Motorized spiral enteroscopy: effectiveness when used for new indications

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Abstract

Background and study aims: **Motorized spiral enteroscopy is proven to be effective in antegrade and retrograde enteroscopy. Nevertheless, little is known about its use in less common indications. The aim of this study was to identify new indications for the motorized spiral enteroscope.**

Methods: **Monocentric retrospective analysis of 115 patients who underwent enteroscopy using PSF-1 motorized spiral enteroscope between January 2020 and December 2022.**

Results: **A total of 115 patients underwent PSF-1 enteroscopy. 44 (38%) were antegrade procedures and 24 (21%) were retrograde procedures in patients with normal gastrointestinal anatomy with conventional enteroscopy indications. The remaining 47 (41%) patients underwent PSF-1 procedures for secondary less conventional indications: n=25 (22%) enteroscopy-assisted ERCP, n=8 (7%) endoscopy of the excluded stomach after Roux-en-Y gastric bypass, n=7 (6%) retrograde enteroscopy after previous incomplete conventional colonoscopy and n=7 (6%) antegrade pan-enteroscopy of the entire small bowel. In this group of secondary indications, technical success rate was significantly lower (72.5%) as compared to technical success rates in the conventional groups (98-100%, p<0.001 Chi-square). Minor adverse events occurred in 17/115 patients (15%), all treated conservatively (AGREE I and II).**

Conclusion: **This study demonstrates the capabilities of PSF-1 motorized spiral enteroscope for secondary indications. PSF-1 is useful to complete colonoscopy in case of long redundant colon, to reach the excluded stomach after Roux-en-Y gastric bypass, to perform unidirectional pan-enteroscopy and to perform ERCP in patients with surgically altered anatomy. However, technical success rates are lower as compared to conventional antegrade and retrograde enteroscopy procedures, with only minor adverse events.** (Acta gastroenterol. belg., **2023,** 86, **269-275**).

Keywords: Motorized spiral enteroscopy, pan-enteroscopy, incomplete colonoscopy, altered anatomy, ERCP.

Introduction

The small intestine represents a unique challenge in gastrointestinal endoscopy. Over the past two decades, advancements in technology have enabled gradual progress in examining and performing therapeutic procedures within the small bowel (1). Video capsule endoscopy was the first tool used to screen the entire small bowel. Subsequently, balloon-assisted enteroscopes enabled therapeutic interventions, ushering in the era of the push-and-pull technique, with double-balloon enteroscopy in 2001, single-balloon enteroscopy in 2007, and spiral enteroscopy in 2008, which required manual torque motion of the spiral device (2).

In 2019, a motorized version of the spiral enteroscope became available as the PowerSpiral motorized spiral enteroscope (PSF-1). The PSF-1 is a video-enteroscope that is motor-propelled and has axial view. It is combined with the PowerSpiral overtube, which has soft, spiral-shaped fins that allow for progression in the small bowel with a helix-like movement (Figure 1) (3). It was developed to overcome the limitations of other types of device-assisted enteroscopy, such as balloon-assisted enteroscopy. Early reports suggest that this new device allows deeper and even complete enteroscopy with a similar profile to previous enteroscope models with regards to safety and diagnostic and therapeutic rates (4-6).

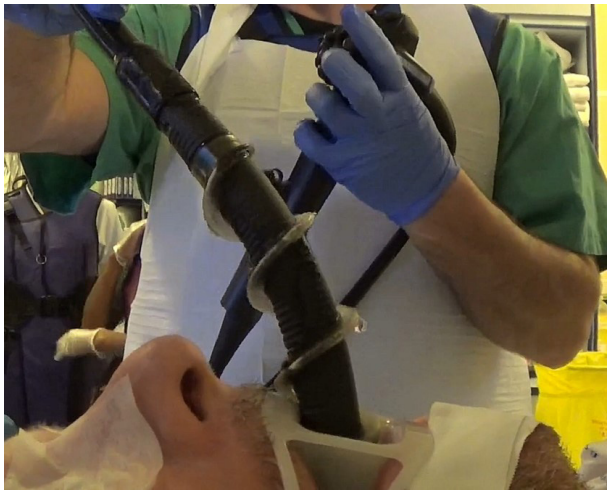

Figure 1. — Oesophageal insertion of the PSF-1 motorized spiral enteroscope loaded with the spiral overtube in a patient under general anesthesia with endotracheal intubation.

