

# Fecal tag CT colonography with a limited 2-day bowel preparation following incomplete colonoscopy

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Received: 3 January 2015 / Accepted: 8 April 2015 / Published online: 21 April 2015  
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## Abstract

**Purpose** This study aimed to assess the feasibility and patient tolerance of a 2-day limited fecal tag bowel preparation in computed tomographic colonography (CTC) performed for incomplete conventional colonoscopy (CC) patients.

**Materials and methods** Seventy-five patients who underwent a CTC examination because of incomplete CC were included. A low-residue diet was given for 2 days before CTC. Fecal tagging (FT) was done using a barium sulfate suspension. The quality of the preparation, success of tagging and patient experience with the bowel preparation were investigated.

**Results** Four hundred fifty bowel segments were evaluated. The number of solid stool balls of 6–9 mm size was 284; the corresponding figure was 93 for solid stool balls  $\geq 10$  mm. Residual fluid was present in about one-third of the segments. The fecal tagging efficacy for  $\geq 6$  mm residual stool balls was 92 %. Overall, 16 (21.3 %) patients presented with colonic lesions at CTC. Three out of four colonic mass lesions had not been diagnosed with CC. Most patients reported mild discomfort.

**Conclusion** FT-CTC performed after a limited 2-day bowel preparation seems to be a technically feasible, safe and acceptable procedure that allows a complete a colonic study in incomplete CC patients.

**Keywords** CT colonography · Fecal tag · Incomplete conventional colonoscopy · Colorectal carcinoma · Limited preparation

## Introduction

Colorectal cancer (CRC) represents the third most common malignancy worldwide and is the second most common cause of cancer-related deaths in the USA [1]. Although conventional colonoscopy (CC) is the gold standard method for evaluating the colon [2, 3], incomplete examinations failing to reach the level of the cecum comprise 6–26 % of all colonoscopies [4–6] and have been reported to occur in up to 40 % of the very elderly undergoing CC [7]. Causes of incomplete colonoscopy include procedure intolerance, poor bowel preparation, tortuous colonic segments and colonic disease, such as stenosis or obstruction caused by colonic cancer or diverticular disease [8, 9]. Moreover, the risk of complications, mainly electrolyte imbalance, appears to impair the safety profile of bowel preparation for CC [10].

Computed tomographic colonography (CTC) is a non-invasive imaging modality that offers certain advantages over conventional colonoscopy such as rapid data acquisition and minimal patient discomfort [5, 11, 12]. Previous studies of CTC yielded a sensitivity of up to 90 % in the diagnosis of polyps  $\geq 10$  mm in size [13–16]. The American Gastroenterological Society recognizes CTC as the imaging modality of choice for cases of incomplete CC

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[17]. CTC is generally well tolerated by patients [18, 19], although bowel preparation still remains a challenge [19]. Most previous studies used high-dose cathartics to obtain better vision, which potentially impairs patient satisfaction and comfort [20–22].

The use of fecal tagging (FT) before CTC has proven effective in combination with a reduced cathartic cleansing [23]. Currently, non-ionic contrast agents with a small allergic risk and a relatively high cost are used for this purpose. Barium on the other hand is a cheap and well-tolerated fecal-tag agent with almost no allergic potential, representing an alternative to nonionic agents. However, the success of the FT-CTC technique still depends on the quality of the bowel preparation.

We hypothesized that using a less cathartic regimen consisting of a low-fiber diet, bisacodyl and senna but extending the duration of bowel preparation, along with fecal tagging using an agent with a good tolerability profile (barium), would help improve patient comfort and imaging quality. Thus, this study assessed the feasibility and patient tolerance of a 2-day limited fecal-tag bowel preparation in CTC performed for incomplete colonoscopy patients.

## Materials and methods

### Patients

Seventy-five patients (mean age 58 years, range: 46–84) who underwent a CTC examination between April 2011 and March 2013 were included in this single-center prospective study. Patients had undergone colonoscopy previously, and the procedure was incomplete in all of them. Thirty-three patients were female (44 %) and 42 were male (56 %). The reasons for referral to CTC included incomplete CC due to poor colonic preparation and residual colonic content ( $n = 28$ ), patient intolerance during CC examination ( $n = 22$ ), colonic tortuosity ( $n = 13$ ), sigmoid diverticular disease ( $n = 10$ ) and adhesions ( $n = 2$ ). CTC was performed within 2 weeks after incomplete colonoscopy, with a mean interval of 10 days. The study protocol was approved by local ethics committee and conducted in accordance with Declaration of Helsinki. All participants provided written informed consent prior to study entry.

