Original Research

MR Colonography for the Assessment of Colonic Anastomoses

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Purpose: To assess colonic anastomoses in patients after surgical treatment by means of MR colonography (MRC) in comparison with conventional colonoscopy (CC).

Materials and Methods: A total of 39 patients who had previously undergone colonic resection and end-to-end-anastomosis were included in the study. MRI was based on a dark-lumen approach. Contrast-enhanced T1-weighted (T1w) three-dimensional (3D) images were collected following the rectal administration of water for colonic distension. The MRC data were evaluated by two radiologists. The criteria employed to evaluate the anastomoses included bowel wall thickening and increased contrast uptake in this region. Furthermore, all other colonic segments were assessed for the presence of pathologies.

Results: In 23 and 20 patients the anastomosis was rated to be normal by MRC and CC, respectively. In three patients CC revealed a slight inflammation of the anastomosis that was missed by MRI. A moderate stenosis of the anastomosis without inflammation was detected by MRC in five patients, which was confirmed by CC. In the remaining 11 patients a relevant pathology of the anastomosis was diagnosed by both MRC and CC. Recurrent tumor was diagnosed in two patients with a history of colorectal carcinoma. In the other nine patients inflammation of the anastomosis was seen in seven with Crohn's disease (CD) and two with ulcerative colitis. MRC did not yield any false-positive findings, resulting in an overall sensitivity/specificity for the assessment of the anastomosis of 84%/100%.

Conclusion: MRC represents a promising alternative to CC for the assessment of colonic anastomoses in patients with previous colonic resection.

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COLONIC RESECTION with end-to-end-anastomosis is a common procedure in colorectal surgery for patients with colorectal malignancy or chronic inflammatory bowel diseases (1–4). However, postoperative recurrences at the site of anastomosis with consecutive stricture are frequent. Even after the second or third resection, the perianastomotic area remains the most frequent site of disease recurrence (4–8).

Conventional colonoscopy (CC) represents the gold standard for the evaluation of the colon (9). However, procedure-related discomfort and technical challenges limit the success of colonoscopy in patients with colonic elongation, as well as inflammatory or tumor-based stenosis (10,11). Virtual computed tomography (CT) and magnetic resonance colonography (MRC) based on the acquisition of three-dimensional (3D) data sets can overcome this limitation (12). Because of their noninvasive nature, these techniques are preferred over CC by a majority of patients (12,13).

Recently, dark-lumen MRC based on the acquisition of T1-weighted (T1w) 3D data sets following colonic distension with a water-enema and the administration of paramagnetic contrast (12) has shown a high diagnostic accuracy for detecting colorectal pathology (12,13).

The aim of this study was to assess the diagnostic accuracy of dark-lumen MRC for evaluating colonic anastomoses after surgical treatment, using conventional endoscopy as the gold standard.

MATERIALS AND METHODS

The study was performed according to good clinical practice (GCP) rules and was approved by the local ethics committee. Written informed consent was obtained from all patients, who were not charged for the examination. Exclusion criteria included contraindications to MRI, such as the presence of a pacemaker, metallic implants in the central nervous system, or claustrophobia.

Subjects

Over a seven-month period MRC was performed on 39 patients (16 men and 23 women, age range = 29–70 years, mean age = 54.2 years) who had previously undergone end-to-end-anastomosis after surgical treatment. The patients had been referred for CC for various indications, including abdominal pain (N = 8), suspected recurrence of Crohn's disease (CD) or ulcerative colitis (N = 15), chronic diarrhea (N = 4), a positive fecal occult blood test (N = 2), and yearly routine control after surgical treatment (N = 10).

The underlying reasons for surgical treatment included the presence of a colorectal carcinoma (N = 15), CD (N = 11), ulcerative colitis (N = 7), or diverticulitis (N = 6). The sides of the colonic anastomoses were as follows: ileoascendostomy (N = 10), ileotransversostomy (N = 8), ascendotransversostomy (N = 5), descendosigmoidostomy (N = 4), and descendorectostomy (N = 12). The time between surgery and the MR examination was 11–54 months (average = 22 months).

