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CT colonography with fecal tagging after incomplete colonoscopy

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Abstract The objective of this study was to evaluate dietary fecal tagging (FT) as a cleansing method prior to CT colonography (CTC) in patients with incomplete conventional colonoscopy (CC). After written informed consent was obtained, 24 patients had standard colonoscopic preparation (ScCl), and 25 patients had FT as cleansing method. Segmental distention, fluid levels, fecal residues, tagged appearance of fluid levels, and residual stool were evaluated. Mann–Whitney *U* test was used to test for significant differences between FT and ScCl groups. Compared with ScCl, FT improved distention (p=0.001), reduced the amount of fluid (p=0.043), but suffered from residual stool (p=0.046). A clear correlation was found between distention and fluid. No differences were found in stool size between FT and ScCl. FT showed a good labeling of fecal residues, and acceptable labeling of fluid levels. Compared with ScCl, FT reduces fluid, favors distention, but suffers from fecal residues. The tagged nature of these residues, however, allows differentiation from polyps.

Keywords CT colonography · Preparation technique · Tagging incomplete colonoscopy

Introduction

A variable but significant portion of conventional colonoscopies is incomplete, with reported rates of incomplete colonoscopy in 5–15% of patients. Reported reasons for incomplete colonoscopy are intolerance of the procedure, poor bowel preparation, tortuous colonic segments, and colonic disease, such as stenosis or obstruction caused by colonic cancer or diverticular disease [1–9].

Although initial reports suggested a predominantly left-sided location of colonic disease, there is growing evidence of a rightward shift of colon cancer [10], as well as an important incidence (up to 55%) of synchronous lesions in colorectal cancer patients and a subsequent need for total colon examination [11].

Various techniques have been reported to evaluate the proximal colon: use of thinner colonoscopes, intraoperative colonoscopy, barium enema, and computed tomography, with or without IV contrast material, with or without 3D rendering (virtual CT colonoscopy [CTC]) [12–24]. CTC especially is gaining interest as an adjuvant technique in cases of incomplete conventional colonoscopy. However,

similar to CTC in a screening population, the success rate of the technique is related to bowel preparation.

Therefore, the purpose of our study was to evaluate whether fecal tagging improves the results of total colon examination in CTC, performed after incomplete conventional colonoscopy.

Materials and methods

Patient demographic data

The mean patient age in the FT group was 58 years (range 33–82 years). The mean patient age in the ScCl group was 56 years (range 30–79 years). This difference was not statistically significant (p=0.56, Student's t test). There were 10 female patients and 15 male patients in the FT group, compared with 13 female patients and 11 male patients in the ScCl group.

Patient groups

Between February 2002 and April 2003, 49 patients with incomplete colonoscopy examinations were referred by the colonoscopist for CT colonography (CTC). Indications for colonoscopy were CRC screening (those aged over 50 years or with a personal or family history of colorectal cancer, n=15) or evaluation of symptoms, including stools with positive hemocult test results (n=13), abdominal pain (n=10), or change in stool habit (n=11).

Twenty-four patients had same-day CTC, within 3–5 h after conventional colonoscopy. This group is referred to as the standard colon cleansing group (ScCl) group hereafter. This group of 24 patients was a historical cohort, consisting of the first 24 patients investigated after incomplete colonoscopy, at the time, FT was not yet available.

Once FT was available, the next 25 patients were consecutively assigned to preparation with a dedicated preparation kit consisting of magnesium citrate (16.4 g of orally administered magnesium citrate solution, Loso Prep; E-Z-E-M, Westbury, NY, USA), four orally administered bisacodyl tablets, and fecal tagging with barium (Nutra-Prep; E-Z-E-M), within 2–3 weeks after incomplete colonoscopy. This group is referred to as the fecal-tagging (FT) group hereafter.

Reasons for incomplete colonoscopy were dolichocolon or redundancy (ScCl, n=3; FT, n=6), diverticular disease (ScCl, n=12; FT, n=12), or obstructive tumoral disease (ScCl, n=9; FT, n=7). Patients with obstructive tumoral disease (nine patients in the ScCl group, and seven in the FT group) or with polyps >1 cm, in segments that were unreachable with conventional colonoscopy (CC) were referred for surgery (one patient in the FT group). Patients with polyps <1 cm in segments that are unreachable for CC were taken in to follow-up by CTC (five patients in the ScCl group; four patients in the FT group).

The study was approved by the local ethics committee, and written informed consent was obtained.

Colon cleansing

ScCl Group

A first group of 24 patients underwent a standard PEG-based colonoscopic cleansing.

The day before the procedure, patients had a normal breakfast, a normal lunch, and a small dinner. After dinner, only clear liquids were allowed. Patients were asked to avoid coffee, tea, or cola drinks. The morning of the procedure, PEG was administered as follows: 59 g/l per 20 kg body weight. When the stool was watery and completely clear, the patient proceeded to the examination. There was a delay of at least 2 h between the administration of PEG and CTC. This was done to reduce the amount of residual fluid.

FT Group

A second group of 25 patients underwent FT as cleansing prior to CTC. This was done within 3–5 weeks after incomplete colonoscopy.

Two days before the CTC, patients were instructed to reduce the amount of their fat intake.