### Bowel preparation

All patients followed a low-residue diet for 2 days before CTC, during which they were instructed to completely avoid consuming fiber-rich food, including fruits, vegetables, whole-grain bread and whole-grain cereals. On the day prior to CTC, only a liquid diet was allowed, which

consisted of only clear and opaque liquid foods with a smooth consistency.

Fecal tagging was done using a 225-ml barium sulfate suspension (E.Z.CAT barium sulfate suspension, Opakim Medical Products Inc., E-Z-EM Canada Inc.) diluted with 500 ml of water or fruit juice (2.1 % w/v barium sulfate). The suspension was divided into three equal portions to be taken 15 min after breakfast, lunch and dinner on day 2. In addition, Bekunis tablets (Abdi Ibrahim, Turkey), containing bisacodyl (5 mg) and sennoside B (3 mg) as active ingredients with stool softening properties were used for bowel preparation. All patients were instructed to take two tablets at 7:00 PM on the 1st and 2nd day of their preparation diet (i.e., a total of 4 tablets were taken). In the morning before the procedure, no breakfast was allowed. CTC was performed between 8:30 and 9:30 AM.

### CT colonography technique

All CTC examinations were performed using a 64-row scanner (Toshiba Aquillion TSX-101A, Japan) with a  $64 \times 0.5$ -mm detector collimation at 120 kV and 100 mAs (0.8 pitch and 0.5 s gantry rotation). In the left lateral decubitus position, the colon was gently insufflated with room air by a radiologist using a lubricated foley catheter placed in the rectum until the patient requested that air insufflation be discontinued or distention was believed to be adequate (30–50 bulb compressions). Colonic distention was assessed on the scout view. In the event of insufficient colonic distention, additional insufflation was performed. In the event of good colonic distention, the patient underwent scanning while supine with the tube still in the rectum. The patient was subsequently turned to the prone position. If necessary, additional inflation of the colon was performed. If the patient was not able to lie in prone position, the patient was scanned in the left decubitus position. To avoid concealment of rectal polyps by the rectal tube, the tube was removed at this time. To reduce radiation exposure, patients were scanned at a reduced dose of 50 mAs when acquiring the images in the prone position. CT images were reconstructed with 5-mm slice thickness at 0.5 mm intervals. The whole abdomen from the diaphragm to the symphysis pubis was scanned in a single breath-hold over an average of 8 s.

### CTC image analysis and grading the quality of bowel preparation

The CT data sets were post-processed using commercially available software (Aquarius iStation, TeraRecon, Foster City, CA, USA). Two radiologists independently analyzed each patient directly on a dedicated workstation, and disagreements were solved by consensus. Both radiologists

were experienced in the procedure. K.M and N.B had performed more than 200 and 100 colonographies, respectively. The quality of the preparation and success of tagging was also retrospectively evaluated by the same study team members using a modified grading system originally proposed by Lefere et al. and Taylor et al. [20, 21]. The colon was evaluated per patient and per segment. For the purposes of the analysis, the colon was divided into six segments: the cecum, ascending, transverse, descending and sigmoid colon, and rectum.

Residual solid stool was categorized and scored as follows: 1, no stool; 2, small stool ( $\leq 6$  mm); 3, moderate-size stool (6–9 mm); 4, large stool ( $\geq 10$  mm) [24]. Scoring was based on 2D measurements using electronic calipers, and the presence of residual solid stool in colonic segments was evaluated. In segments with different solid stool sizes, only the largest solid stool size was considered.

Residual fluid grading was based on the maximum anterior-posterior (AP) diameter of the colonic lumen that was submerged. For each colonic segment, scores were as follows: 1, no fluid; 2,  $<25\%$  of the AP diameter; 3,  $25\text{--}50\%$  of the AP diameter; 4,  $>50\%$  of AP diameter [21]. In segments with different fluid levels, only the largest fluid level was considered.

Residual tagged solid stool scores were assigned as follows: 1, all residual solid stool untagged; 2, 1 to  $<25\%$  tagged; 3, 25 to  $<50\%$  tagged; 4, 50 to  $<75\%$  tagged; 5,  $75\text{--}100\%$  tagged [21]. The tagged appearance of residual fluid was assessed on a visual basis: tagged or non-tagged [20].

