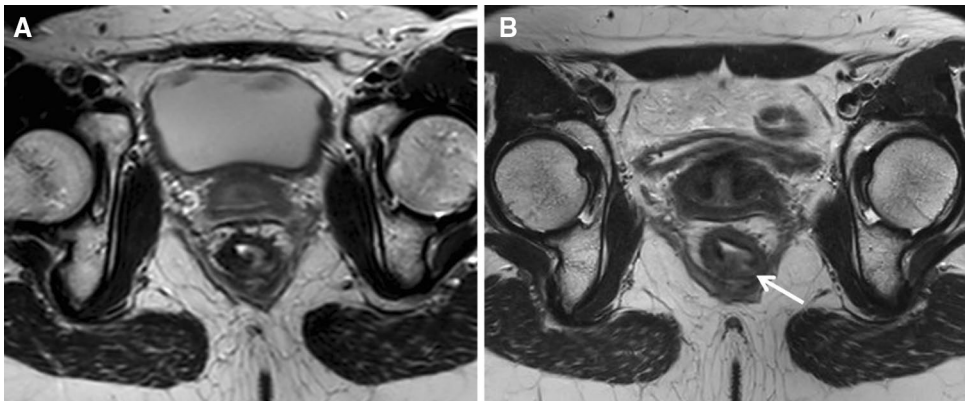

Fig. 14 Tumor regrowth during "watch and wait." **a** Axial T2-weighted image demonstrates no residual measurable tumor following chemoradiation therapy. **b** Axial T2-weighted image from follow-up MRI obtained 6 months later demonstrates a new rounded area of intermediate signal intensity (arrow). The patient underwent abdominoperineal resection, and adenocarcinoma was found at histology

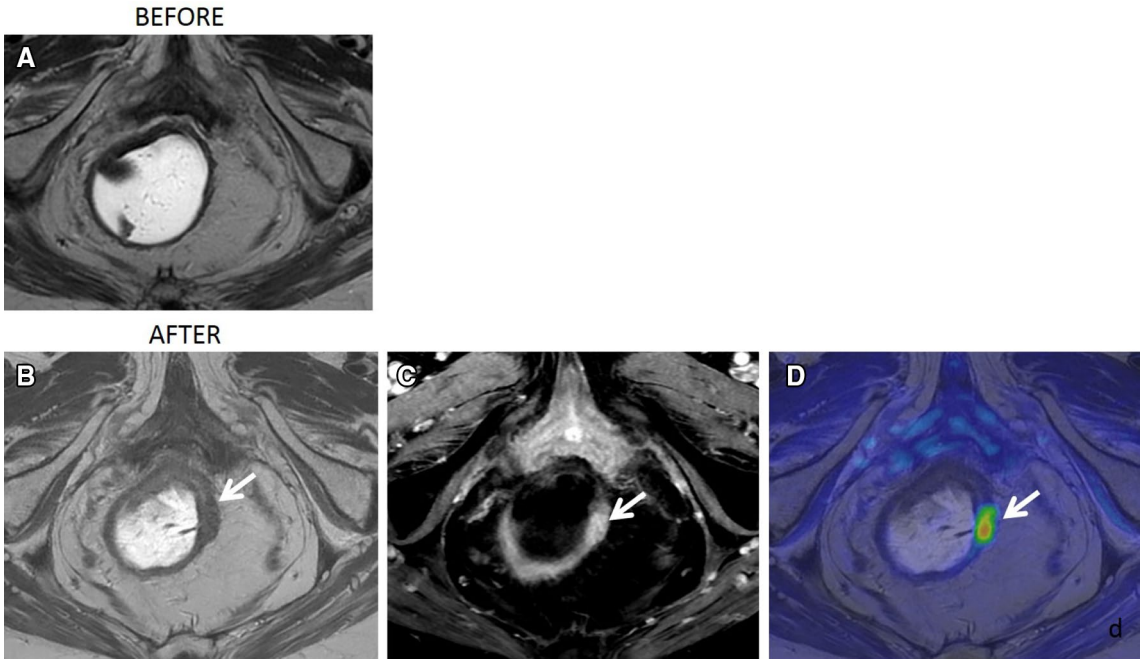

Fig. 15 Tumor regrowth during watch and wait. Initial stage was cT3NOMO. The patient underwent standard cycle of chemoradiotherapy with complete response based on MRI, clinical exam, and repeated biopsies during colonoscopy. The axial oblique T2 post-treatment MRI (**a**) shows a complete response with a complete restitution of the normal wall anatomy. On the third follow-up MRI at 6 months, axial oblique T2WI (**b**) shows a focal rectal wall thickening in the previous treated area (arrow) with enhancement on T1FS post-contrast images (**c**, arrow) and restricted diffusion on fused T2 + DWI axial (**d**, arrow) in keeping with tumor regrowth

FDG PET/MRI

FDG PET/MRI is a relatively new tool for the assessment of rectal cancer patients with suspected recurrence. In a study of forty-four patients with resected rectal cancer who underwent FDG PET/MRI, sensitivity in detecting recurrence was 94% with 94% specificity, 97% positive predictive value, 90% negative predictive value, and 94% accuracy [109]. PET/MRI performed similarly to MR with a liver-specific contrast agent in the detection of liver metastases in colorectal cancer patients [93].

Summary

Locally recurrent rectal cancer remains an important medical and health care issue with associated significant morbidity and mortality despite improvements in management of the primary rectal cancer. Multiple tumor

and treatment-related factors influence the risk of local recurrence in rectal cancer. Neoadjuvant chemotherapy and type of surgical resection of primary rectal cancer are the most important risk factors for recurrence, confirming the importance of a multidisciplinary approach for rectal cancer management. There are different patterns of local recurrence with multiple reported classification systems, without universally accepted classification at this time. These classification systems are important for surgical decision making and have prognostic significance. Different surveillance strategies after treatment of the primary rectal cancer have been reported with some studies showing no benefit from active surveillance. However, availability of potentially curative surgical treatments for locally recurrent rectal cancer has led to increased use of imaging as a sensitive tool for early detection of recurrence and for final surgical management decisions. CT is the primary surveillance imaging modality for patients who have undergone abdominoperineal resection or low anterior resection. MRI is the primary surveillance modality for patients with a complete clinical response to chemoradiation therapy who are enrolled in a watch-and-wait strategy and for patients who have undergone transanal resection. PET/CT in general has higher accuracy than CT and is usually used as problem-solving modality. Pelvic MRI has high accuracy for detection of disease extent and invasion of local structures. There is an ongoing research on the use of relatively new promising hybrid modality of PET/MRI for patients with rectal cancer recurrence. Imaging surveillance for detection of locally recurrent rectal cancer would potentially lead to early surgical intervention, optimal surgical planning, decrease in post-surgical complications, and ultimately may improve patient's quality of life.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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