Bowel Preparation

All patients underwent a standardized bowel cleansing procedure with 3000 mL of a polyethylene glycol solution (Golytely®: sodium chloride 1.46 g, sodium hydrogencarbonate 1.68 g, sodium sulfate 5.68 g, potassium chloride 0.75 g, polyethylene glycol 4000 59 g; Braintree Laboratories, Braintree, MA, USA). The patients ingested 2000 mL of the solution the night before and 1000 mL the morning of the examination day.

MRI

MR examinations were performed on a 1.5 T MR system (Magnetom Sonata, Siemens Medical Solutions, Erlangen, Germany) equipped with a high-performance gradient system characterized by a maximum gradient amplitude of 40 mT/m and a slew rate of 200 mT/m/msec, with the subjects in the prone position. Imaging in the prone position reduces breathing artifacts. A combination of two surface coils was used in conjunction with the built-in spine array coil for signal reception to permit coverage of the entire colon. To minimize bowel peristalsis, 40 mg of scopolamine (Buscopan; Boehringer Ingelheim, Germany) were injected intravenously prior to the enema. No patient presented any contraindications for the administration of scopolamine. Following the placement of a rectal enema tube (E-Z-Em, Westbury, NY, USA), the colon was filled with approximately 2000–2500 mL of warm tap water. Following bowel distension, a T1w 3D gradient-echo data set with integrated fat suppression (using the volumetric interpolated breathhold examination (VIBE) sequence) was collected in the coronal plane. The sequence parameters included TR/TE = 1.64/0.6 msec, flip angle = 15°, field of view (FOV) = 450 × 450 mm, matrix = 168 × 265, and effective slice thickness = 1.5–2.0 mm. Depending on the patient's size the total number of the calculated slices was 90–96. The 3D data were collected with breath-holding in 22 seconds. Subsequently, paramagnetic contrast (Gd-BOPTA; Multihance, Bracco, Italy) was administered i.v. at a dose of 0.2 mmol/kg and a flow rate of 3.5 mL/second. Following a delay of 75 and 120 seconds, respectively, two more 3D data sets were acquired with identical parameters to ensure enhanced image quality. Furthermore, a 2D fast low-angle shot (FLASH) image of the entire abdomen was acquired in the axial plane (sequence parameters: TR/TE = 125/1.8 msec, flip angle = 70°, slice thickness = 5 mm). Finally, if deemed necessary, an additional 2D TrueFISP image of the abdomen was obtained in the coronal plane (TR/TE = 4.5/2.2 msec, flip angle = 70°, slice thickness = 3 mm). After the MRC the enema water was let back into the enema bag.

CC Procedure

CC was performed using standard equipment (model CFQ 140; Olympus, Tokyo, Japan). All endoscopic examinations were performed within three days of the MRC. The attending gastroenterologist was unaware of the MR findings. The patients were given sedatives (2.5–5 mg Midazolam: Dormicum®; Roche, Grenzach-Wyhlen, Germany) and/or a low dose of analgesics (Dolantin®; Hoechst, Bad Soden, Germany) when necessary. The location and size of colorectal pathologies were recorded. Suspicious cancers and inflammatory lesions were biopsied. All biopsy materials were analyzed by histopathology.

Data Analysis

Both native and contrast-enhanced 3D data sets from each subject were transferred to a postprocessing workstation (Virtuoso; Siemens Medical Solutions, Erlangen, Germany). The 3D MRC data sets were assessed interactively in the multiplanar reformation mode by two experienced radiologists (>4 years' experience in abdominal MRI), which allowed them to scroll through the 3D data sets in all three orthogonal planes. The two radiologists had no knowledge of the colonoscopy findings, and assessment was performed by consensus.