All pathologic findings within the colon were documented including all colonic masses ( $\geq 30$  mm) and large (10–29 mm) and medium-sized (6–9 mm) polyps. The

classification of the detected colonic polyps, mass lesions and extracolonic incidental findings was based on the CT Colonography Reporting and Data System (C-RADS) [25]. When a suspected polypoid lesion was detected, coronal, sagittal and oblique multiplanar reconstructions as well as 3D images were analyzed to confirm the lesion and to increase the diagnostic yield. The maximum diameter of all polyps was measured using an electronic ruler on the 2D images.

**Patient tolerance**

To evaluate patient tolerance to the preparation, all patients were asked to fill a questionnaire the morning before CTC that gathered information on global discomfort and side effects (headache, nausea, vomiting, abdominal cramps and diarrhea) associated with the limited bowel preparation. Global discomfort was rated as follows: 0, none; 1, mild; 2, moderate; 3, severe. After CTC, a second questionnaire was administered that posed the following question: “Which of these two examinations would you prefer if you were to have it again in the future: CC or CTC.”

**Results**

**Evaluation of bowel preparation**

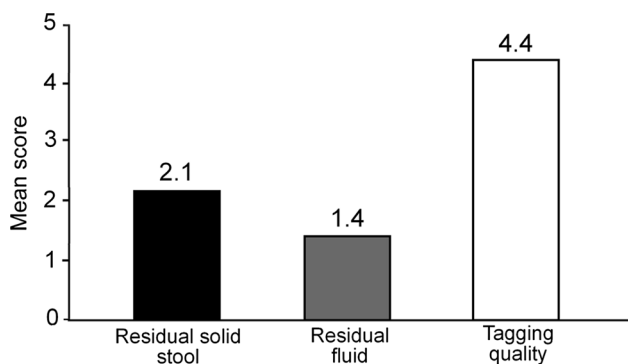
A total of 450 bowel segments were evaluated. Table 1 shows the distributions of residual solid stool, residual fluid and tagging quality across these segments. The number of solid stool balls of 6–9 mm size was 284; the corresponding figure was 93 for solid stool balls  $\geq 10$  mm. Residual fluid

**Table 1** Distributions of residual solid stool, residual fluid and tagging quality across colonic segments

	Score		Entire colon	Cecum	Ascending	Transverse	Descending	Sigmoid	Rectum
Residual solid stool	1	Absent	156 (34.7)	19 (25.7)	27 (36.0)	26 (34.7)	28 (37.3)	26 (34.7)	30 (40.0)
	2	$<6$ mm	143 (31.8)	14 (18.3)	26 (34.7)	22 (29.3)	27 (36.0)	30 (40.0)	24 (32.0)
	3	6–9 mm	104 (23.1)	28 (37.3)	16 (21.3)	18 (24.0)	15 (20.0)	12 (16.0)	15 (20.0)
	4	$\geq 10$ mm	47 (10.4)	14 (18.7)	6 (8.0)	9 (12.0)	5 (6.7)	7 (9.3)	6 (8.0)
Residual fluid	1	0 %	303 (67.3)	33 (44.0)	46 (61.3)	56 (74.6)	57 (76.0)	58 (77.3)	53 (70.6)
	2	$<25\%$	108 (24.0)	31 (41.4)	18 (24.0)	15 (20.0)	13 (17.3)	12 (16.0)	19 (25.4)
	3	$25\text{--}50\%$	27 (6.0)	4 (5.3)	8 (10.7)	3 (4.0)	5 (6.7)	4 (5.3)	3 (4.0)
	4	$>50\%$	12 (2.7)	7 (9.3)	3 (4)	1 (1.4)	0 (0)	1 (1.4)	0 (0)
Tagging quality		Absent	156 (34.7)	19 (25.3)	26 (34.6)	25 (33.3)	29 (38.7)	26 (33.9)	31 (41.4)
	1	0 %	17 (3.8)	0 (0)	0 (0)	2 (2.7)	4 (5.3)	7 (10.7)	4 (5.4)
	2	$<25\%$	8 (1.8)	1 (1.3)	0 (0)	0 (0)	2 (2.7)	4 (5.4)	1 (1.3)
	3	$25\text{--}50\%$	11 (2.4)	3 (4.0)	3 (4.0)	2 (2.7)	1 (1.3)	1 (1.8)	1 (1.3)
	4	$50\text{--}75\%$	56 (12.4)	23 (30.7)	7 (9.4)	3 (4.0)	5 (6.7)	7 (8.9)	11 (14.6)
	5	$>75\%$	202 (44.9)	29 (38.7)	39 (52.0)	43 (57.3)	34 (45.3)	30 (39.3)	27 (36.0)