The conventional indications for enteroscopy are well-established for antegrade and retrograde enteroscopy (such as treating arteriovenous malformations, retrieving foreign bodies, performing intestinal polypectomy, placing a percutaneous jejunostomy, dilating strictures, and performing mucosal biopsies deep in the small bowel) (2). However, it is unknown whether the newly developed motorized spiral enteroscope can also be used for secondary, less common indications, such as incomplete conventional colonoscopy in case of long redundant colon or accessing the excluded gastrointestinal tract in surgically altered anatomy with

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the intention of performing therapeutic interventions like ERCP.

Initially, the manufacturer (Olympus, Tokyo, Japan) recommended against the use of the PSF-1 enteroscope in patients with surgically altered anatomy of the gastrointestinal tract because of safety concerns. The current study aimed to identify secondary less conventional indications for the use of the motorized spiral enteroscope in daily practice.

Methods

This monocentric retrospective study of a prospective cohort was conducted at Saint-Luc University Hospital in Brussels, Belgium. Between January 2020 and December 2022, 115 patients underwent endoscopy of the gastrointestinal tract using the PSF-1. Patients were not cross-included in other ongoing clinical PSF-1 studies, and data were extracted from the electronic medical file (Epic, Epic Systems Corporation, Verona, WI, USA) and analyzed using Microsoft Excel® (Microsoft, Redmond, WA, USA). All patients provided written informed consent for the procedure, and no distinction was made concerning prior abdominal surgery. Exclusion criteria were known oesophageal varices, recent (less than 2 weeks) abdominal surgery, active anticoagulant therapy, and inclusion in other clinical trials. This retrospective study was approved by the local Ethical Committee (2021/07AVR/162).

The PowerSpiral (PSF-1) motorized spiral enteroscope used in this study, is a video-enteroscope developed by Olympus Medical System Corp (Tokyo, Japan). With a length of 1680mm and an external diameter in the distal part of 11.5mm, its design is comparable to a colonoscope. The enteroscope provides an axial vision and a working channel of 3.2mm, allowing the use of conventional endotherapy instruments. It is combined with the single-use PowerSpiral overtube (DPST-1), which is mounted and locked onto the PSF-1. The overtube has soft spiral-shaped fins with a total diameter of 31.1mm (Figure 1). The PowerSpiral control unit (PSCU) drives the integrated motor mounted on the shaft of the enteroscope and is activated by foot pedals to provide forward and backward rotation of the spiral overtube. A dynamometer (MAJ2179) controls the forward and backward force gauge and provides a visual indication of the rotational direction and the motor power.

All procedures were performed under deep propofol sedation with endotracheal intubation, CO_2-insufflation, and fluoroscopic guidance. Bowel preparation was used for retrograde enteroscopy and in case of incomplete colonoscopy.

Study endpoint

The aim of this study was to evaluate the feasibility of using the PSF-1 motorized spiral enteroscope in secondary, less common indications. More specifically, we investigated its use in the following indications. PSF-1-assisted colonoscopy after a failed conventional colonoscopy due to long, redundant dolichocolon. The second indication was enteroscopy to reach the excluded stomach after Roux-en-Y gastric bypass (RYGB). The third indication was complete unidirectional pan-enteroscopy through the antegrade approach in patients with normal gastrointestinal anatomy. Lastly, we evaluated the PSF-1 usefulness in enteroscopy-assisted ERCP in patients with surgically altered anatomy.

Definition

Technical success was defined as:

- Advancement of PSF-1 beyond the ligament of Treitz for antegrade enteroscopy.
- Advancement of PSF-1 beyond the ileocaecal valve for retrograde enteroscopy.
- Reaching the caecum through the antegrade approach for pan-enteroscopy.
- Reaching the caecum after failed conventional colonoscopy.
- Reaching the biliary tract for ERCP procedures in surgical altered anatomy.
- Reaching the excluded stomach in RYGB patients.