For analysis the colon was divided into two segments: the pre- and postanastomotic. The distension of pre- and postanastomotic segments was graded as follows: 1 = well distended; 2 = moderately distended; and 3 = poorly distended. Furthermore, the image quality of the pre- and postanastomotic segments was evaluated concerning the presence of artifacts, including motion and susceptibility artifacts, and was graded on a three-point scale: 1 = no artifacts; 2 = moderate artifacts, diagnostic image quality; and 3 = extensive artifacts, not diagnostic. In addition, the quality of visualization of the anastomotic region was assessed and classified as follows: 1 = well visualized; 2 = moderately visualized; and 3 = poorly visualized. The criteria employed to evaluate the anastomoses included bowel wall thickening and increased contrast uptake in this region as a sign of recurrent inflammation. Furthermore, all other colonic segments and extraintestinal organs were assessed for the presence of pathologies.

The ratings of the pre- and postanastomotic segments were compared by means of a Wilcoxon rank test, with a P-value < 0.05 considered to indicate statistical significance.

Table 1
Image Quality of the Pre- and Postanastomotic Segments

Image quality	Preanastomotic	Postanastomotic
Well distended	19	23
Moderately distended	20	16
Poorly distended	0	0
No artifacts	31	23
Moderate artifacts	8	16
Extensive artifacts	0	0

RESULTS

All of the MR examinations were completed without complications, and there were no complications associated with the CC or endoscopic biopsies. In all 39 cases the CC was completed.

MR image quality was sufficient for diagnosis in all patients. Colonic distension proved to be robust, with no statistically significant difference ($P < 0.054$) between pre- (distension value = 1.6) and postanastomotic segments (distension value = 1.4). The assessment for artifacts failed to show a statistically significant difference ($P < 0.051$) between pre- and postanastomotic segments (1.27 and 1.30, respectively). All data regarding image quality are listed in Table 1. Regarding the qualitative assessment of the anastomotic region, the visualization grade was high (average = 1.7).

In 23 and 20 patients the anastomosis was rated as normal by MRC and CC, respectively (Fig. 1). In three patients rated as having a normal anastomosis, CC revealed a slight inflammation of the anastomosis (two patients with CD and one patient with diverticulitis; Fig. 2a and b). A moderate stenosis of the anastomotic region without inflammation was detected by MRC in five patients (Fig. 3), which was confirmed by CC. In the remaining 11 patients a relevant pathology of the anastomosis was diagnosed both by MRC and CC. In two patients with a history of colorectal carcinoma, a recurrent tumor was diagnosed (17 and 22 mm in diameter, respectively; Fig. 4). In the other nine patients, inflammation of the anastomosis was seen in seven patients with CD (Fig. 5) and two with ulcerative colitis. MRC did not yield any false-positive findings, resulting in an overall sensitivity/specificity for the assessment of anastomosis of 84%/100%.

Furthermore, in seven patients inflammation of colonic segments (five pre- and two postanastomotic segments) were diagnosed by MRC and confirmed by CC (Fig. 6). In one patient with CD, a fistula that ended blindly in the mesentery was detected by both MRC and CC (Fig. 7). All findings are listed in Table 2.

MRC permitted the assessment of extracolonic parenchymal organs. A variety of relevant and nonrelevant pathologies were identified. Hepatic metastases were detected in one patient with a history of colorectal tumor (Fig. 8), and multiple mesenteric lymph nodes were identified in nine patients. Liver and renal cysts and osteochondrosis were seen in 11 patients.

DISCUSSION

The presented data underscore the usefulness of dark-lumen MRC for assessing colonic anastomoses, with sensitivity and specificity values amounting to 84% and 100%, respectively.

Colorectal cancer is an important cause of morbidity and mortality in the Western world, and is the second-most common cancer after bronchial (male) and breast cancer (female) (9,14). However, while inflammatory bowel diseases (IBD), such as CD and ulcerative colitis (UC), are the main pathologies of the large bowel, CD predominantly involves the distal bowel (20%), the colon (30%), and the small and large bowels (50%). In addition, diverticulitis is a common occurrence in the elderly, with serious complications, and mainly affects the distal large bowel (15–18). Despite many recent advances in medical therapies, surgery remains an essential component of the management of these conditions (6,19–22).

