Digestive Diseases and Sciences (2020) 65:1429–1435
https://doi.org/10.1007/s10620-019-05882-2

ORIGINAL ARTICLE

When Experts Fail: Use of a Short Turning Radius Colonoscope Facilitates Successful Completion of Colonoscopy in Patients with Bowel Fixity

Mohit Girotra[1] · Saurabh Sethi[1] · Monique T. Barakat[1] · Robert J. Huang[1] · Shai Friedland[1] · Uri Ladabaum[1] · Subhas Banerjee[1]

Received: 13 June 2019 / Accepted: 9 October 2019 / Published online: 19 October 2019

Abstract

Background Rates of incomplete colonoscopy in non-expert settings range up to 13%. Expert colonoscopists can complete ~ 95% colonoscopies when other endoscopists fail; however, a small number remain incomplete even in expert hands, typically due to bowel fixity.

Aims Pentax Retroview™ (EC-3490TLi) is a new slim colonoscope with a short turning radius (STR) and greater tip deflection (210°), which allows easy maneuverability across sharply angulated/fixed colonic bends. We evaluated the utility of this colonoscope for completing colonoscopies that fail even in the hands of expert colonoscopists.

Methods Retrospective chart review was performed, and main outcomes measured included cecal intubation rate, lesions detected, dosage of sedation used, and complications.

Results Using the STR colonoscope, complete colonoscopy to the cecum was possible in 34/37 patients (91.9%). No loss of lumen/blind advancement was necessary in any of the procedures. No adverse events occurred. Among the completed colonoscopies, 6/34 (17.6%) patients had adenomas, all proximal to the site of prior failure, including one advanced adenoma. All failures ($n = 3$, 8.1%) had a history of cancer surgeries, with peritoneal carcinomatosis/extensively fixed/frozen bowel (two patients) and an additional diverticular stricture with colo-vesical fistula (one patient).

Conclusion STR colonoscope facilitates completion of a high proportion (91.9%) of colonoscopies that previously failed in expert hands. Its STR allows easy maneuverability across segments of sharp angulation with bowel fixity without need for blind advancement. The use of this colonoscope led to the detection of adenomas in 17.6% of patients, all proximal to the site of prior failed colonoscopy.

Keywords Short turning radius colonoscope · Incomplete colonoscopy · New colonoscope · Colonoscope retroflexion · Colon cancer · Failed colonoscopy

Background

Colorectal cancer is the second leading cause of cancer in the USA [1]. Colonoscopy is widely considered a valuable screening modality for detection and resection of precancerous colorectal polyps to prevent colorectal cancer [2].

Complete colonoscopy to the cecum is critical for exclusion of right-sided colonic lesions, and hence, cecal intubation remains an important quality metric [3]. Various factors are associated with challenging and/or incomplete colonoscopy, including patient-related (older age, female gender), anatomy-related (length of colon, tortuosity, diverticulosis, history of abdominal or pelvic surgeries or IBD), and procedure-related (outpatient setting, scope looping, poor bowel preparation, patient discomfort) factors [4, 5]. The rates of failure to complete colonoscopy are highly variable, with up to 13% reported from North America and 19% from Sweden [3, 6]. Lower rates of incomplete colonoscopy (3–5%) have been reported from US tertiary care centers, and even lower rates of incomplete colonoscopy have been reported in

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s10620-019-05882-2) contains supplementary material, which is available to authorized users.

✉ Subhas Banerjee
SBanerje@Stanford.edu

[1] Division of Gastroenterology and Hepatology, Stanford University School of Medicine, 300 Pasteur Drive, MC: 5244, Stanford, CA 94305, USA

the hands of colonoscopy experts at these academic referral centers [7].

Incomplete colonoscopy may have serious implications, with a recent study from a regional referral center for complex colonoscopies in the USA, indicating that approximately 57% of adenomas, 58% of sessile serrated polyps, 27% of hyperplastic polyps, and all nine cancers detected by the completion colonoscopy were proximal to the extent of the previous incomplete examination [8]. Another study from the UK reported a fivefold higher risk of colorectal cancer in patients who had undergone a previously failed colonoscopy, compared with those who underwent a complete colonoscopy (14.3% vs. 2.9%, respectively) [9].