Diagnostic yield was defined as the percentage of procedures with positive clinical findings related to the indication or corroborated previous gastrointestinal imaging.

Adverse events

Adverse events were analyzed under the scope of the new classification for adverse events in gastrointestinal endoscopy (AGREE) (7).

Statistics

We used descriptive statistics to analyze the data using Microsoft Excel® (Microsoft, Redmond, WA, USA). Continuous data were expressed as mean with standard error of the mean. Technical success rates and diagnostic yields were compared using Chi-square statistics. $P<0.05$ was considered to be significantly different.

Results

Patients characteristics

A total of 115 patients have been registered in the database and underwent a PSF-1 enteroscopy procedure between January 2020 and December 2022. The cohort comprised 68 (59%) men and 47 (41%) women, with a mean patient's age of 60±2 years (range 17-92).

Table 1. — **Comparison of the PSF-1 use in conventional antegrade and retrograde enteroscopy with procedures for less common indications**

Procedure	Antegrade enteroscopy	Retrograde enteroscopy	Enteroscopy-assisted ERCP	Roux-en-Y gastric bypass	Incomplete colonoscopy	Unidirectional pan-enteroscopy
Number (%)	44 (38%)	24 (21%)	25 (22%)	8 (7%)	7 (6%)	7 (6%)
Technical success (%)	98%	100%	76%	50%	86%	NA*
Diagnostic yield (%)	75%	54%	76%	63%	100%	71%
Duration (min)	55±3	51±4	65±4	61±7	48±7	94±5
Adverse events						
AGREE I						
Mucosal lacerations	11	-	1	2	-	1
AGREE II						
Small bowel perforation	-	1	1	-	-	-
Biliary leak	-	-	1	-	-	-

* : Technical success of unidirectional pan-enteroscopy was the selection criteria for this patient group. NA : not applicable. See text for detailed explanation and statistical analysis.

Procedures (Table 1)

Of all procedures 44 (38%) were antegrade procedures and 24 (21%) were retrograde procedures in patients with normal gastrointestinal anatomy with conventional enteroscopy indications. The remaining 47 patients (41%) underwent PSF-1 procedures for secondary less conventional indications: n=25 (22%) underwent enteroscopy-assisted ERCP after surgically altered anatomy (Figure 2); n=8 (7%) underwent antegrade enteroscopy to reach the excluded stomach after RYGB (Figure 3); n=7 (6%) underwent retrograde enteroscopy after previous incomplete conventional colonoscopy due to long redundant dolichocolon (Figure 4); n=7 (6%) underwent complete unidirectional pan-enteroscopy via the antegrade approach (Figure 5).

Indications

Anemia and obscure gastrointestinal bleeding were the frontrunners of indications with respectively 43% and 35% of all indications in antegrade and retrograde enteroscopy. Suspected intestinal tumoral lesions or known small bowel polyps were the indication in 18%. Indications for enteroscopy-assisted ERCP were exclusively of biliary origin (hepaticojejunostomy stricture and/or biliary stones), in patients who underwent liver transplantation with Roux-en-Y reconstruction