Food and beverages as well as cleansing medication and barium suspension for the day before the procedure were delivered in one kit. The colon cleansing the day before the procedure consisted of a nutritional and physical bowel cleansing. Nutritional bowel cleansing incorporated a structured low-residue diet to control fat intake and decrease fecal residues: powdered drinks (vanilla, fruit), soup, applesauce, potato poppers, and nutrition bars. Physical bowel cleansing included magnesium citrate oral solution, bisacodyl tablets (four tablets) ,and a bisacodyl suppository the morning of the procedure. Fecal tagging was achieved with three doses of 250 cm^3 barium (2.5% w/v), given with each meal. Magnesium citrate and bisacodyl tablets were to be taken at 1800 hours the day before the procedure. The suppository was to be placed the morning of the procedure [23]. The morning of the procedure, no breakfast was allowed. At 0830 hours, CTC was performed.

CT acquisition

Prior to CTC, smooth-muscle relaxation was obtained with 10 ml scopolamine-butyl bromide (Buscopan; Boehringer Ingelheim) diluted in 100 ml of 0.9% sodium chloride and administered intravenously at a rate of 10 ml/min.

A barium enema tip was inserted in the rectum and the colon was inflated with room air up to patient tolerance (between 30 and 50 bulb compressions) by the roentgen technician. Helical CT data were acquired in the supine and the prone positions [24, 25] by using a HiSpeed CT/i scanner (GE Medical Systems, Milwaukee, WI, USA) with a 600-ms gantry rotation period. During a single breath-hold, CT images of the colon were obtained by using a 2.5-mm collimation, 120 kVp, 70 mA, and a pitch of 1.35. The data were reconstructed at 1.3-mm intervals. The images obtained were transferred to a workstation equipped with Innerview GI (E-Z-E-M), powered by Vital Images' Vitrea 2 software (Vital Images, Plymouth, MN, USA). For the FT group, no i.v. contrast medium was administered. For the ScCl group, supine images were acquired following intravenous administration of 120 ml of ioversol (Optiray 320; Mallinkrodt, St Louis, MO, USA).

Evaluation of CTC

For both groups, CTC was evaluated by two readers (S.G. and P.L.) in consensus. Both readers have experience of over 300 CTCs.

The colon was divided into eight segments: cecum, ascending colon, hepatic flexure, transverse colon, splenic flexure, descending colon, sigmoid colon, and rectum. The different segments were evaluated on axial images in prone and supine position [25].

The presence of residual fluid and residual stool was graded by a numeric scale of 0–3 as follows [25]: 0 = 0% of the lumen filled with residual fluid or stool; 1 = <25% of the lumen filled with residual fluid or stool; 2 = 25–50% of the lumen filled with residual fluid or stool; 3 = >50% of the lumen filled with residual fluid or stool. Stool size was graded as follows: 0 = no stool; 1 = <5 mm; 2 = 6–9 mm; 3 = >10 mm. Segmental distention was graded as follows: 0 = >75% of estimated maximal distention; 1 = 51–75% of estimated maximal distention; 2 = 25–50% of estimated maximal distention; 3 = <25% of maximal distention. The tagged appearance of residual stool and fluid was graded on a visual basis: 0 (nontagged) or 1 (tagged). Stool and fluid in a given segment were considered as a whole and graded 1 only if 100% was tagged.

The worst bit of a segment was used to define the segmental score.

The distention scores, fluid scores, and residual stool scores were separated into three categories: supine, prone, and combined supine/prone position. The evaluation was done on a segmental basis for the supine, prone, and combined positions.

Additionally, an overall distention, fluid, and stool (quantity and size) score was defined as the sum of the segmental scores.

The Mann–Whitney *U* test for nonparametric distributions was used to test for statistically significant differences in residual stool, residual fluid, and distention, between the FT and ScCl groups (i.e., unpaired data).

Linear regression was used to test for correlations. For all statistical analysis, a p value less than or equal to 0.05 was considered as statistically significant.

Polyp detection

All lesions that were detected on CTC were measured and localized according to their segmental location in the colon. Polyps were measured on zoomed axial slices, taking into account the largest diameter. The result of the CT colonography was reported to the referring clinician who decided whether or not to refer the patient for surgery. CT colonographic data were reviewed for true-positive, true-negative, false-positive, and false-negative results. From conventional colonoscopic images, the following data were collected for each lesion: location (by using the same segmental classification scheme as used for CT colonography) and size (measured by means of comparison with an open-biopsy forceps). If the patient was referred for surgery, the same data were collected from the pathology specimen, immediately after surgery, prior to formol-fixation. Findings on conventional colonoscopy or pathology specimens were considered the reference standard. Since only selected patients were referred for further evaluation (e.g., surgery, repeated conventional colonoscopy), the generated bias prevents us from calculating sensitivity and specificity ratios for the whole group. For the controlled cohort, sensitivity and diagnostic performance were calculated on a per lesion basis.

Results

Degree of distention

The distention scores were separated into three categories: supine, prone, and combined supine/prone position. The results are listed in Table 1. The degree of distention was significantly better for the FT group compared with the ScCl group for the supine and prone positions separately and in combination.