The incidence of local recurrence following curative surgery for colorectal cancer, CD, UC, or diverticulitis is high, and has been reported to range from 3.7% to 50% within the first two years (1–5,21,23). Therefore, it is important to obtain a rapid and exact diagnosis of local recurrence to plan subsequent therapy and possibly surgical reresection of the recurrence. CC is the standard method used to assess the colon and its pathologies, including the anastomotic region, after surgical

Figure 1. Dark-lumen MRC of a 55-year-old male patient with a history of colorectal carcinoma and descendorectostomy. Coronal T1w 3D VIBE source image (TR/TE = 1.64/0.6 msec, flip angle = 15°) shows a normal end-to-end anastomosis (arrow) without any wall thickness or pathologic contrast enhancement.

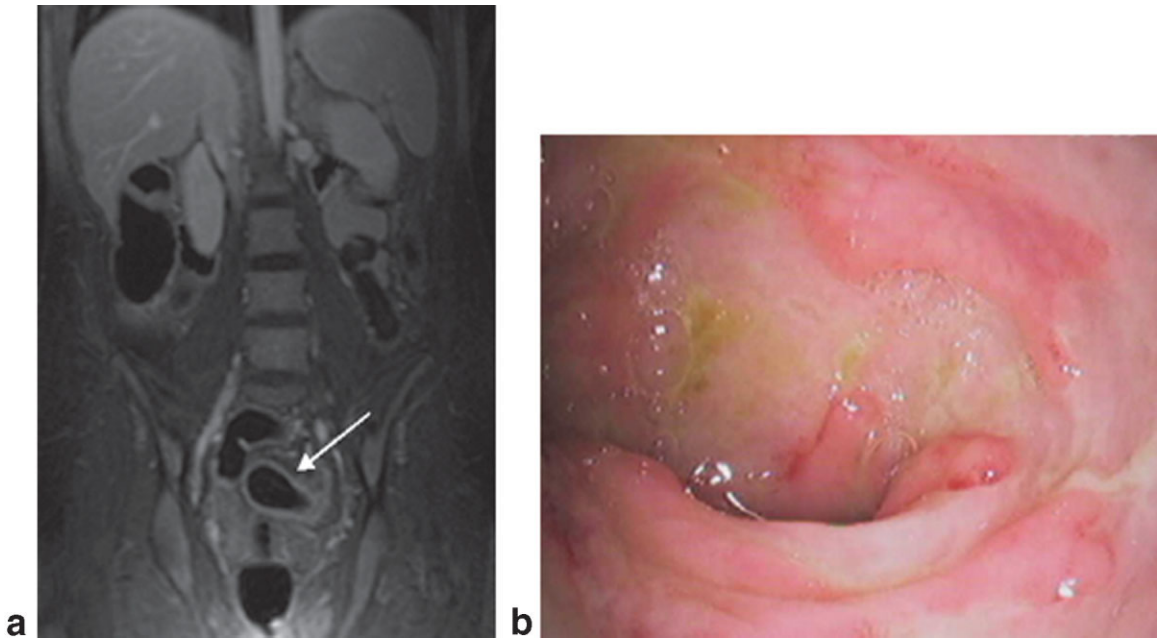

Figure 2. a: Contrast-enhanced VIBE image of a 57-year-old female patient with a history of sigmoid diverticulitis and descendosigmoidostomy who underwent MRC. MRC classified the anastomotic region as normal (arrow). **b:** CC confirmed the presence of a slight inflammation of the anastomosis.