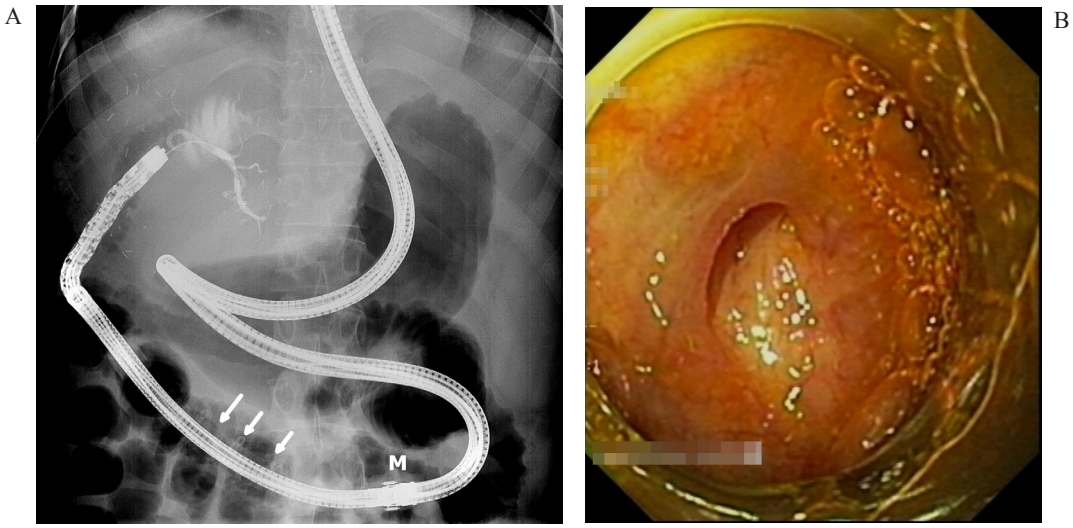

Figure 2. — Fluoroscopic image of enteroscopy-assisted ERCP in a patient with Roux-en-Y liver transplantation (A). The integrated motor in the enteroscope is clearly visible (M) as are the fins of the spiral overtube (arrows). Endoscopic aspect of the hepaticojejunostomy in the same patient (B). Note the use of a distal transparent cap during enteroscopy-assisted ERCP.

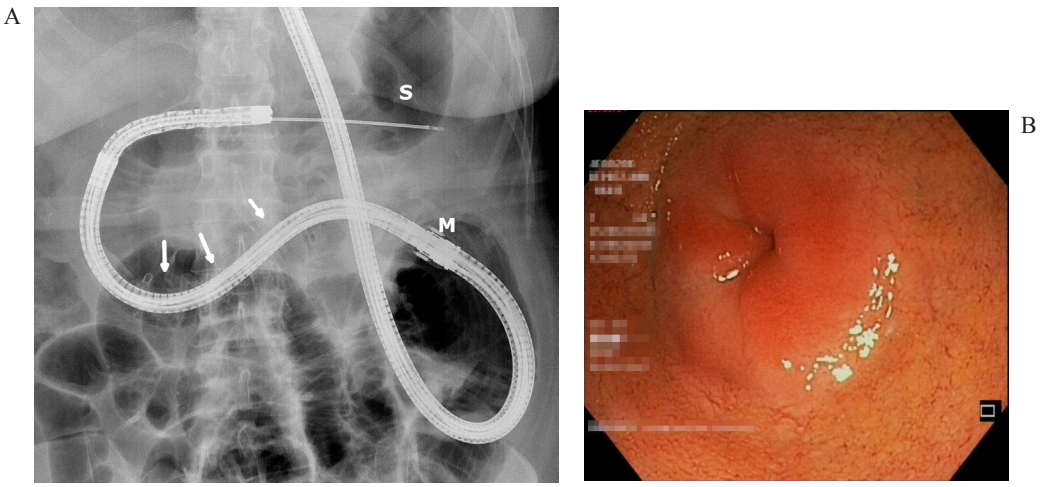

Figure 3. — Fluoroscopic image of the PSF-1 enteroscope reaching the excluded stomach (S) in a patient with Roux-en-Y gastric bypass (A). The integrated motor in the enteroscope is clearly visible (M) as are the fins of the spiral overtube (arrows). Endoscopic aspect of the distal approach to the pylorus seen from within the duodenum in the same patient (B).