Residual fluid

The fluid scores were also separated into three categories: supine, prone, and combined supine/prone position. The results are listed in Table 2. The amount of residual fluid was significantly less for the FT group compared with the

Table 1 Distention scores (FT, *N*=200; ScCl, *N*=192). *N* Number of segments, *%* percentage of segments, *FT* fecal tagging, *ScCl* standard colon cleansing, *Score 0* >75% of estimated maximal distention, *Score 1* lumen 51–75% distended, *Score 2* lumen 25–50% distended, *Score 3* <25% of maximal distention

Number and percentage of segments with distention scores 0, 1, 2, 3

	FT								ScCl							
	0		1		2		3		0		1		2		3	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Supine	173	86.5	8	4	12	6	7	3.5	129	67.2	17	8.9	20	10.4	26	13.5
Prone	173	86.5	17	8.5	7	3.5	3	1.5	129	67.2	20	10.4	20	10.4	23	12
Combined	187	93.5	8	4	4	2	1	0.5	157	81.8	14	7.3	16	8.3	5	2.6

Overall distention scores

	FT		ScCl	
	Mean	Range	Mean	Range
Supine[a]	2.36	0–14	6.04	1–14
Prone[b]	1.6	0–14	5.54	0–14
Combined[c]	0.54	0–10	0.76	0–10

[a] $p<0.005$, FT better than ScCl, Mann–Whitney
[b] $p<0.005$, FT better than ScCl, Mann–Whitney
[c] $p=0.001$, FT better than ScCl, Mann–Whitney

Table 2 Fluid scores (FT, *N*=200; ScCl, *N*=192). *N* Number of segments, *%* percentage of segments, *FT* fecal tagging, *ScCl* standard colon cleansing, *Score 0* 0% of the lumen filled with fluid, *Score 1* <25% of the lumen filled with fluid, *Score 2* lumen 25–50% distended, *Score 3* >50% of the lumen filled with residual fluid

Number and percentage of segments with fluid scores 0, 1, 2, 3

	FT								ScCl							
	0		1		2		3		0		1		2		3	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Supine	125	62.5	46	23	11	5.5	18	9	117	60.9	28	14.6	17	8.9	30	15.6
Prone	130	65	46	23	15	7.5	9	4.5	127	66.1	26	13.5	19	9.9	20	10.4
Combined	191	95.5	7	3.5	1	0.5	1	0.5	177	92.2	13	6.8	1	0.5	1	0.5

Overall fluid scores

	FT		ScCl	
	Mean	Range	Mean	Range
Supine[a]	4.9	0–14	8.3	0–17
Prone[b]	4.1	0–14	8.2	2–21
Combined[c]	0.48	0–3	0.75	0–3

[a] $p=0.01$, FT better than ScCl, Mann–Whitney
[b] $p=0.001$, FT better than ScCl, Mann–Whitney
[c] $p=0.043$, FT better than ScCl, Mann–Whitney

Table 3 Residual stool (FT, *N*=200; ScCl, *N*=192). *N* Number of segments, *%* percentage number of segments, *FT* fecal tagging, *ScCl* standard colon cleansing, *Score 0* 0% of the lumen filled with residual stool, *Score 1* <25% of the lumen filled with residual stool, *Score 2* lumen 25–50% filled with residual stool, *Score 3* lumen >50% filled with residual stool

Number and percentage of segments with residual stool scores 0, 1, 2, 3

	FT								ScCl							
	0		1		2		3		0		1		2		3	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Supine	160	80	38	19	2	1	0	0	182	94.8	6	3.1	4	2.1	0	0
Prone	158	79	40	20	2	1	0	0	183	95.3	5	2.6	4	2.1	0	0
Combined	194	97	6	3	0	0	0	0	189	98.4	3	1.6	0	0	0	0

Overall residual stool scores

	FT		ScCl	
	Mean	Range	Mean	Range
Supine[a]	1.72	0–9	0.54	0–6
Prone[b]	1.76	0–8	0.63	0–5
Combined[c]	0.4	0–3	0.2	0–2

[a] $p=0.004$, ScCl better than FT, Mann–Whitney
[b] $p=0.03$, ScCl better than FT, Mann–Whitney
[c] $p=0.0456$, ScCl better than FT, Mann–Whitney

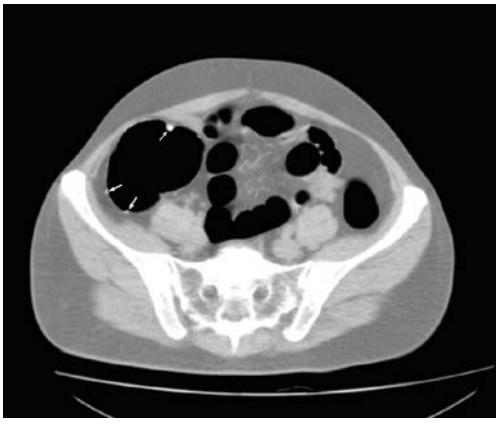

Fig. 1 Appearance of tagged fecal residues. Supine axial 2D image shows two small and one larger nodular lesion. The lesions are tagged, indicative of fecal residues.

ScCl group for the supine and prone positions separately and in combination.

Residual stool

As for fluid and distention scores, the residual stool scores were also separated into three categories: supine, prone, and combined supine/prone position. The results are listed in Table 3. The amount of residual stool was significantly less for the ScCl group compared with the FT group for the supine and prone positions separately. When supine and prone position were considered in combination, the difference remained just significant. No significant differences were found in stool size between ScCl and FT (mean stool size for FT group = 0.4 [range 0–3] vs mean stool size for ScCl group = 0.32 [range 0–3]).