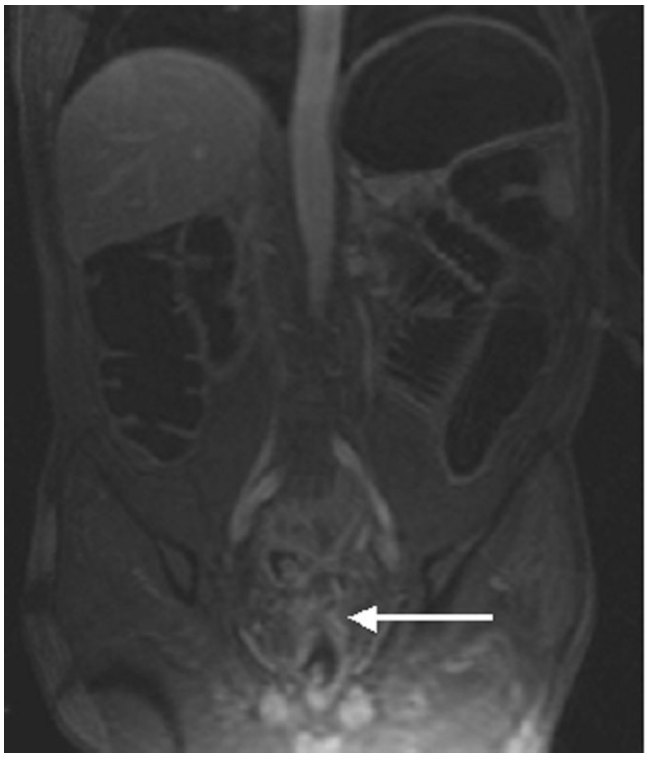

Figure 3. Coronal T1w 3D VIBE source image of dark-lumen MRC of a 62-year-old female patient with a history of colorectal carcinoma and descendorectostomy. A moderate stenosis of the anastomosis is shown (arrow) with wall thickness but without increased contrast enhancement. CC confirmed the MR findings, and histopathologic results revealed a fibrosis.

Figure 4. Contrast-enhanced coronal 3D VIBE image of a 65-year-old male patient with a history of sigmoid carcinoma and descendorectostomy. In the anastomosis (arrow) a large lesion was depicted, which was confirmed as a recurrent tumor by CC.

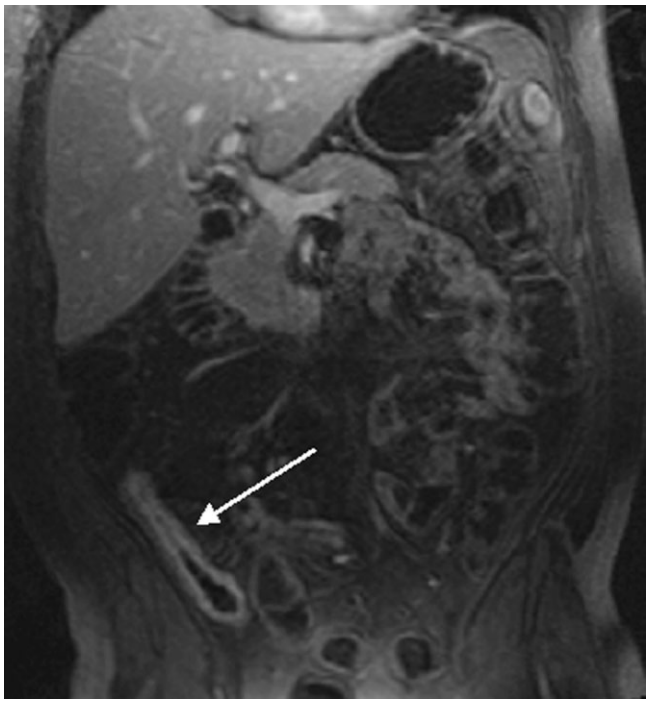

Figure 5. Contrast-enhanced coronal 3D VIBE image of a patient with CD and a history of ileoascendostomy. Increased contrast uptake of the distal ileum close to the anastomosis confirmed the recurrence of inflammatory disease (arrow).

Figure 6. Coronal source image of a 55-year-old female patient with a history of diverticulitis and descendosigmoidostomy. The anastomotic region was normal; however, in the pre-anastomotic segments inflammation due to a loss of haustral markings (arrows) was diagnosed and confirmed by CC.

