ORIGINAL ARTICLE

Diagnostic yield and therapeutic impact of novel motorized spiral enteroscopy in small-bowel disorders: a single-center, real-world experience from a tertiary care hospital (with video)

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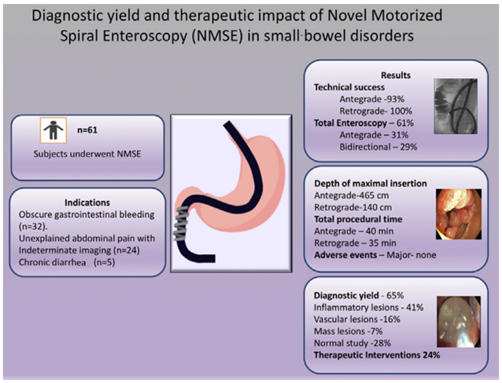
GRAPHICAL ABSTRACT



Background and Aims: Novel motorized spiral enteroscopy (NMSE) is a recent advancement in the field of enteroscopy and offers multiple features, including self-propulsion, better irrigation, and shorter enteroscope length with a larger channel. The aim of this study was to evaluate the efficacy in terms of diagnostic yield and therapeutic success of NMSE in patients undergoing enteroscopy by antegrade and/or retrograde approaches for suspected small-bowel disease.

Methods: We retrospectively evaluated consecutive patients with symptomatic small-bowel disease who underwent enteroscopy over a 6-month period. Diagnostic yield, therapeutic success, total enteroscopy rate (TER), technical success, total procedural time, depth of maximal insertion, and adverse events related to the NMSE procedure were noted.

Results: Of 61 patients (mean age, 45.67 ± 15.37 years; 43 men) included for NMSE, 57 patients underwent successful enteroscopy with a technical success of 93.4%. The overall diagnostic yield was 65.5% (95% confidence interval, 52.31-77.27) and 70.1% (95% confidence interval, 56.60-81.57) in patients who underwent successful NMSE; TER was 60.6%: 31.1% by the antegrade approach and 29.5% by a combined antegrade and retrograde approach. Depth of maximal insertion and procedural time was of 465 cm (range, 100-650) and 40 minutes (range, 25-60), respectively,

Abbreviations: APC, argon plasma coagulation; BAE, balloon-assisted enteroscopy; DBE, double-balloon enteroscopy; NMSE, novel motorized spiral enteroscopy; SBE, single-balloon enteroscopy; SE, spiral enteroscopy; TER, total enteroscopy rate.

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by the antegrade approach and 140 cm (range, 50-200) and 35 minutes (range, 30-60) by the retrograde route. Lesions were classified as inflammatory (n = 25), vascular (n = 10), and mass (n = 4). Biopsy specimens were obtained in 50.8% subjects, and 23% patients underwent therapeutic procedures. No major adverse events were seen.

Conclusions: NMSE is a promising technology, showing high efficacy as a diagnostic and therapeutic tool in the management of otherwise difficult-to-treat small-bowel disease. (Gastrointest Endosc 2020;■:1-11.)

Small-bowel disorders remain a diagnostic and therapeutic challenge for the endoscopist because of its unfavorable anatomy for endoscopy. It is almost impossible to do deep enteroscopy of the long, redundant, and lengthy small intestine by the bare endoscope; many times the operator ends up pushing the small bowel rather than traveling through it.

The last 2 decades have seen a paradigm shift in the management of small-bowel disorders with the introduction of deep enteroscopy,[1-4] including double-balloon enteroscopy (DBE; Fujifilm, Tokyo, Japan), single-balloon enteroscopy[5] (SBE; Olympus Medical Systems, Tokyo, Japan), and spiral enteroscopy[6] (SE; Spiral Medical, LCC, West Bridgewater, Mass, USA). The DBE and SBE techniques have had varied results as far as depth of insertion is concerned; moreover, both are time-consuming, which has been a major limiting factor. SE,[6] introduced in 2007, is a 2-operator technique where a spiral-shaped overtube (discovery small bowel) was used to pleat the small bowel over the enteroscope by manual rotation of the overtube.