Data presented as *n* (%)

was present in about one-third of the segments. When only segments with residual stool were considered ( $n = 294$ ), in only 17 of them was stool untagged (5.8 %). The fecal tagging efficacy for  $\geq 6$  mm residual stool balls was 92 %. Non-tagged fluid was detected in 10.2 % (15/147) of segments. None of the non-tagged fluid segments covered more than 50 % of the colonic segments. Overall, the tagging percentage of residual fluid in colonic segments was

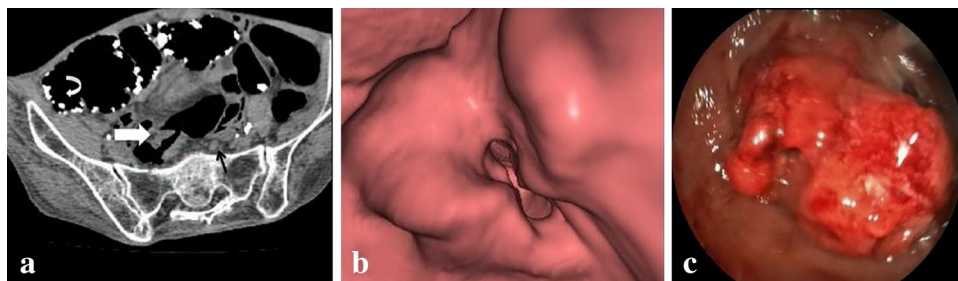


**Fig. 1** Mean scores for residual solid stool, residual fluid and tagging quality for the entire colon

89.8 % (132/147). Figure 1 shows mean scores for residual solid stool, residual fluid and tagging quality for the entire colon.

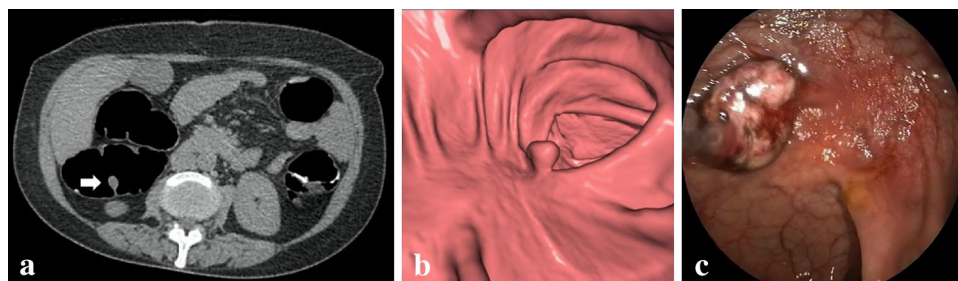
### Colonic and extracolonic findings

Overall, 16 (21.3 %) patients presented with colonic lesions at CTC. Colonic lesions included four colonic masses (C-RADS category C4), three colonic polyps  $>10$  mm (C-RADS category C3), and nine colonic polyps between 6 and 9 mm (C-RADS category C2). Colonic mass lesions were located in the following locations: two in the sigmoid colon (Fig. 2), one in the descending colon and one in the cecum. Three out of four colonic mass lesions had not been diagnosed with CC. All patients with colonic mass lesions underwent surgery (one case underwent right hemicolectomy and three had left hemicolectomy) and were confirmed to be adenocarcinomas. Two of the three polypoid lesions larger than 10 mm were pedunculated polyps (Fig. 3), and one was a sessile polyp. All colonic polyps larger than 10 mm were confirmed by successive colonoscopies and successfully resected. Two out of three polyps were tubulo-villous adenomas with a high grade of



**Fig. 2** A 67-year-old male with a positive fecal occult blood test and anemia underwent incomplete conventional colonoscopy of the sigmoid because of patient intolerance. **a** Axial CT scan showing a neoplastic mass (arrow), narrowing the lumen of the sigmoid

colon. Enlarged lymph nodes (black arrow) were present. **b** Three-dimensional threshold-rendered endoluminal CT colonography shows a similar endoscopic appearance of the mass. **c** Optical colonoscopy image of the neoplastic mass