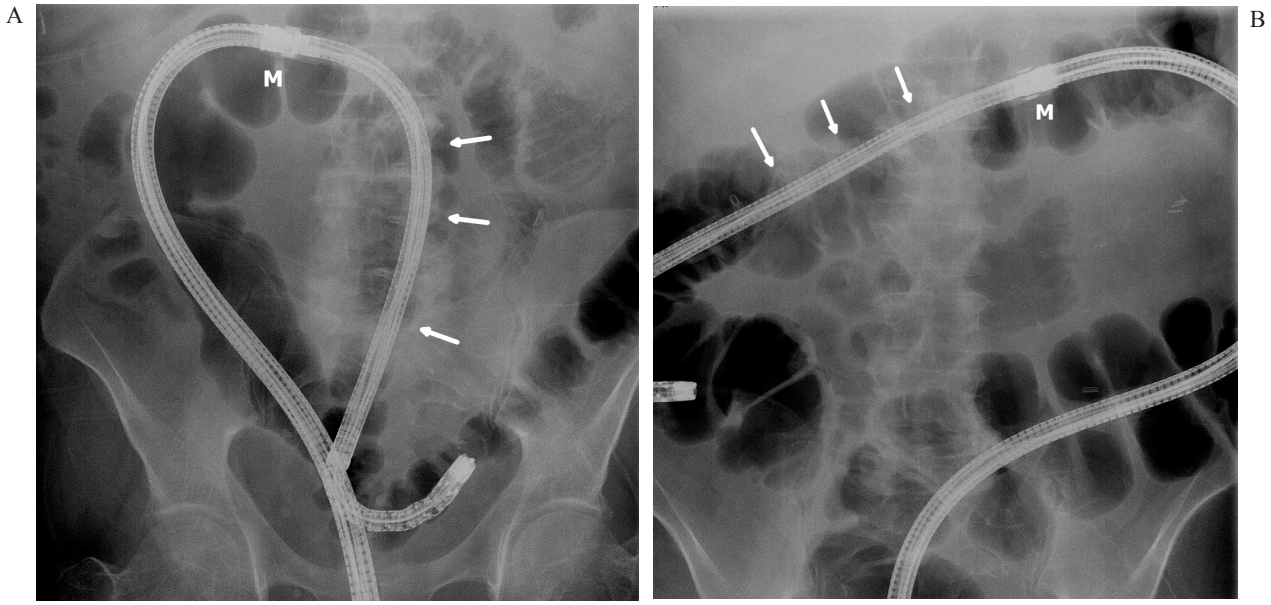

Figure 4. — Fluoroscopic image of the PSF-1 enteroscope during colonoscopy in a long redundant colon with loop formation in the sigmoid colon (A). The integrated motor in the enteroscope is clearly visible (M) as are the fins of the spiral overtube (arrows). Fluoroscopic image of the PSF-1 enteroscope reaching the caecum in the same patient after reducing the sigmoid loop and folding of the long colon over the enteroscope (B).

(n=9, 36%), in patients who underwent Whipple's duodenopancreatectomy variants (n=7, 28%), in patients with RYGB (n=6, 24%), in patients with a Roux-en-Y hepaticojejunostomy (n=2, 8%) and in 1 patient with Roux-en-Y total gastrectomy (4%). Indications to explore the excluded stomach in patients with RYGB were very diverse ranging from anemia, obscure gastrointestinal bleeding, abdominal pain, diarrhea,… In the group who underwent PSF-1-assisted colonoscopy, all patients had previous incomplete conventional colonoscopy due to long redundant dolichocolon. Finally, analysis of the pan-enteroscopy procedures presented anemia, obscure bleeding and suspected small bowel polyps as indication.

Technical success (Table 1)

For the conventional antegrade and retrograde enteroscopy procedures, technical success rates were high, 98% and 100% respectively. Overall technical success rates of the grouped secondary less common indications was significantly lower (72.5%, $p<0.001$ Chi-square), with overall technical success rate of 86% in the PSF-1-assisted colonoscopy group, 76% in the enteroscopy-assisted ERCP group, and only 50% success rate to reach the excluded stomach in RYGB patients. Technical success rate of the pan-enteroscopy group was not included in this analysis since only successful pan-