Deep endoscopic access to the small bowel with all available methods is still a complex, cumbersome, time-consuming procedure and requires high endoscopic skills. Novel motorized spiral enteroscopy[7] (NMSE; Olympus Medical Systems) is a recent advancement in the field of enteroscopy (Fig. 1). This enteroscope works on the same principle as that of SE and comes with an integrated user-controlled motor in the handle of the enteroscope. The integrated electric motor is controlled with the help of a footswitch for rotating a short spiral overtube to pleat and unpleat the small bowel. This increases acceleration of the procedure, facilitates insertion, and simplifies the technique with a single operator. The procedure can be done with both antegrade and retrograde approaches. Data are scarce on the utility, safety, and efficacy of NMSE for evaluation in patients with suspected small-bowel disease by both the routes of examination. Hence, this study was done to examine the role of NMSE in patients with suspected small-bowel disease using both antegrade and retrograde approaches.

METHODS

Patients

This study was a retrospective analysis of patients undergoing enteroscopic procedures from September 2019 to March 2020 at the Department of Gastroenterology, Asian Institute of Gastroenterology, Hyderabad, India. Retrospective collection of data was done Hospital Information System (HIS, 21st Century Software Solutions Pvt Ltd, Vizag, India), clinical records, and from pro forma, which was filled during each NMSE procedure.

Ninety-two consecutive patients with suspected small-bowel disorders based on clinical presentation, small-bowel imaging, and/or capsule endoscopy were included. After exclusion of 31 patients, 61 patients who underwent NMSE were analyzed (Fig. 2). Demographic details including age, gender, indication for enteroscopy, findings of prior upper and lower GI endoscopies, prior capsule endoscopy, balloon-assisted enteroscopy findings, and any prior abdominal surgery were collected. Radiologic studies including barium studies, CT/CT enteroclysis, where available, were noted. The study was approved by the institutional review board.

Definitions

Inclusion and exclusion criteria are shown in Table 1. Technical success was defined as successful advancement of the enteroscope beyond the ligament of Treitz for antegrade procedures or successful advancement of the enteroscope proximal to the ileocecal valve for retrograde procedures. The total enteroscopy rate (TER) was defined by examination of the entire small bowel from the duodenojejunal flexure to the cecum achieved by the antegrade approach alone or combined antegrade and retrograde approaches if total enteroscopy was indicated by findings on pre-NMSE small-bowel imaging or capsule endoscopy.

Partial enteroscopy was defined when the enteroscopy was stopped because of further nonadvancement of the enteroscope or if the lesion found could explain about the clinical diagnosis satisfactorily. The depth of maximal insertion was defined as the point where rotation of NMSE was not effective in advancing the endoscope forward based on estimation by the method described by Akerman et al[8] and current European Society of Gastrointestinal Endoscopy technical guidelines[2,9] for device-assisted enteroscopy.

Diagnostic yield was defined as the percentage of procedures that either confirmed a diagnosis from previous studies or established a new definitive diagnosis at the anatomic location identified in previous studies or findings that could explain the clinical symptoms. Therapeutic