Tagging

Overall, most fecal residues were nicely tagged, allowing good differentiation between fecal residues and polyps (Figs. 1 and 2).

In the fecal tagging group, in all patients, all residues larger than 10 mm were labeled. Seven segments in three patients had nontagged 6–9 mm fecal residue. Tiny fecal residues smaller than 5 mm were found in 70% of segments.

Sixteen segments in four patients had nontagged fluid levels. Three of these fluid levels covered between 25 and 50% of the lumen. All other nontagged fluid levels covered less than 25% of the lumen.

Correlations

When all segments were included for analysis, linear regression showed a strong positive correlation between fluid and distention for both FT and ScCl for the combined prone–supine position (Figs. 3 and 4).

Lesion detection

Results of lesion detection are summarized in Tables 4 and 5.

Standard colon cleansing

Twenty-five patients were referred to CTC within 3–5 h after incomplete colonoscopy.

CTC identified a cause for incomplete colonoscopy in 24 patients: these included redundant, tortuous loops (*n*=3),

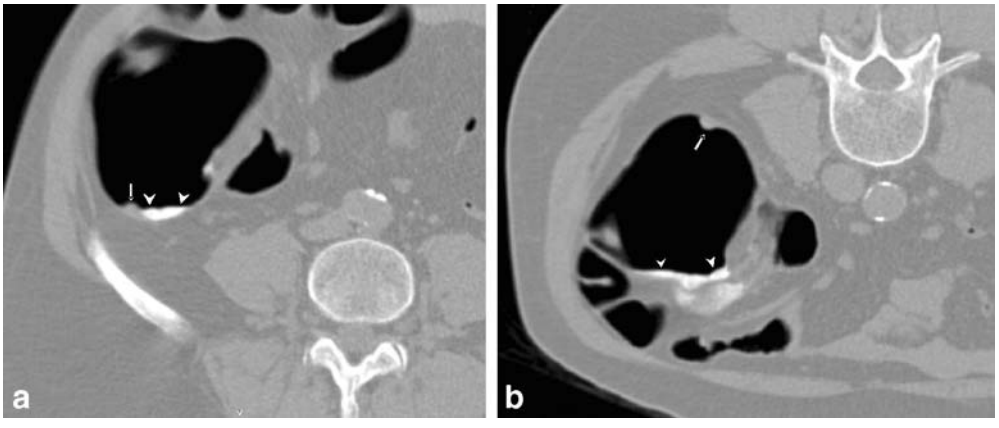

Fig. 2 Advantage of fecal tagging—ease of differentiating fecal residues from polyps. Patient with incomplete colonoscopy due to redundancy. **a** Supine zoomed axial 2D image shows one nodular nontagged lesion (*arrow*), adjacent to tagged lesion (*arrowheads*). Tagging indicates fecal residue. The nontagged appearance of the nodular lesion is indicative for a 6-mm polypoid lesion. **b** Prone zoomed axial 2D image shows the nontagged nodular lesion (*arrow*) on the same anatomic location compared to supine position (**a**), again indicative for a 6-mm sessile polyp. The densely tagged lesion has moved to the opposite site (*arrowheads*), indicative for fecal residue.