The approach for colonic evaluation following an incomplete colonoscopy remains controversial [10], but the majority of endoscopists favor either computed tomography colonography (CTC) or a repeat attempt at colonoscopy. Failed procedures due to procedural/anatomical complexity may be referred to expert endoscopists within the same institution or in a tertiary care referral center [7, 8]. The European Society for Gastrointestinal Endoscopy currently endorses CTC as the next tool of investigation after incomplete colonoscopies [11]. One European study indicated that CTC was the primary method used for complete colonic evaluation following an incomplete colonoscopy and a repeat colonoscopy was performed in only 6.4% of patients [12]. The colon capsule is also being investigated as an alternative strategy following an incomplete colonoscopy [13]. Although CTC and capsule colonoscopy strategies are favored by many, as they are usually uniformly successful and can be performed the same day, these strategies are purely diagnostic [14–16] and a repeat attempt at colonoscopy becomes necessary if polyps are noted in the proximal colon.

When repeat colonoscopy is performed following an incomplete colonoscopy, several rescue methods have been proposed to facilitate cecal intubation [17], including performing the procedure on same or separate day using same or different equipments [7, 18, 19], using small-caliber colonoscopes [7], variable stiffness colonoscopes [20], enteroscopes [21], an overtube alone or equipped with single or double balloon [22, 23], and attaching a hood or cap to the tip of the colonoscope [10]. The success rate with these endoscopic approaches is variable [7, 10, 14, 17–19, 21–24].

Failed procedures due to procedural/anatomical complexity may be referred to expert endoscopists within the same institution or in a tertiary care referral center [7, 8], and very high success rates in such procedures have been reported in expert hands [7]. However, tertiary care center experts occasionally fail as well [7]. In our own institution, the predominant reason for the rare failure of colonoscopy in expert hands is bowel fixity at the level of the sigmoid colon.

A short turning radius (STR) slim colonoscope has become available (Retroview™ Pentax Medical, Montvale, NJ), designed with a shorter bending section at its distal tip, that results in smoother navigation through fixed and sharply angulated sigmoid colon, without loss of luminal views (Figs. 1, 2). We found that this STR colonoscope usually resulted in successful completion of rescue colonoscopy,

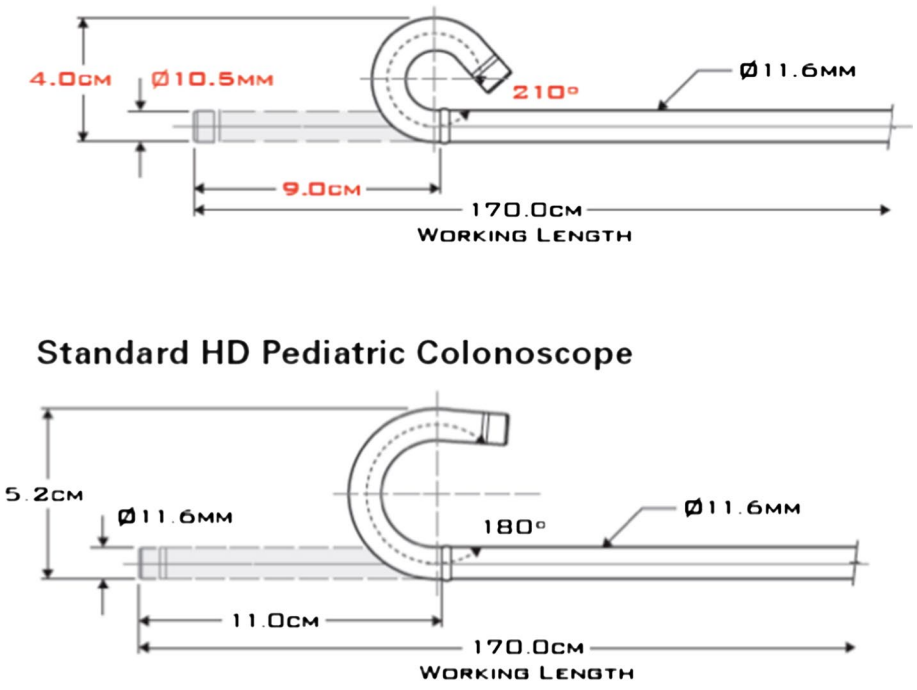

Fig. 1 Comparison of Retroview™ colonoscope (on the top) and standard pediatric colonoscope (greater tip deflection, tapered end and shorter turning radius). (Picture used with permission from Pentax Medical, Montvale, NJ)