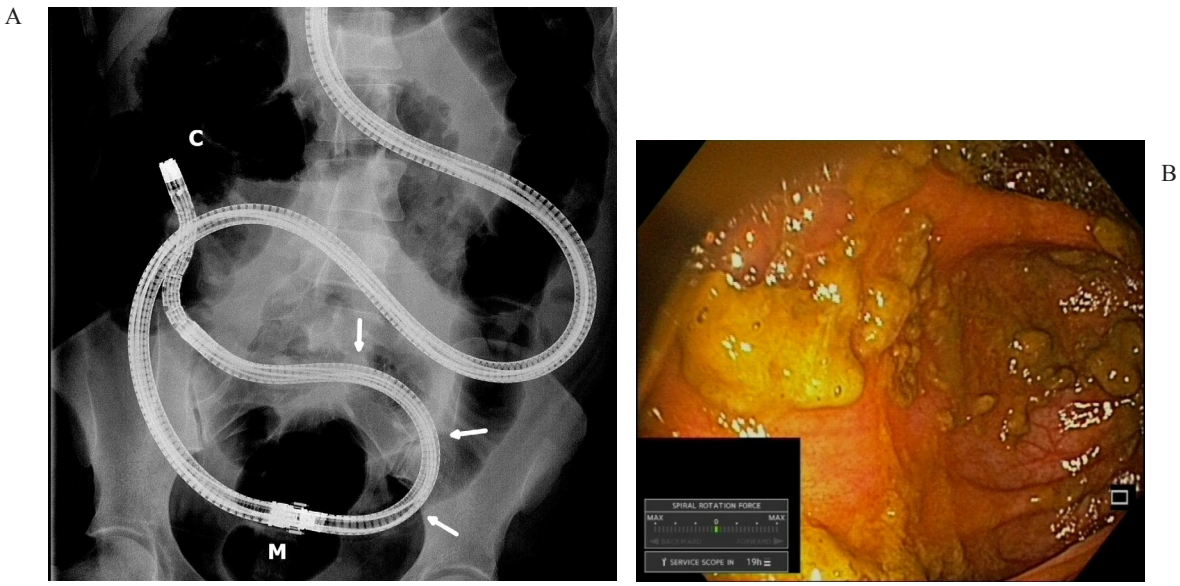

Figure 5. — Fluoroscopic image of antegrade pan-enteroscopy reaching the caecum (C) (A). The integrated motor in the enteroscope is clearly visible (M) as are the fins of the spiral overtube (arrows). Endoscopic image of the caecum from within the ileocaecal valve in the same patient (B). Note the screen-in-screen image of the PowerSpiral control unit (PSCU) with forward and backward rotation of the spiral overtube.

enteroscopy procedures were retrospectively assessed. No patients were referred for intentional unidirectional pan-enteroscopy. Technical failure was only encountered in 1 patient who underwent conventional antegrade enteroscopy with inability to intubate the oesophagus due to a stricture at the upper oesophageal sphincter. Technical failures in the group of less conventional secondary indications were: a stricture of a colo-anal anastomosis not allowing introduction of the DPST-1 PowerSpiral overtube in the PSF-1-assisted colonoscopy group; in 4 patients with RYGB the PSF-1 was not able to pass the upper oesophageal sphincter, the alimentary limb, the biliopancreatic limb or the pylorus, each in 1 patient; in 2 patients the hepaticojejunostomy was not reached and in 4 patients Vater's papilla was not successfully cannulated during enteroscopy-assisted ERCP.

Diagnostic yield (Table 1)

For antegrade and retrograde procedures diagnostic yields were 75% and 54%, respectively (p=0.079 Chi-square). The diagnostic yields found in the secondary indications were 71% in the pan-enteroscopy group (p=0.840 compared to antegrade enteroscopy), 63% in the RYGB group (p=0.463 compared to antegrade enteroscopy), 100% in the PSF-1-assisted colonoscopy group (p=0.026 compared to retrograde enteroscopy) and 76% in the enteroscopy-assisted ERCP group. In the latter group, therapeutic endoscopy was performed to treat hepaticojejunostomy strictures and/or biliary stones by means of anastomotic balloon dilatation with or without stone extraction (n=7, 28%), or plastic stent insertion (n=7, 28%) or stent removal (n=2, 8%), or to treat common bile duct stones in patients with intact papilla by means of biliary sphincterotomy and stone extraction (n=2, 8%), and 1 patient underwent cholangiography without further intervention (n=1, 4%).