**Fig. 3** A 56-year-old female who had an incomplete conventional colonoscopy of the transverse colon because of patient intolerance. **a** Axial image shows a pedunculated polypoid lesion (arrow) of the ascending colon vegetating within the colonic lumen. Histopathologi-

cal examination confirmed tubulo-villous adenoma with low-grade dysplasia. **b** A 3D threshold-rendered endoluminal CT colonography of the ascending colon shows a 15-mm polypoid pedunculated lesion (arrow). **c** Optical colonoscopy image for polyp

dysplasia upon pathological diagnosis; the remaining polyp was adenocarcinoma. Among the nine 6–9 mm polypoid lesions, two were pedunculated polyps and seven were sessile polyps. Six of nine colonic polyps between 6 and 9 mm underwent CC; five were confirmed and resected by CC, but one 6-mm polyp was not confirmed. Three out of five polyps were tubulo-villous adenoma with low-moderate grade dysplasia at pathological diagnosis; the remaining two were hyperplastic polyps. Diverticular disease was detected in 24 (32 %) patients. To the best of our knowledge based on the medical records of our hospital, none of the negative cases developed into colorectal cancer.

Eighty-nine extracolonic findings were detected with CTC (Table 2). Of these, 7 (7.9 %) were categorized as having high clinical importance (C-RADS category E4), 27 (30.3 %) as having moderate clinical importance (C-RADS category E3) and the remaining 55 (61.8 %) as having low clinical importance (C-RADS category E2). C-RADS category E4 lesions were as follows: pericolic and parailiac lymph nodes ( $n = 5$ ) and pulmonary nodules >1 cm ( $n = 2$ ).

**Patient satisfaction**

Seventy-five patients completed the questionnaire. Among them, 28 (37.3 %) reported symptoms, the most common being diarrhea ( $n = 16$ ; 21.4 %) followed by abdominal cramps ( $n = 5$ ; 6.6 %), headache ( $n = 5$ ; 6.6 %) and nausea

**Table 2** Summary of colonic and extracolonic findings on CTC ( $n = 450$ )

Finding	<i>n</i> (%)
Colonic findings	16 (3.6)
C-RADS category C4	4 (0.9)
C-RADS category C3	3 (0.7)
C-RADS category C2	9 (2.0)
Extracolonic findings	89 (19.8)
C-RADS category E4	7 (1.6)
C-RADS category E3	27 (6.0)
C-RADS category E2	55 (12.2)

**Table 3** Patient discomfort and satisfaction ( $n = 75$ )

	<i>n</i> (%)
Discomfort	
Mild discomfort	53 (70.6)
Moderate discomfort	22 (29.4)
Severe discomfort	0 (0.0)
Preference	
Prefer FT-CTC	69 (92.0)

( $n = 2$ ; 2.7 %). No major complication was observed during the CTC examination. Fifty-three of the 75 patients (70.6 %) reported mild discomfort, and 22 (29.4 %) reported moderate discomfort (Table 3). None of the patients reported severe discomfort (Table 3). A majority of the patients in the study (69/75, 92 %) stated that they would prefer FT-CTC to CC if they need to have this procedure in the future.

**Discussion**

The findings of this study show that an FT-CTC using a 2-day limited bowel preparation appears to be feasible and safe in patients with a previous failure in CC. In addition, this 2-day limited bowel preparation of FT-CTC allows accurate visualization of the colon while at the same time avoiding the risks associated with a full cathartic preparation.

Incomplete visualization of the colon with CC is a relatively common occurrence in clinical practice. In a study by Gollub et al. [8], redundant/tortuous colon, patient intolerance and angulation of the colonic loops emerged as the most common causes of incomplete CC, while in a more recent study by Neerinx et al. [26] looping of the scope, patient discomfort and obstructive tumors were identified as the most frequent causes. However, although patient discomfort was also a common reason for incomplete CC in our participants as in other studies, poor preparation/residual colonic content represented the foremost cause of CC failure necessitating CTC among our patient group.

In this study, a markedly reduced cathartic regimen with bisacodyl and senna was used for bowel preparation. The amount of residual solid stool detected by CTC was higher than that reported by previous studies where higher doses of cathartics were used [20, 21]. On the other hand, the amount of residual fluid was lower as compared to previous reports. Given the markedly reduced cathartic regimen, the former observation was an expected outcome. However, the latter finding was quite unexpected. Both cathartics used in this study, i.e., bisacodyl and senna, induce peristalsis through local parasympathetic effects, and this mechanism of action may explain the reduction in residual colonic fluid volume.