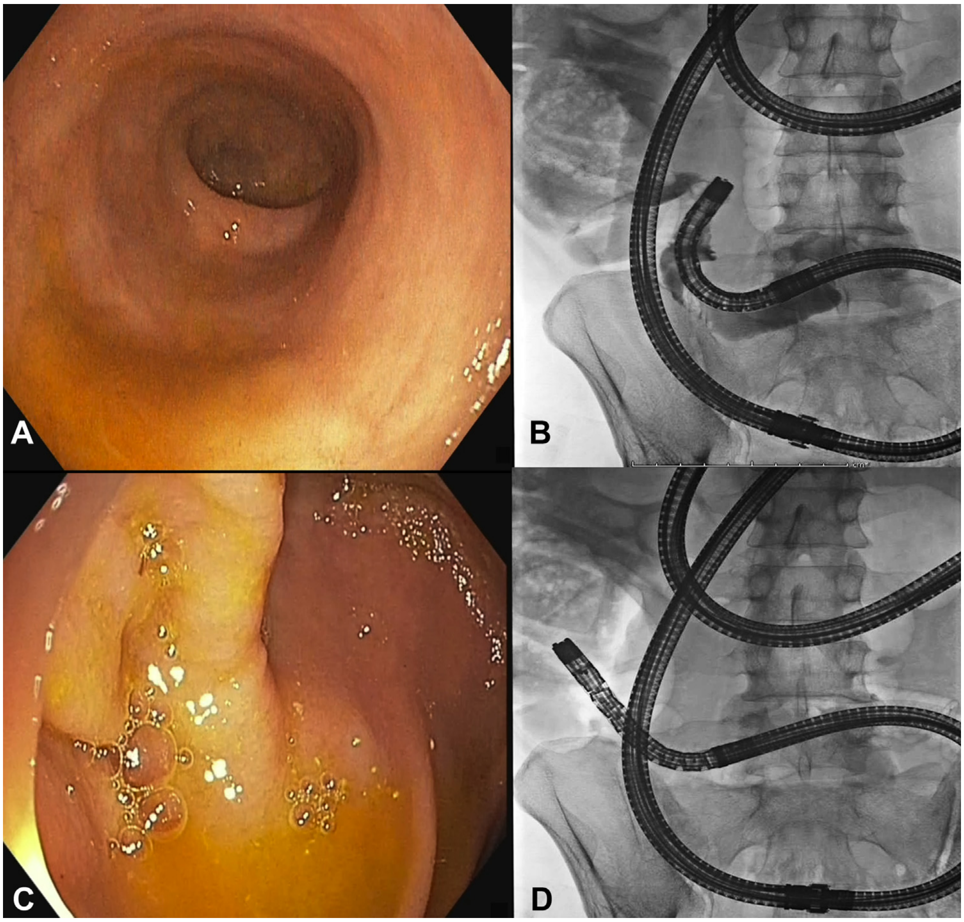

Figure 1. Enteroscopic images of visualization of the terminal ileum (**A**) and cecum (**C**) using the antegrade approach. Fluoroscopy images of passage of the enteroscope along the ileocecal valve using the antegrade approach at the terminal ileum (**B**) and cecum (**D**) forming 2 loops.

success was defined as successful endoscopic interventions such as for GI bleeding, polypectomy, and so on.

Adverse events were defined as minor or major. Minor adverse event was defined as superficial esophageal or colonic trauma, sore throat less than 72 hours in duration, abdominal discomfort lasting less than 48 hours, and mild nausea or vomiting not requiring hospital admission. Major adverse events were defined as perforation, significant bleeding requiring blood products, pancreatitis, or any hospital admission related to the procedure.

Aims and objectives

The primary aim of this study was to evaluate the efficacy in terms of diagnostic yield and therapeutic success of NMSE in patients undergoing enteroscopy by both antegrade and retrograde approaches for suspected small-bowel disease. Secondary objectives were to evaluate the TER, technical success, procedural time, depth of maximal insertion, and adverse events.

Instrument

NMSE[7] (Olympus Medical Systems) is composed of 3 subsystems (Fig. 3). The first is a reusable endoscope with an insertion section working length of 168 cm, an outer diameter of 12.8 mm, and a large-caliber accessory channel with an inner diameter of 3.2 mm with an integrated motor permitting the rotation of a spiral overtube. Additional features of improved maneuverability during therapeutic interventions are a high-force transmission function designed to facilitate the transmission of push and pull forces and rotational torque, applied by the operator to the connector end of the endoscope; high-definition imaging; optical image enhancement technology capabilities (narrow-band imaging); and a separate dedicated irrigation channel. A major advantage is that the routine colonoscopic accessories can be used for therapeutic procedures.[10] The second subsystem is a short, single-use, power spiral overtube (length, 24 cm; maximum outer diameter, 31 mm) placed on the insertion tube portion of the endoscope. The third subsystem is a power spiral control unit with a foot pedal and visual force gauge. During the procedure, a visual force gauge allows the operator to monitor the direction of the overtube rotation and the resistance encountered by the spiral overtube in the small bowel. If excessive rotational resistance is detected, the motor stops automatically to avoid mucosal trauma to the intestine.