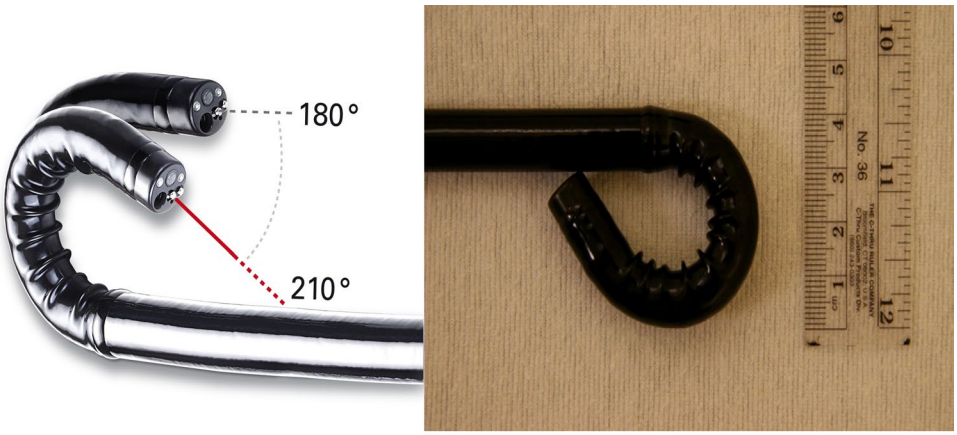

Fig. 2 Tip deflection (210°) of Retroview™ colonoscope. (Picture used with permission from Pentax Medical, Montvale, NJ)

(Picture used with permission from Pentax Medical, Montvale, NJ)

following a failed colonoscopy with a pediatric colonoscope. Based on this impression, we reviewed procedures in which rescue colonoscopy was performed by expert colonoscopists at our institution using the STR colonoscope.

Materials and Methods

This study utilized a prospectively maintained endoscopy database and was approved by the Stanford University Institutional Review Board. All procedures were performed on an outpatient basis. Carbon dioxide and/or water insufflation was utilized during all procedures. All patients underwent standard bowel preparation before the colonoscopy examination. Colonoscopies were performed under moderate sedation with intravenous midazolam and fentanyl. Occasional patients required monitored anesthesia care.

Patients with incomplete colonoscopy related to bowel fixity, referred from outside hospitals, and patients with incomplete colonoscopy within our tertiary care center underwent repeat colonoscopy by one of the three experienced endoscopists (SB, SF, and UL), who have each performed more than 10,000 colonoscopies. Colonoscopy by the expert endoscopists was typically performed using a pediatric colonoscope, although very occasionally an adult colonoscope was used if a pediatric colonoscope was not immediately available. If the adult colonoscope failed to advance, repeat colonoscopy was immediately attempted using a pediatric colonoscope.

Every effort was made to succeed using a standard pediatric colonoscope including patient position changes and application of pressure/splinting prior to discontinuation of efforts with the pediatric colonoscope. Data were not collected on patients in whom complete colonoscopy was successfully accomplished by the expert endoscopists using an adult or a pediatric colonoscope.

Patients in whom colonoscopy with a pediatric colonoscope was again unsuccessful even in the hands of the expert endoscopists were included in this study (Fig. 1). All of these patients then underwent rescue colonoscopy during the same session by the same experienced endoscopist, using the Pentax Retroview™ STR colonoscope (EC-3490TLi) (Fig. 3).