In limited bowel preparations, adequate tagging of residual contents becomes increasingly more important when one considers the fact that more fecal residual is expected under these circumstances. In the present study, a barium sulfate suspension was used as a tagging agent, which is well tolerated and carries no risk of allergic reactions [20, 21, 27]. The first ESGAR consensus statement on CTC suggested that polyps less than 5 mm should not be reported in asymptomatic screening examinations. For

the symptomatic patients, a reasonable minimum size for polyps to be reported is 5 or 6 mm [28]. Therefore, we assessed the tagging quality for residual stool balls  $\geq 6$  mm and found a tagging efficacy of 92 %, which is comparable with previous studies [20, 21]. In addition, the tagging of residual fluid was also good in our study. Non-tagged fluid was mostly negligible. None of the non-tagged fluid segments covered more than 50 % of the colonic segments.

The importance of completing a colonic study cannot be overemphasized. In our study, the detection rate of colorectal cancer that was previously missed by an incomplete CC was 4 % for FT-CTC performed with a 2-day limited bowel preparation. The corresponding figure in the study by Iafrate et al. [22] was 3 %. In this regard, it is important to remember that the results of previous studies have clearly established the diagnostic role of CTC in patients with incomplete CC [29, 30].

CTC also detected the presence of a large polyp in 4 % of the patients in our study. CTC was previously shown to have a diagnostic sensitivity of up to 90 % for polyps of 10 mm or greater [13–15]. It is a well-known fact that a substantial proportion of polyps greater than 1 cm represent cancerous growths [31, 32]. Despite this, only one large polyp was subsequently diagnosed as adenocarcinoma. In addition, nine colonic polyps between 6 and 9 mm were detected, and a subsequent CC was performed for six of them, five of which were confirmed.

Extracolonic findings were reported in 19.8 % of patients ( $n = 89$ ) in this study. In seven patients, these were deemed clinically significant (C-RADS category E4) [25]. In terms of E4 results, our study is comparable to previous reports [22, 33].

The responses to the questionnaires used for the assessment of patient tolerance showed that the limited bowel preparation regimens utilized in our study were well accepted by the patients. Accordingly, 92 % of the patients stated that they would prefer FT-CTC to CC if they were to have a similar examination in the future. Taylor et al. [21] studied the fecal tagging using four different diet regimens and reported lower patient tolerance than our study. We believe that the lower doses of cathartics used in our study might explain the variance between the results with regard to patient tolerance. To assess patient tolerance without a cathartic agent, Iafrate et al. [22] used diatrizoate meglumine and diatrizoate sodium as the FT agent for bowel preparation. These authors reported that 77 % of the patients would be willing to repeat the test if necessary, again indicating somewhat lower tolerance than in our study. Therefore, our results suggest that a markedly reduced cathartic preparation with barium sulfate as an FT agent is a reasonable approach, particularly in patients with poor tolerance to CC bowel preparations.

Several limitations of this study should be mentioned. First, the sensitivity and specificity of the FT technique for detection of polyps could not be evaluated in this study, since our patient group consisted of incomplete CC patients who were not able to undergo the gold standard CC as to enable a comparison. In addition, patient tolerance was markedly higher than in previous reports, requiring some explanation. This could be partly attributed to the fact that our patients were referred to CTC after an incomplete CC, which could have been associated with certain adverse psychological/physical effects. Another limitation relates to the use of manual room air insufflation in our study. Many authors now advocate carbon dioxide administered via an automated pump to achieve colonic distention and also to allow faster absorption to reduce patient discomfort after CTC [34, 35]. However, others such as Shinnars et al. observed no significant overall colonic distention advantage with either gas [34]. Finally, absence of follow-up questionnaire assessments after discharge (e.g., at 2 or 4 weeks post-discharge) may be considered to be another shortcoming regarding the evaluation of patients' tolerance levels.

In conclusion, our study shows that FT-CTC performed after a limited 2-day bowel preparation is a technically feasible and safe procedure that allows a complete a colonic study in incomplete CC patients. Positive acceptance from the patients without compromising the detection rate of colorectal cancer and colonic polyps of  $>1$  cm suggests that it may be a viable option in clinical practice.

**Acknowledgments** The authors thank their colleagues, Zeynep Gamze Kilicoglu and Can Gonen, for their kind assistance in the preparation of the manuscript.

**Ethical standard** All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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

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