Procedure Time (Table 1)

Total procedure times per group were 55±3 min (range 23-107) for conventional antegrade enteroscopy, 51±4 min (range 26-89) for conventional retrograde enteroscopy, 65±4 min (range 43-89) for enteroscopy-assisted ERCP, 61±7 min (range 49-89) to reach the excluded stomach in RYGB patients, 48±7 min (range 25-78) for PSF-1-assisted colonoscopy and 94±5 min (range 70-112) to achieve unidirectional pan-enteroscopy. The latter procedure required an important time investment. The other procedures generally took about 1 hour.

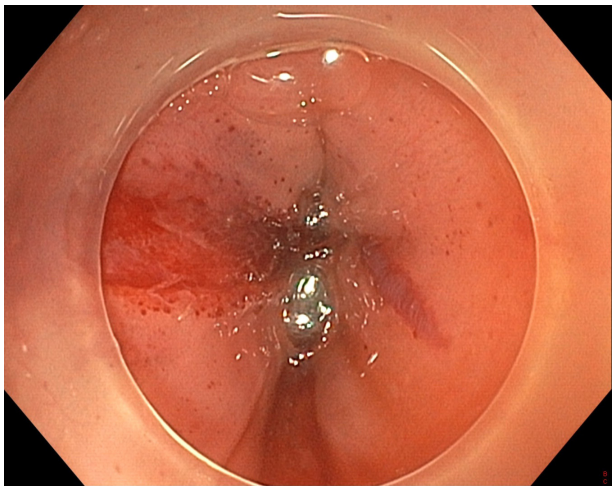

Figure 6. — Superficial mucosal lacerations in the upper part of the oesophagus after PSF-1 enteroscope withdrawal.

Adverse events (Table 1)

Minor adverse events occurred in 17/115 patients (15%) with no severe adverse events nor procedure-related mortality registered. Most of them (n=13) were superficial mucosal lacerations in the upper oesophagus not requiring any treatment, corresponding with AGREE grade I (Figure 6). In 1 patient who underwent antegrade enteroscopy, superficial mucosal lacerations were seen in the jejunum during enteroscope withdrawal. Two patients underwent postprocedural abdominal CT scan because of abdominal pain after the procedure, showing air bubbles around the small bowel suspect for intestinal perforation, n=1 after retrograde enteroscopy and n=1 after enteroscopy-assisted ERCP. Both patients completely recovered after medical treatment with antibiotics (AGREE grade II). One patient presented a biliary leak related to the ERCP procedure, not to the enteroscopy procedure, and was treated conservatively with antibiotics (AGREE grade II).

Discussion

First described in 2016 in a case report, motorized spiral enteroscopy using the PSF-1 enteroscope is a recent technique to explore the small bowel (3). Preliminary studies showed the efficacy and the safety of antegrade and retrograde motorized spiral enteroscopy in the exploration of the small intestine with normal anatomy (4-6). Initially, the manufacturer recommended against the use of the PSF-1 enteroscope in patients with surgically altered anatomy of the gastrointestinal tract because of suspected safety issues. However, recent reports have shown that motorized spiral enteroscopy can be safely used in patients with surgically altered anatomy, under the condition that a time interval of at least two weeks is respected between the surgery and the enteroscopy (8). In the current study, only minor adverse events were encountered, the majority being superficial mucosal lacerations in the upper part of the oesophagus. This is a frequent adverse event, related to the inward and/or outward rotational passage of the 31.1 mm wide overtube, rendering it a more traumatic technique as compared to balloon-assisted enteroscopy (9). However, generous lubrification of both the enteroscope and spiral overtube at their insertion into the oesophagus reduces friction and local trauma of the oesophageal mucosa. No serious adverse event was recorded in our study which matched with the ESGE recommendation of serious adverse event rate of <5% in therapeutic enteroscopy (10). Furthermore, we did not encounter clinical signs of acute pancreatitis which is a known adverse event occurring at a rate of 0.3% after antegrade device-assisted enteroscopy (11).