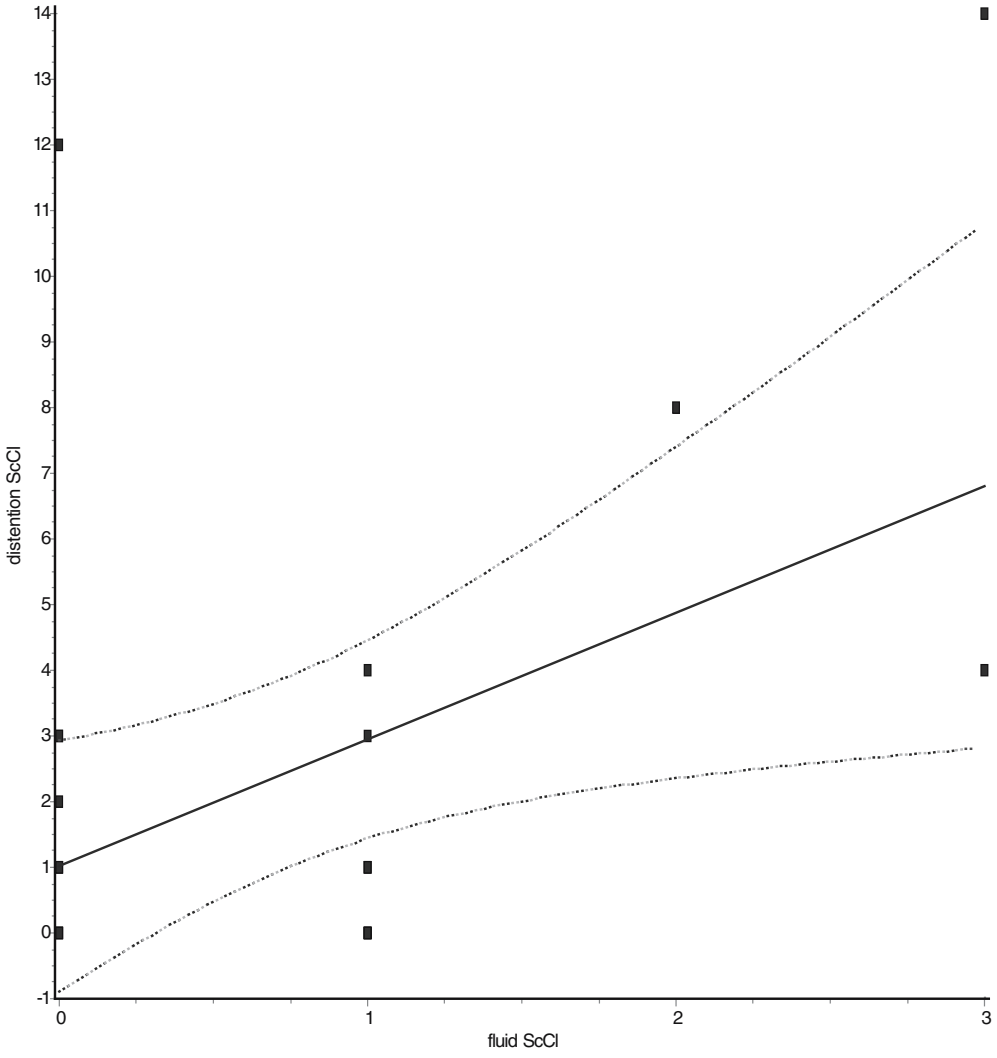

Fig. 3 Correlation between fluid and standard colon cleansing for the standard colon cleansing group. *ScC1* Standard colon cleansing, *continuous line* linear regression, *broken line* 95% confidence interval, *distention* overall distention scores for combined prone–supine position, *fluid* overall fluid scores for combined prone–supine position. There is a significant and positive correlation between fluid and distention scores (correlation coefficient, r=0.5), resulting in a slope that is significantly different from zero (p=0.0241).

severe diverticular disease (n=12), and obstructing tumoral masses in 9 patients (sigmoid, n=8; and ascending colon, n=1).

Nine tumoral masses were identified on CTC.

Additionally, nine polypoid lesions were suspected in seven patients on CTC. In five patients, three lesions measured 5 mm or less, four lesions measured 6–9 mm. In one single patient, one lesion was found proximal to a tumoral mass in the sigmoid, measuring 13 mm. In another patient, in which redundancy caused incomplete colonoscopy of the ascending colon, a lesion measuring 10 mm was suspected in the transverse colon (Fig. 5). The lesions were distributed in the transverse colon (n=3), descending colon (n=2), and sigmoid colon (n=4).

All nine tumoral lesions were confirmed on surgery.

The largest polypoid lesion (13 mm), being detected proximal to a sigmoid tumor in one single patient, was confirmed on the resection specimen. In this patient, a second polypoid lesion, measuring 17 mm, was additionally found on the resection specimen. Retrospective evaluation of the CTC showed the lesion was not detected due to the fluid-filled segment proximal to the tumoral lesion.

In one patient with incomplete colonoscopy due to redundancy, CTC identified a 10-mm lesion in the transverse colon. Since on repeated colonoscopy the colon was reached beyond the hepatic flexure, and no lesion was identified in the transverse colon, the lesion was interpreted as a false positive due to adherent residue (Fig. 5).

The other five patients, with suspected polypoid lesions measuring less than 1 cm in endoscopically nonvisualized segments, were not further investigated, and have been taken into follow-up.

Fecal tagging

Twenty-four patients, assigned to the fecal tagging group, were referred to CTC within 2–3 weeks after incomplete colonoscopy.