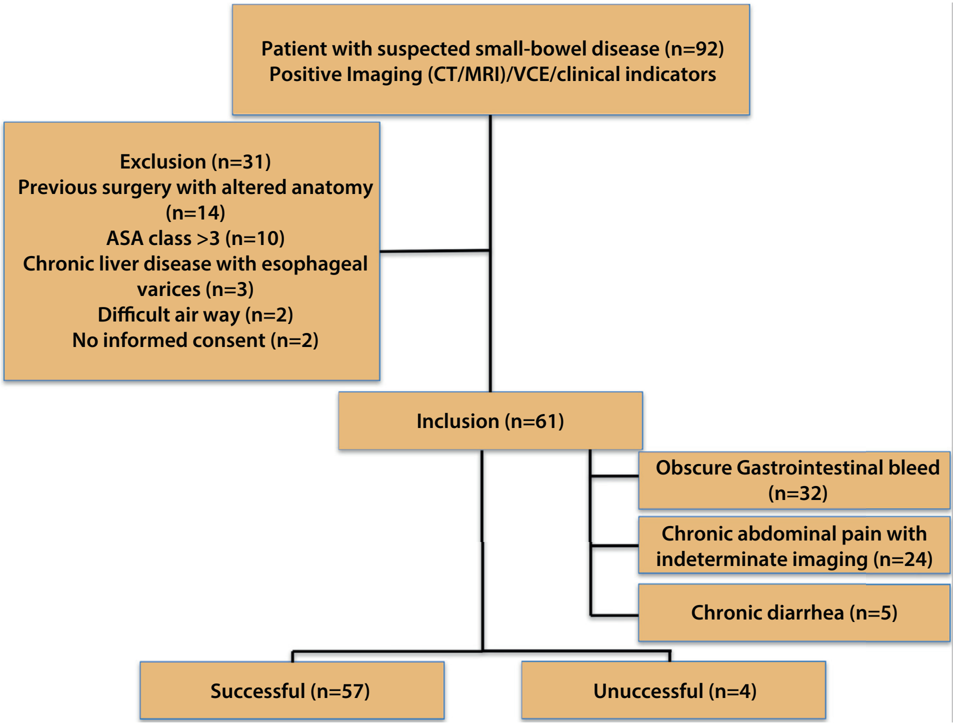

Figure 2. Flowchart of inclusion and exclusion of patients. *ASA*, American Society of Anesthesiologists; *MRI*, magnetic resonance imaging; *VCE*, video capsule endoscopy.

TABLE 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
1. Age ≥18 y 2. Patients with suspected small-bowel pathology based on clinical presentation, small-bowel imaging, or capsule endoscopy indicated for diagnostic and/or therapeutic enteroscopy 3. Written informed consent available	1. Contraindications for endoscopy because of comorbidities 2. Unable to provide written informed consent 3. Patients with known severe GI tract inflammation, intestinal obstruction, and gastro-esophageal varices that preclude a safe enteroscopy procedure 4. Coagulopathy or thrombocytopenia that could not be corrected by blood product transfusion 5. Pregnant patients 6. Health status American Society of Anesthesiologists class >3 7. Inability to tolerate sedation or general anesthesia for any reason 8. Prior abdominal surgery 9. Pediatric patients (infants and toddlers) 10. Eosinophilic esophagitis

Technique

Patients were placed in the left lateral decubitus position initially. However, if during the procedure there was no forward propulsion for 3 minutes, patient position was changed to facilitate application of manual abdominal pressure[7] (Video 1, available online at www.giejournal.org). Manual pressure was also applied to facilitate terminal ileal intubation through the ileocecal valve while performing retrograde enteroscopy. Routine colonoscopy bowel preparation was done.

All procedures were performed with the patient under general anesthesia by nasotracheal intubation by an expert anesthesia team. This was done to secure and stabilize the airway in case of unanticipated adverse events because withdrawal of enteroscope could take a few minutes, although retrograde enteroscopy was performed with the patient under monitored anesthesia care.[11] A wire-guided esophageal bougienage dilatation up to 18 to 20 mm was done before the procedure to reduce the potential risk of esophageal trauma and undesired stoppage of the motor and forward propulsion of the enteroscope because of unexpected esophageal strictures or web. The technique of NMSE has been previously described.[7,10] All NMSE procedures in our study were performed by a single endoscopist who had extensive experience in diagnostic and interventional endoscopy and had performed more than 500 balloon-assisted enteroscopies.