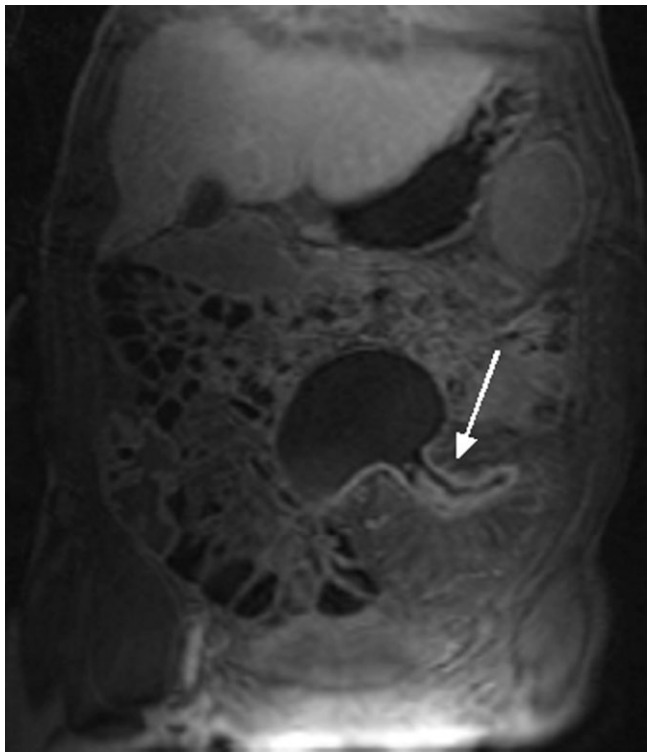

Figure 7. Dark-lumen MRC of 43-year-old female patient with known CD and descendosigmoidostomy. The anastomotic region was normal; however, MRC diagnosed a blind mesenteric fistula with high contrast enhancement, which was confirmed by CC.

therapy (9). However, the invasiveness, procedure-related discomfort, and poor patient acceptance of this method have driven the exploration of alternatives to endoscopy for diagnosing colorectal pathologies (12,24–26).

Carcinoembryonic antigen (CEA) and inflammatory signs such as leukocytosis and C reactive protein (CRP) are recommended as serologic markers to monitor a recurrence of colorectal carcinoma and inflammation (27–32). However, elevations of these markers due to other causes may lead to a misdiagnosis of recurrent pathology of anastomoses, and do not deliver exact and direct information about colonic anastomoses.

The main objective of postoperative follow-up is to detect recurrent disease as early as possible so that the appropriate therapy can be implemented. In addition to assessing colonic anastomoses, diagnostic imaging can be used to perform a general body screening to assess pericolic fat tissue and extraintestinal organs, including the liver and lymph nodes. Endoluminal sonogra-

Table 2
Assessment of the Colonic Anastomosis by MRC Compared to CC

Findings	MRC	CC
Normal	23	20
Moderate stenosis	5	5
Recurrent tumor	2	2
Recurrent inflammation	9	9