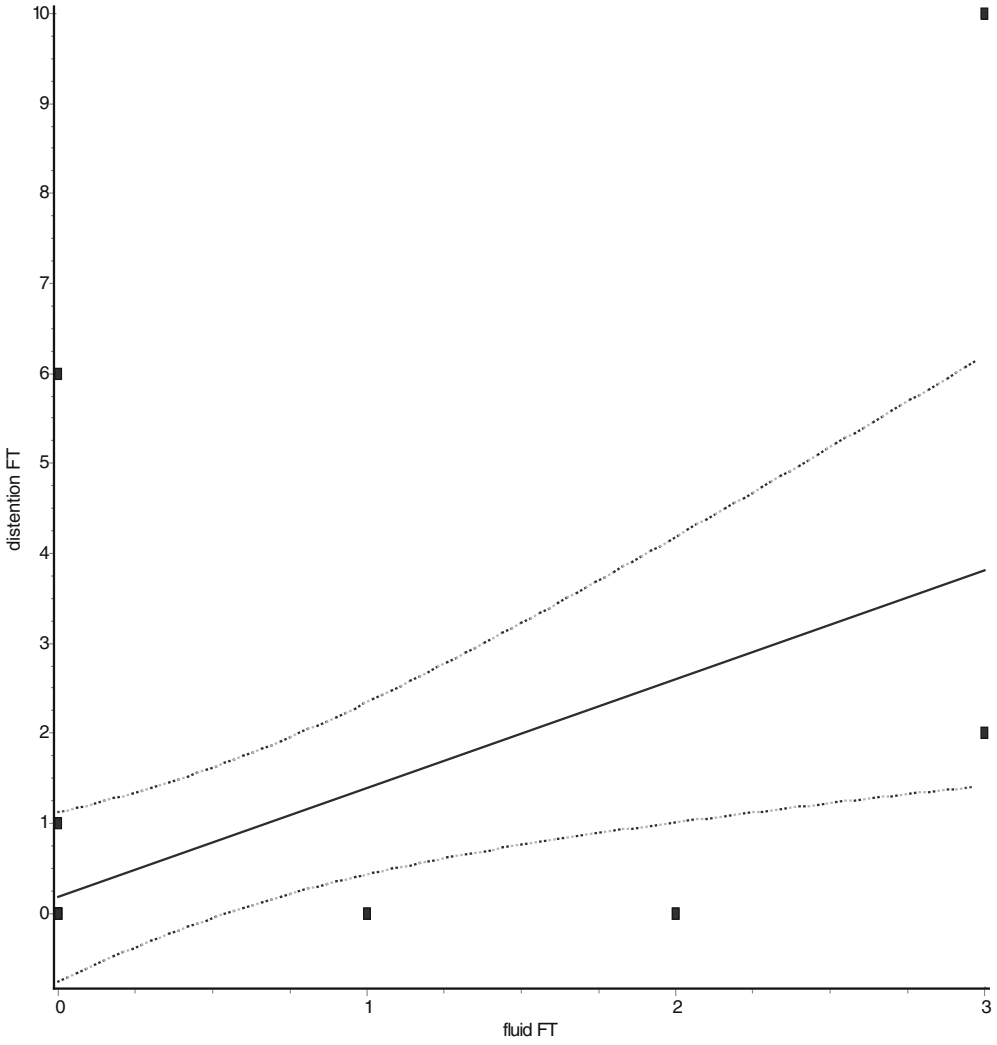

Fig. 4 Correlation between fluid and fecal tagging for the FT group. *FT* Fecal tagging, *continuous line* linear regression, *broken line* 95% confidence interval, *distention* overall distention scores for combined prone–supine position, *fluid* overall fluid scores for combined prone–supine position. There is a significant and positive correlation between fluid and distention scores (correlation coefficient, r=0.5), resulting in a slope that is significantly different from zero (p=0.00097).

CTC identified a cause for incomplete colonoscopy in 22 patients: these included redundant, tortuous loops (n=3), severe diverticular disease (n=12), and obstructing tumoral masses in seven patients (sigmoid, n=5; ascending colon, n=1; and transverse colon, n=1).

Seven tumoral masses were identified on CTC.

Additionally, 15 polypoid lesions were identified in nine patients on CTC in the endoscopically nonvisualized segments of the colon. Of these lesions, five lesions measured 5 mm or less, four lesions measured 6–9 mm, and six lesions in five patients were larger than 1 cm. The lesions were distributed in the transverse colon (n=3), ascending colon (n=7), cecum (n=3), and sigmoid colon (n=2).

All seven tumoral lesions were confirmed on surgery. All patients with lesions larger than 1 cm were operated on (n=5). Surgery confirmed one stalked 17-mm polyp in the sigmoid in one patient; one large 25-mm lesion in the transverse colon, one 25-mm polypoid lesion in the cecum in a patient with an obstructive tumor in the ascending colon, and one large 18-mm flat adenoma in the cecum in a single patient, with incomplete colonoscopy due to redundancy. Finally, in one patient with incomplete colonoscopy due to redundancy, CTC showed seven lesions (two lesions >10 mm, one 6-mm lesion, one 8-mm lesion, and three lesions <5 mm). In this patient, a right hemicolectomy was performed, which additionally revealed an 3-mm lesion, not seen on CTC (Fig. 6).

The other four patients, with suspected polypoid lesions in endoscopically nonvisualized segments, measuring less

Table 4 Results of FT and ScCl in patients with a gold standard. Data are number of patients

Number of patients with a gold standard	
FT	12[a]
ScCl	10[b]

[a]All 12 patients were explored at surgery
[b]Nine patients were explored at surgery; one patient had repeated colonoscopy

Table 5 FT vs ScCl group: sensitivity and diagnostic performance on a per-lesion basis. Data are number of lesions

Variable	True-positive result	False-positive result	False-negative result	Sensitivity (%)
A. Sensitivity of CT colonography for polyp detection in endoscopically visualized segments				
ScCl group	9	0	0	100
FT group	7	0	0	100
B. Sensitivity of CT colonography for polyp detection in endoscopically nonvisualized segments				
ScCl group				
Overall	1	1	1	50
≥10 mm	1	1[a]	1	50
6–9 mm				
≤5 mm				
FT group				
Overall	11	0	1	92
≥10 mm	6	0	0	100
6–9 mm	2	0	0	100
≤5 mm	3	0	1	75

[a]Ten-millimeter lesion in the transverse colon, found to be a false positive on repeated colonoscopy (Fig. 5)

than 1 cm, were not further investigated, and have been taken into follow-up.

Discussion

For several reasons, evaluation of the entire colon is important and necessary. First of all, there is growing evidence that many lesions are located in the right hemicolon [10]. This is particularly important for patients with polypoid lesions in the distal colon, since polyps in the distal colon are predictive for polyps in the proximal colon [26–29]. Second, the prevalence of synchronous lesions in patients with colorectal tumor varies from 1.5% to 9% for carcinomas and 27–55% for adenomas. Moreover, early detection of those synchronous lesions improves prognosis [30–33].

More recently, CTC is gaining interest as a total colon examination technique after incomplete colonoscopy [12, 14, 20–22, 34].