Records for all patients who underwent rescue STR colonoscopy between July 2011 and June 2017 were extracted from our prospectively maintained endoscopy database. The following patient and endoscopic data were recorded: patient demographics, including age, gender, body mass index (BMI), and indication for colonoscopy; details of previous failed procedure including site/reason for failure; previous medical and surgical history; details of the present procedure including

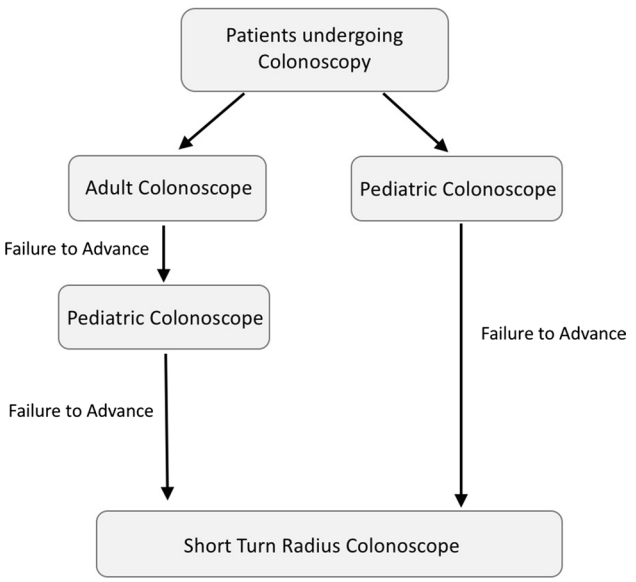

Fig. 3 Study flow diagram

sedation type/dose, types of scopes used, location of failure before rescue colonoscopy; colonoscopy findings; success with STR including pathology detected proximal to the site of previous failure; and adverse events.

An anonymous electronic survey (SurveyMonkey, Palo Alto, CA) was distributed to each of the expert endoscopists in this study to quantify their experience with colonoscopies performed using the STR colonoscope (Supplementary Figure 1).

Statistical Analysis

All analyses were conducted using SPSS® version 17 for Windows (SPSS Inc., Chicago, IL). Descriptive statistics are used in reporting of data.

Results

During the 6-year study period, 37 patients with bowel fixity and failed colonoscopy using a standard pediatric colonoscope in the hands of our expert endoscopists underwent rescue colonoscopy with the short turning radius (STR) Retroview™ (EC-3490TLi) colonoscope. The mean ± SD age of these patients was 65.48 ± 7.63 (range 51–78) years, and 83.78% were women. The mean BMI was 27.06 ± 6.47 kg/m^2 (range 13.7–43.6 kg/m^2). Sixteen patients (43.24%) had a history of diverticulosis, based on prior procedures or imaging, and three patients (8.1%) had experienced a recent episode of diverticulitis. Twenty-three patients (62.2%) had previous abdominal surgeries, and another five (13.5%) had pelvic surgeries. The primary stated reason for the previous failed colonoscopy was bowel fixity with sharp angulation (100%). Additional stated factors included diverticulosis (62.2%), adhesions (24.3%), tortuosity with looping (21.6%), and a frozen pelvis (2.7%). The most common site of previous failure was sigmoid colon in 34 patients (91.9%), with transverse colon (5.4%) and ascending colon (2.7%) as less common sites of previous failure. The indications for colonoscopy included screening in 11 (29.7%), surveillance in 18 (48.6%), and diagnostic in 8 (21.6%) patients. For the diagnostic colonoscopies, symptoms included abdominal pain, constipation, and iron deficiency anemia (Table 1).

Table 1 Patient characteristics, indications for colonoscopy, location of failures, and reasons for previous incomplete colonoscopy ($N = 37$)

Age, mean ± SD, range (years)	65.48 ± 7.63, range 51–78 years
Gender, women %	83.78%
BMI, mean ± SD, range (kg/m^2)	27.06 ± 6.47, range 13.7–43.6 kg/m^2
Indications for colonoscopy, n (%)	
Screening	11 (29.7%)
Surveillance	18 (48.6%)
Diagnostic	8 (21.6%)
Symptoms, n (%)	
Abdominal pain	28 (75.7%)
Iron deficiency anemia	21 (56.7%)
Recent change in bowel habits	10 (27.02%)
Hematochezia	4 (10.8%)
Constipation	21 (56.7%)
Diverticulitis follow-up	3 (8.1%)
Known diverticulosis, *n* (%)	16 (43.24%)
Previous abdominal surgeries, *n* (%)	23 (62.2%)
Previous pelvic surgeries, *n* (%)	5 (13.5%)
Location of previous colonoscopy failure, n (%)	
Ascending colon	1 (2.7%)
Transverse colon	2 (5.4%)
Sigmoid colon	34 (91.9%)
Reasons for previous colonoscopy failure, n (%)	
Bowel fixity	37 (100%)
Diverticulosis	23 (62.2%)
Adhesions	9 (24.3%)
Tortuosity and/or looping	8 (21.6%)
Frozen pelvis	1 (2.7%)