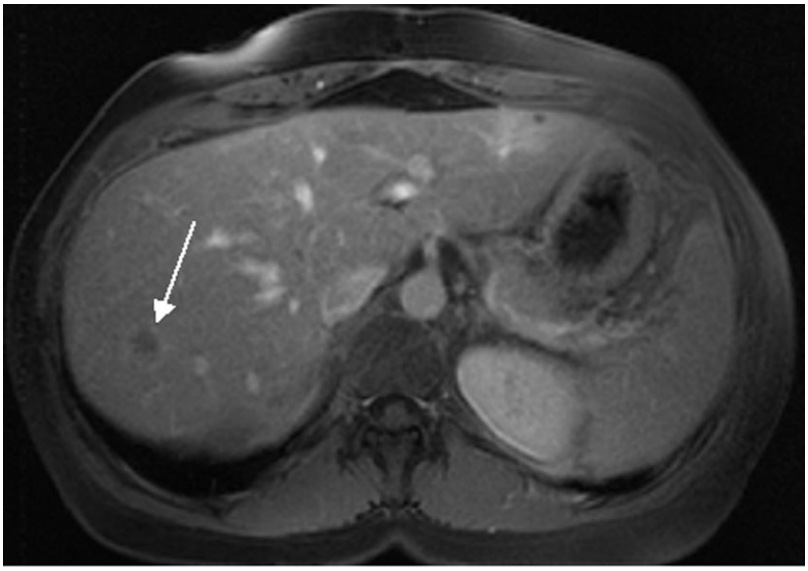

Figure 8. Axial source image of MRC of a 61-year-old male patient with a history of colorectal carcinoma and ascendotransversostomy. The anastomotic region was normal in both MRC and CC; however, MRC confirmed a liver metastasis (arrow).

phy (ES), virtual CT, MRI, and positron emission tomography (PET)/CT have also been used for these purposes (33–40).

Transrectal or transvaginal ES for the assessment of rectal anastomosis has shown an accuracy of 94% (36). ES is advantageous because it can directly assess the colonic wall; however, not all colonic anastomoses can be assessed with ES. In addition, ES has a low sensitivity and specificity for the detection of lymph nodes or extracolonic metastases (33).

Because it is widely available, CT is the most commonly used method to assess colonic anastomoses, with high sensitivity values of 73–98% for the detection of anastomotic pathologies (35,36,39). Laghi et al (40) evaluated the impact of contrast-enhanced CT colonography for follow-up in patients with previous colorectal cancer. CT colonography was compared with conventional endoscopy as well as liver ultrasonography. All surgical colonic anastomoses were visualized by means of CT colonography. However, in that trial, no patient showed recurrent disease at the anastomosis site. Therefore, the question as to whether virtual colonoscopy is an alternative to optical colonoscopy could not be answered. In another study, virtual CT colonoscopy was used to depict colonic anastomoses in 16 patients with CD (39). While conventional endoscopy revealed perianastomotic recurrence in 15 of 16 patients, these changes were detected by contrast-enhanced virtual CT in only 11 patients, resulting in a sensitivity of 73%. Since there were no false-positive findings, the specificity amounted to 100%. CT and PET scans can document the presence of wall thickness and show increased contrast uptake in the anastomotic region. However, both modalities are associated with considerable doses of ionizing radiation. Therefore, MRI should be favored because it offers superior spatial resolution, is more reliable for soft-tissue differentiation, and avoids the use of ionizing radiation, which is especially important in younger patients.

Dark-lumen MRC combining an aqueous enema with intravenous administration of gadolinium-based contrast agents is a rapidly evolving, almost noninvasive method for evaluating the entire colon (12,13). The results of several preliminary studies indicate that this technique has a high sensitivity for detecting colorectal pathologies (13). MRC is based on focal uptake of T1-shortening contrast material in colonic lesions, which are displayed as bright areas on T1w sequences, whereas the lumen is rendered totally dark due to water or water-based solutions that serve as filling material (12). The latter leads to uniform luminal darkening as well as sufficient distension of the colon. Thus, the anastomotic region can be better assessed and the presence of recurrent diseases or fibrosis can better classified with MRC.

Clearly, the present study is not without its limitations. First and foremost, the study involved a rather heterogeneous cohort of patients with both tumors and inflammatory bowel pathologies. However, the patient numbers were too small to seriously differentiate between these entities. Furthermore, the underlying patient selection reflects the reality of the daily clinical routine, in which the reason for previous colonic resection and formation of a colonic anastomosis plays only a secondary role. In practice, the endoscopist only has to assess whether there is any recurrent disease at the anastomosis.

In conclusion, MRC represents a promising alternative to CC for the assessment of colonic anastomoses in patients with previous colonic resection. Thus, MRC may replace endoscopic procedures, especially for follow-up examinations, in this patient group. In addition to the anastomosis itself, all pre- and postanastomotic bowel segments and extracolonic organs can be evaluated.

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