As the technique of CTC is under continuous development, many parameters have been found to improve results. These include the use of reduced colon cleansing to reduce the amount of fluid [35, 36], the added use of oral iodinated contrast material to tag residual fluid [37], the use of barium [22] or iodinated contrast material to tag residual stool [38], the use of multidetector CT to optimize resolution and decrease scan time [39], the combined use of prone and supine, or supine and left decubitus scanning [40, 41], and the use of smooth muscle relaxant [42, 43] to optimize distention. All these technical parameters have been used and optimized in patients where conventional colonoscopy was complete.

The use of i.v. administration of contrast material has been found to be useful in routine CTC, as well as in CTC following incomplete colonoscopy. The latter being mainly related to the improved staging in case of tumoral pathology [44–48]. Finally, experience and training have been found to significantly influence reader performance [49].

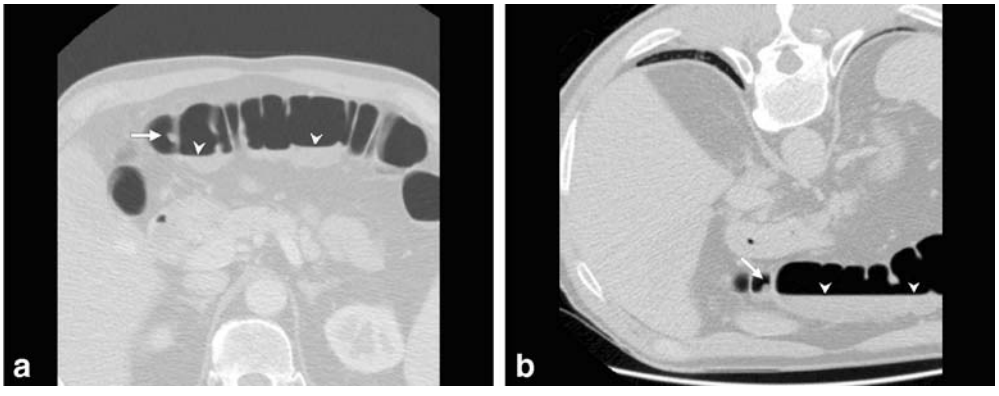

Fig. 5 Standard colonoscopic cleansing: false-positive diagnosis of polyp due to adherent fecal residue. Supine (**a**) and prone image (**b**) in a patient with incomplete visualization of the cecum due to redundancy suggested the presence of a 10-mm polypoid lesion in the transverse colon. Since the transverse colon was reached on repeated conventional colonoscopy, and no lesion was detected, this lesion was interpreted as a false positive due to adherent fecal residue. *Arrowheads* in **a** and **b**: nontagged fluid levels, adherent to standard colonoscopic preparation.