Procedure-Related Outcomes

Thirty-four colonoscopies were performed with moderate sedation (91.9%). The mean ± SD doses of fentanyl and versed were 125.8 ± 55.43 mcg and 4.77 ± 2.05 mg, respectively. Three procedures (8.1%) were performed under monitored anesthesia care due to medical comorbidities as determined by our endoscopy scheduling team. Cecal incubation was achieved successfully in 91.9% of all rescue colonoscopy procedures (34/37) with the STR colonoscope. In each of these patients, the colonoscope could be advanced with luminal views maintained, obviating the need for blind advancement.

Failures despite the use of the STR colonoscope by the expert endoscopists occurred in 3 of the 37 patients (8.1%). Two of these patients had previous oncologic surgery, with subsequent development of peritoneal carcinomatosis and extensively frozen bowel. The third patient had extensive diverticulosis with significant sequelae, including recurrent diverticulitis, a diverticular stricture, a colo-vesical fistula, and marked bowel fixity as a consequence of these complications. Of note, the STR colonoscope was successfully advanced beyond the previous site of failure in all three of these patients, but could not be advanced beyond the left colon due to additional sites of bowel fixity in the more proximal left colon. In each of these three STR colonoscope failures, a subsequent attempt at advancing a gastroscope also failed in the left colon. All colonoscopies included in this study were challenging, given that previous colonoscopy attempts were unsuccessful. With the use of the Retroview™ STR colonoscope, the previously incomplete colonoscopies were graded on difficulty level—only the three colonoscopies which remained incomplete (8.1%) were very difficult, and another 6 (16.2%) were slightly difficult, while 28 (75.7%) were completed without any difficulty.

Successful completion of colonoscopy using the Retroview™ STR colonoscope resulted in the detection of pathology proximal to the level of previously failed colonoscopy in 18 patients (18/34 = 52.9%). These included tubular adenomas in six patients (17.6%), one advanced adenoma (2.9%), benign polyps in nine patients (26.4%), and three patients (8.8%) with other benign diagnostic findings, including one patient each with anastomotic erythema, segmental colitis associated with diverticulosis, and a colonic stricture (Table 2). Successful polypectomy was achieved in all patients with benign (9/34) or premalignant (6/34) polyps (44.1% total). Notably, at the successful complete colonoscopy at our institution, 25 patients (73.5%) were diagnosed with diverticulosis, indicating underdiagnosis of diverticulosis at the time of incomplete colonoscopy.

Table 2 Outcomes with the Retroview™ colonoscope

Cecal intubation rate, *n* (%)	34 (91.9%)
Difficulty during colonoscopy	
Severe	3 (8.1%)
Slight	6 (16.2%)
No	28 (75.7%)
Sedation used	
Monitored anesthesia care	3 (8.1%)
Moderate sedation (fentanyl/versed)	34 (91.9%)
Mean ± SD dose of moderate sedation used (n = 34)	
Fentanyl	125.8 ± 55.43 mcg
Versed	4.77 ± 2.05 mg
Complications, *n* (%)	None
Findings on completed colonoscopy (n = 34)[a]	
Diverticulosis	25 (73.5%)
Benign polyp[b]	9 (26.4%)
Tubular adenoma	6 (17.6%)
Advanced polyp[c]	1 (2.9%)
Normal colon	2 (5.8%)
Other findings[d]	3 (8.8%)

[a]These reported polyps are upstream of the level of previously failed colonoscopy

[b]Benign = two mucosal excrescences, one granulation tissue, six hyperplastic polyps

[c]Advanced polyp = 10 mm tubular adenoma

[d]Other findings = one each with anastomotic erythema, SCAD, diverticular stricture with colo-vesical fistula