The current study aimed to provide answers to the question concerning the efficacy and the safety of this device in less common indications. Apart from its conventional use to perform antegrade and retrograde enteroscopy to diagnose or treat suspected small bowel pathology, it was also used to perform ERCP in patients with surgically altered anatomy, or to reach the excluded stomach in RYGB patients, or to complete colonoscopy in patients with long redundant dolichocolon and finally to perform unidirectional pan-enteroscopy in patients with normal gastrointestinal anatomy. In our series, technical success rates of antegrade and retrograde PSF-1-assisted enteroscopy were very high (98-100%), whereas technical success rates when used for less common indications were lower: 86% for PSF-1-assisted colonoscopy, 76% for enteroscopy-assisted ERCP and only 50% to reach the excluded stomach in RYGB patients. On the other hand, this study also showed that unidirectional antegrade pan-enteroscopy is feasible using PSF-1, which is extremely unlikely when using balloon-assisted enteroscopy techniques. These results illustrate not only the broad spectrum of indications for the use of motorized spiral enteroscopy, but also its limitations (12). The technique of motorized spiral enteroscopy is clearly more efficient than balloon-assisted enteroscopy to obtain deep and even complete enteroscopy in the unidirectional approach or in the combined approach of antegrade and retrograde enteroscopy (5). It is also easier in use to perform retrograde enteroscopy with deep ileal intubation as compared to balloon-assisted enteroscopy. Intubation of the ileocaecal valve and further progression of the enteroscope into the ileum is often challenging when using balloon-assisted enteroscopy (13). The motorized spiral enteroscope also showed to be very useful to perform colonoscopy in a long redundant colon after previously incomplete conventional colonoscopy. Our study also illustrated the usefulness of fluoroscopy for all types of enteroscopy procedures. It helps to estimate insertion depth and to identify enteroscope loops during the procedure. In the indication of dolichocolon, its effectiveness seems comparable to balloon-assisted enteroscopy techniques (14). Moreover, the diagnostic yield of 100% in this group of patients, illustrates the importance of redo colonoscopy using an enteroscope in case of incomplete conventional colonoscopy. On the other hand, motorized spiral enteroscopy was less efficient in reaching the excluded stomach in RYGB patients as compared to balloon-assisted enteroscopy (9). Finally, although (biliary) ERCP using the PSF-1 is feasible in patients with surgically altered anatomy with a technical success rate of 76% in the current study, these results suggest a lower technical success rate as compared to enteroscopy-assisted ERCP using balloon-assisted enteroscopy techniques (15,16). The lower technical success rates to reach the excluded stomach in RYGB patients and to perform ERCP in patient with surgically altered anatomy, is most likely related to the fact that the PSF-1 is a colonoscope loaded with a motorized spiral overtube. The bending of the enteroscope's tip behaves like a colonoscope, whereas balloon-assisted enteroscopes are long and slim gastroscopes, allowing easier access to sharply angulated small bowel limbs or fixed colonic segments (9,17).

The current study presents some limitations. It is a retrospective single-center study held in a tertiary referral center with highly trained endoscopists. Moreover, the number of procedures for the less common indications are low. Therefore, the results presented in the current study will need confirmation by multicenter prospective trials.

In conclusion, despite the initial warning from the manufacturer not to use PSF-1 in patients with surgically altered anatomy, this retrospective study demonstrated its usefulness for secondary less conventional indications in daily practice. Motorized spiral enteroscopy seems useful to complete colonoscopy of a long redundant colon with previous incomplete conventional colonoscopy. It can be used to reach the excluded stomach after Roux-en-Y gastric bypass and to perform biliary ERCP in patients with surgically altered anatomy. Moreover, the technique allows unidirectional pan-enteroscopy in patients with normal gastrointestinal anatomy. However, despite these promising results, it appears that motorized spiral enteroscopy does not outclass balloon-assisted enteroscopy in all indications. Therefore, balloon-assisted enteroscopy and motorized spiral enteroscopy are most likely complementary techniques instead of competitive techniques. Future research will define which technique to be used for which indication.

Acknowledgement

The results of this study were presented during the 35th Belgian Week of Gastroenterology (08-10 March 2023). The presentation was awarded Best Oral Presentation

Conflict of interest

LM and TGM received speaker's fee from Olympus Europe.

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