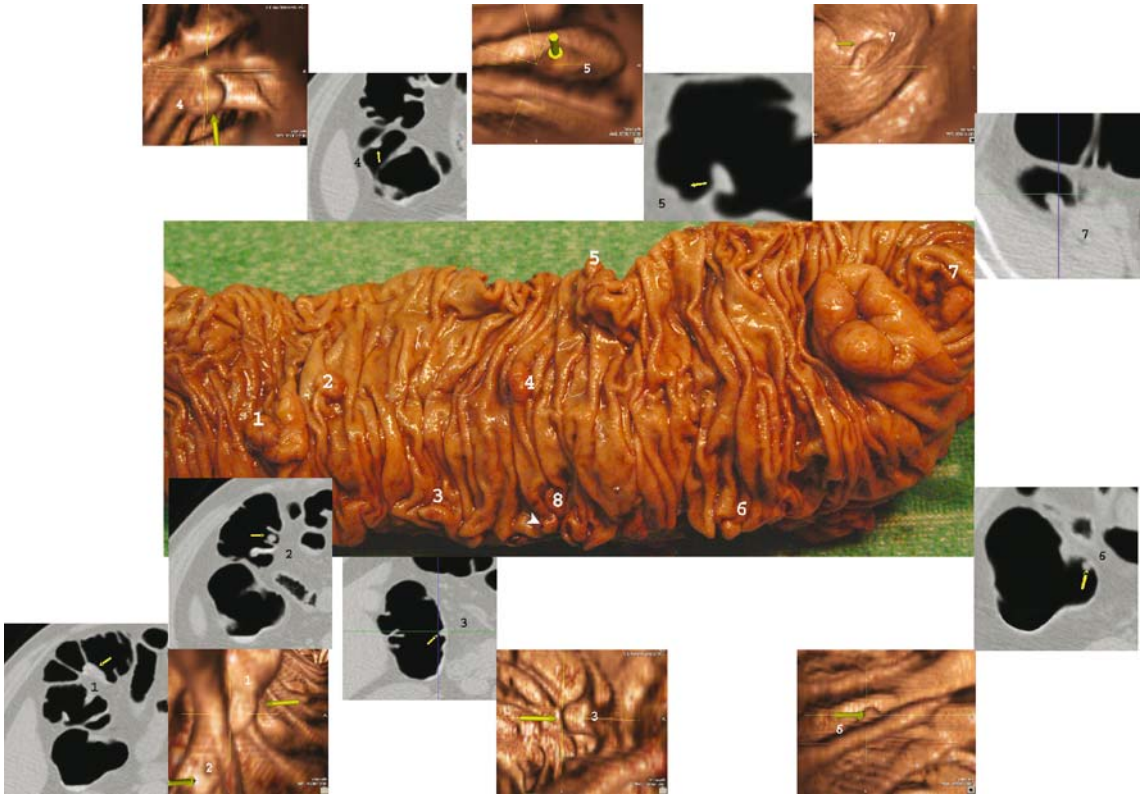

Fig. 6 True-positive and false-negative findings in FT. CTC after fecal tagging identified seven polypoid lesions in the right hemicolon, ranging from 3 mm (no. 5) to 22 mm (no. 1). The patient was operated on. On the resection specimen, all seven lesions were identified (numbered 1–7 on the resection specimen, with corresponding axial 2D and 3D images). An additional eighth lesion, not detected on CTC, was also found (lesion no. 8, *arrowhead* on the resection specimen).

In this study, a multidetector CT, smooth muscle relaxant (Buscopan), combined prone and supine scanning, and i.v. contrast material (for the ScCl group) were used, based on the findings of all these studies. All CTC studies were evaluated by two experienced readers (S.G. and P.L.).

In all other studies, reporting upon the results of CTC after incomplete colonoscopy, CTC was performed after a standard colon cleansing. The purpose of this study was therefore to evaluate the possible use of dietary fecal tagging [22] in case of CTC after incomplete colonoscopy, and to compare the results with standard colon cleansing.

For the combined supine–prone position, we found FT to improve colon distention, and to reduce residual fluid, which is in conjunction with other reports [22, 35, 36]. In the controlled cohort, residual fluid impeded detection of one 17-mm polyp in the ScCl group. In the FT group, no false-negative findings were related to residual fluid. Although the number of patients and lesions in this study are too small to be conclusive, these results at least suggest that reduced residual fluid in the FT group improves sensitivity compared with the ScCl group (Tables 4 and 5).

For the colon distention, it is known from the literature that tumoral lesions and irritable bowel syndrome clearly influence distention, and might cause incomplete colonoscopy. Other factors that are known to influence colon distention are diverticular disease [50], the ileocecal valve, and the patient's age, gender, and sex. In the present study, we additionally found a positive correlation between fluid and colon distention for both ScCl and FT groups. These findings suggest that residual fluid reduces distention. Since ScCl suffers from more residual fluid compared with FT, this might explain a better distention in the FT group. One has however to take into account that the ScCl group had just undergone a difficult failed endoscopy. They therefore may be less tolerant of further colonic distention than those brought back another day. The improved distention in the FT group might thus also be related to increased patient tolerance in "fresh patients." Furthermore, the exact relationship between fluid and distention needs more exploration, since other questions remain unsolved. Does PEG cause more spasm than magnesium citrate? Do fluid pools physically stop distention? Are patients less tolerant of distention if the colon is full of fluid? Our preliminary findings therefore just "suggest" that in the setting of CTC after incomplete colonoscopy, FT is preferred over ScCl, not only to reduce false-negative results due to fluid hiding pathology, but also to optimize distention by reducing residual fluid.

Compared with ScCl, FT suffers from more fecal residues, but the tagged nature of the residues allows correct and easy differentiation from polyps, improving specificity [22]. This is in conjunction with the results in the controlled cohort: one false positive in the ScCl group, related to residual stool, and no false-positive findings in the FT group (Tables 4 and 5; Figs. 2 and 5).

Overall, our results indicate that reduced residual fluid, improved distention, and improved sensitivity and specificity are benefits enjoyed when using FT for colon cleansing prior to CTC. The readers were, however, by definition unblinded to the bowel preparation when scoring the segments (due to presence of tagged stool).This might influence the scoring system as used and is as such a bias in this study, which is however unavoidable.

FT, however, suffers from some major disadvantages in the setting of CTC after incomplete colonoscopy. First of all, the patient is confronted with a repeated colon cleansing, which might deteriorate patient acceptance. It has been shown that added use of intravenous contrast material results in contrast enhancement of polypoid or tumoral colon disease, offering a possible solution for polyps hidden in nontagged residual fluid [45]. Moreover, the use of intravenous contrast material improves detection of extracolonic findings, and improves staging in cases of tumoral disease [44]. In the reported series, we did not combine the use of FT and i.v. contrast material to improve staging in cases of tumoral pathology, since recent reports suggest a clear contrast enhancement of some polyps [45] following administration of intravenous contrast material. This theoretically could cause confusion with tagged residue in cases where FT is used. We therefore did not compare FT and ScCl, both with or both without administration of i.v. contrast, but used i.v. contrast in the ScCl group, and did not use i.v. contrast in the FT group.

Finally, there is the concern of avoiding eventual barolits or barium impaction in case of obstructive tumoral disease.

Conclusion

Since we found the benefits of immediate CTC after incomplete colonoscopy with the use of i.v. contrast to outweigh the advantages of FT in cases of known tumoral disease, we now do not use FT in these circumstances.

In cases of incomplete colonoscopy related to causes other than tumoral pathology, we found the benefit of reduced residual fluid (thus reducing false-negative results), possible improved distention, and tagging instead of i.v. contrast material to differentiate stool from polyps (thus reducing false-positive results due to adherent fecal residue, and excluding possible adverse events related to the administration of i.v. contrast material) to outweigh the disadvantages of FT. We therefore have now adapted FT without i.v. contrast material in those patients.

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