Evaluation of the STR Colonoscope

Expert colonoscopists at our institution (SB, SF, and UL) uniformly endorsed the utility of the STR colonoscope, with 66.7% reporting that the STR colonoscope was 'very easy to use' and 33.3% reporting that the STR colonoscope was 'easy to use'. Colonoscopists, however, noted that the STR colonoscope was 'significantly more likely' (33.3%) and 'more likely' (66.6%) to result in excess looping during colonoscope advancement compared to a standard pediatric colonoscope. Challenges in loop reduction with the STR colonoscope were reportedly more common than those encountered using a pediatric colonoscope for 33% of colonoscopists, and 66.6% felt that loop reduction was similar to a pediatric colonoscope. Preservation of lumen views when navigating sharp fixed turns was reported by the majority (66.6%) to be significantly better compared to a standard pediatric colonoscope. Ease of retroflexion in the right/transverse colon and retroflexed withdrawal were reportedly 'significantly easier' (66.6%) and 'easier' (33.3%) compared to a standard pediatric colonoscope. Colonoscopists would definitely (66.6%) or probably (33.3%) consider using the short turning radius colonoscope as a primary tool in

patients known to have previous colonoscopy failure due to bowel fixity. Colonoscopists unanimously (100%) had an overall positive impression of the STR pediatric colonoscope and believed that tertiary referral centers should possess a STR colonoscope to enable rescue colonoscopies in patients with bowel fixity.

Discussion

The US Multi-Society Task Force on Colorectal Cancer recommends that colonoscopists should achieve cecal intubation in 90% of all patients and in 95% of screening colonoscopies [25]. However, several patient-, anatomy-, and procedure-related factors may prevent completion of colonoscopy, including female gender, history of prior abdominal surgery and diverticulosis. Some colonoscopies fail even in expert hands at tertiary care referral centers, typically due to bowel fixity/immobility preventing navigation beyond sharply angulated segments of the sigmoid colon.

Although the optics of colonoscopy have evolved over the decades, with incorporation of high-definition imaging, wide-angled lenses, and electronic chromoendoscopy, there has not been significant change in the mechanical functionality of colonoscopes over this period of time. The Pentax Retroview™ STR colonoscope represents a rare evolution in colonoscope mechanics. The STR colonoscope is a new slim colonoscope (11.6 mm insertion tube diameter, accessory channel diameter of 3.2 mm), with graduated stiffness technology coupled with a short turning radius (STR) and greater tip deflection (210°), allowing easy maneuverability (Figs. 1 and 2). It allows easy retroflexion in the right or transverse colon and retroflexed withdrawal.

Previous reports have suggested that the smaller diameter and flexible insertion tube of a pediatric colonoscope or of a gastroscope may be advantageous in advancing through sharp colonic angulation and strictures [17, 24]. Our data using the STR colonoscope in patients with failed colonoscopy despite using a pediatric colonoscope indicate that a short turning radius may offer additional navigational advantages. The novel STR colonoscope used in this study combines the advantages of a short turning radius comparable to that of a gastroscope with the length and flexibility of a pediatric colonoscope. Our data indicate that, in the setting of failed colonoscopy due to bowel fixity in the left colon, rescue colonoscopy using the Retroview™ STR colonoscope enables easy maneuverability across segments of sharp angulation with bowel fixity, with the safety and reassurance of maintained central lumen views, obviating the need for blind advancement. These features helped facilitate a high cecal intubation rate (> 90%), with the detection of pathology upstream of the level of previously failed colonoscopy in 52.9% of patients. Notably, there were no colonoscopy-associated adverse events in this population of patients with bowel fixity who have a high prevalence of diverticulosis and are at increased risk of bowel perforation during colonoscopy. This may be attributable to enhanced lumen views with the STR colonoscope, as it enables full lumen views during advancement in angulated bowel segments. Of note, our endoscopists reported excessive looping with the STR colonoscope, with greater difficulty in loop reduction due to its shorter bending section. This was addressed by rotation of the patient and application of external abdominal pressure as necessary and was not a limiting factor in completion of colonoscopies in this study. However, these observations may be pertinent when the colonoscopy has failed due to bowel redundancy with excessive looping. A prior study of the impact of colonoscope turning radius using other prototypes similarly noted that while shorter bending sections facilitate retroflexion, this can negatively impact insertion and intubation of the terminal ileum [26]. The STR colonoscope may be most useful where colonoscopy has failed due to bowel angulation and fixity.

Additional interventions have been tried in patients with incomplete colonoscopy, when referred to tertiary referral centers, including utilization of alternative endoscopes (adult and pediatric colonoscopes, adult gastroscopes, or enteroscopes), propofol sedation, and external devices for abdominal splinting or external straighteners [7]. Water immersion is another technique which may reduce need for external straightening devices and allow completion of previously incomplete colonoscopies [27]. An array of these tools and techniques have allowed expert colonoscopists to successfully complete colonoscopies, which previously failed due to a redundant colon, difficult sigmoid colon, or difficult to sedate patients. Several reports have indicated the utility of single- and double-balloon enteroscopes in the completion of previously failed colonoscopies, especially in patients with long redundant colon or excessive looping [21, 22, 28, 29]. However, not all expert colonoscopists are trained in balloon enteroscopy and advancement of a balloon enteroscope through a fixed angulated sigmoid colon may be unsuccessful [29]. Hence, a STR colonoscope, where available, may remain the best option for completion of failed colonoscopy in patients with bowel fixity.

The primary limitations of our study are the relatively small sample size and the retrospective, single-center experimental design. When failed colonoscopies are referred to tertiary care centers, success rates are very high and, consequently, failure rates using standard adult or pediatric colonoscopes are very low. The present study is necessarily small, as it only included patients in whom colonoscopy had failed in expert hands. Finally, the relative contribution of each mechanical feature of the STR colonoscope to the success in rescue colonoscopy encountered in this study may be difficult to discern; however, the shorter turning radius

of this colonoscope is the mechanical feature which differs from the design of a pediatric colonoscope, and the success of cecal intubation with the STR colonoscope is therefore reasonably attributed to this feature.

In conclusion, we found that the use of the Pentax Retroview™ STR colonoscope resulted in a high cecal intubation rate in patients with bowel fixity and incomplete colonoscopy with a standard pediatric colonoscope, with the detection of pathology in over half of this patient group. Given our findings, this colonoscope would be of value for colonoscopists for polyp resection behind folds and for completion of colonoscopies in patients with extensive bowel fixity. Future prospective randomized multicenter studies comparing this STR colonoscope with standard adult and pediatric colonoscopes would be informative, as would the evaluation of the STR colonoscope as a possible primary tool for routine colonoscopy in patients who are suspected to have significant bowel fixity.

Acknowledgments The authors thank Pentax Corporation for providing the Retroview™ STR colonoscope (EC-3490TLi).

Compliance with Ethical Standards

Conflict of interest An abstract from portion of these data was presented as a poster at Digestive Diseases Week (DDW) 2017, Chicago, IL, USA. None of the authors have any conflicts of interest pertaining to the study to disclose.

References

1. Siegel R, Naishadham D, Jemal A. Cancer statistics, 2012. *CA Cancer J Clin*. 2012;62:10–29.
2. Lin JS, Piper MA, Perdue LA, et al. Screening for colorectal cancer: updated evidence report and systematic review for the US preventive services task force. *JAMA*. 2016;315:2576–2594.
3. Rex DK, Schoenfeld PS, Cohen J, et al. Quality indicators for colonoscopy. *Gastrointest Endosc*. 2015;81:31–53.
4. Koido S, Ohkusa T, Nakae K, et al. Factors associated with incomplete colonoscopy at a Japanese academic hospital. *World J Gastroenterol*. 2014;20:6961–6967.
5. Sachdeva R, Tsai SD, El Zein MH, et al. Predictors of incomplete optical colonoscopy using computed tomographic colonography. *Saudi J Gastroenterol*. 2016;22:43–49.
6. Shah HA, Paszat LF, Saskin R, et al. Factors associated with incomplete colonoscopy: a population-based study. *Gastroenterology*. 2007;132:2297–2303.
7. Rex DK, Chen SC, Overhiser AJ. Colonoscopy technique in consecutive patients referred for prior incomplete colonoscopy. *Clin Gastroenterol Hepatol*. 2007;5:879–883.
8. Bick BL, Vemulapalli KC, Rex DK. Regional center for complex colonoscopy: yield of neoplasia in patients with prior incomplete colonoscopy. *Gastrointest Endosc*. 2016;83:1239–1244.
9. Britton EJSS, Geraghty J, Psarelli E, Sarkar S. The 5-year outcome of patients having incomplete colonoscopy. *Colorectal Dis*. 2015;17:298–303. https://doi.org/10.1111/codi.12901.
10. Lee YT, Hui AJ, Wong VW, et al. Improved colonoscopy success rate with a distally attached mucosectomy cap. *Endoscopy*. 2006;38:739–742.
11. Spada C, Stoker J, Alarcon O, et al. Clinical indications for computed tomographic colonography: european Society of Gastrointestinal Endoscopy (ESGE) and European Society of Gastrointestinal and Abdominal Radiology (ESGAR) Guideline. *Eur Radiol*. 2015;25:331–345.
12. Bollart AS, Manfredi S, Piette C, et al. Frequency and efficacy of additional investigations following incomplete colonoscopies: a population-based analysis. *Dig Liver Dis*. 2015;47:720–725.
13. Baltes P, Bota M, Albert J, et al. PillCamColon2 after incomplete colonoscopy—a prospective multicenter study. *World J Gastroenterol*. 2018;24:3556–3566.
14. Kao KT, Tam M, Sekhon H, et al. Should barium enema be the next step following an incomplete colonoscopy? *Int J Colorectal Dis*. 2010;25:1353–1357.
15. Maggialetti N, Capasso R, Pinto D, et al. Diagnostic value of computed tomography colonography (CTC) after incomplete optical colonoscopy. *Int J Surg*. 2016;33:S36–S44.
16. Triantafyllou K, Viazis N, Tsibouris P, et al. Colon capsule endoscopy is feasible to perform after incomplete colonoscopy and guides further workup in clinical practice. *Gastrointest Endosc*. 2014;79:307–316.
17. Morini S, Zullo A, Hassan C, et al. Endoscopic management of failed colonoscopy in clinical practice: to change endoscopist, instrument, or both? *Int J Colorectal Dis*. 2011;26:103–108.
18. Gawron AJ, Veerappan A, Keswani RN. High success rate of repeat colonoscopy with standard endoscopes in patients referred for prior incomplete colonoscopy. *BMC Gastroenterol*. 2014;14:56.
19. Neerincx M, Terhaar sive Droste JS, Mulder CJ, et al. Colonic work-up after incomplete colonoscopy: significant new findings during follow-up. *Endoscopy*. 2010;42:730–735.
20. Kaffes AJ, Mishra A, Ding SL, et al. A prospective trial of variable stiffness pediatric vs. standard instrument colonoscopy. *Gastrointest Endosc*. 2003;58:685–689.
21. Keswani RN. Single-balloon colonoscopy versus repeat standard colonoscopy for previous incomplete colonoscopy: a randomized, controlled trial. *Gastrointest Endosc*. 2011;73:507–512.
22. Pasha SF, Harrison ME, Das A, et al. Utility of double-balloon colonoscopy for completion of colon examination after incomplete colonoscopy with conventional colonoscope. *Gastrointest Endosc*. 2007;65:848–853.
23. Schembre DB, Ross AS, Gluck MN, et al. Spiral overtube-assisted colonoscopy after incomplete colonoscopy in the redundant colon. *Gastrointest Endosc*. 2011;73:515–519.
24. Friedland S, Soetikno RM. Small caliber overtube-assisted colonoscopy. *World J Gastroenterol*. 2007;13:5933–5937.
25. Rex DK, Boland CR, Dominitz JA, et al. Colorectal cancer screening: recommendations for physicians and patients from the U.S. multi-society task force on colorectal cancer. *Gastroenterology*. 2017;153:307–323.
26. Kessler WR, Rex DK. Impact of bending section length on insertion and retroflexion properties of pediatric and adult colonoscopes. *Am J Gastroenterol*. 2005;100:1290–1295.
27. Vemulapalli KC, Rex DK. Water immersion simplifies cecal intubation in patients with redundant colons and previous incomplete colonoscopies. *Gastrointest Endosc*. 2012;76:812–817.
28. Hermans C, Zee DV, Gilissen L. Double-balloon endoscopy after incomplete colonoscopy and its comparison with computed tomography colonography. *Clin Endosc*. 2018;51:66–71.
29. Sulz MC, Frei R, Semadeni GM, Sawatzki M, Borovicka J, Meyenberger C. The role of single-balloon colonoscopy for patients with previous incomplete standard colonoscopy: is it worth doing it? *Surg Endosc*. 2016;30:1876–1882.