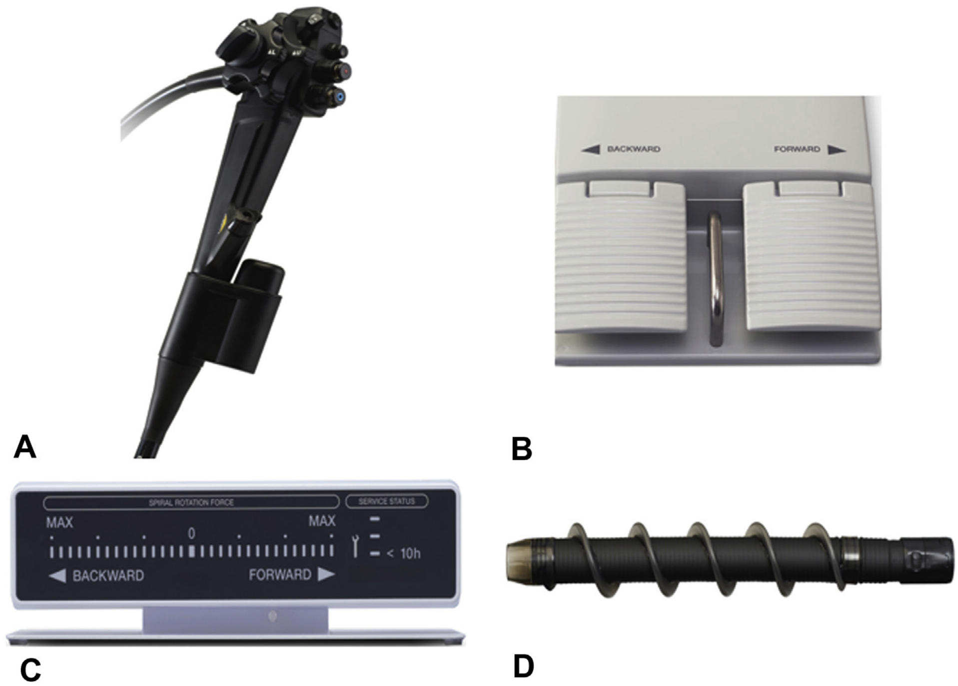

Figure 3. A, Novel motorized spiral enteroscope with integrated electric motor (PSF-1; Olympus Medical Systems, Tokyo, Japan). **B,** Footswitch for rotating a short spiral overtube. **C,** A visual force gauge is used to control how much torque (represented by the electric current needed for spiral rotation) is being applied to the small bowel. **D,** Disposable atraumatic spiral overtube to be attached to the rotation coupler.

The NMSE was advanced until the maximal depth of insertion was reached or the diagnostic lesion was reached. If the objective was not achieved using the antegrade approach and if indicated by findings on pre-MSE small-bowel imaging or capsule endoscopy, India ink tattooing/hemoclipping was done at the site of maximum depth of insertion. Retrograde enteroscopy was done on the same day, which enabled us to complete the procedure using the same anesthesia and the same overtube for both approaches. Total enteroscopy was achieved using the antegrade approach alone or a combined antegrade and retrograde approach. The enteroscope was withdrawn gradually by anticlockwise rotation of NMSE. Trauma was recorded on withdrawal of the enteroscope within the small intestine, stomach, and esophagus. Radiologic guidance using fluoroscopy images with contrast was used during the procedure to monitor the movement of NMSE when deemed necessary (Fig. 1).

The depth of enteroscope insertion was estimated in the following manner.[2,8,9] Once a point was reached where the rotation of the NMSE overtube was not effective in advancing the enteroscope forward or the lesion of interest was reached, a visual reference point at the tip of the scope (eg, a circumferential fold) was identified by an assistant physician. Then, on endoscope withdrawal initiation, the same landmark was observed until an estimated 10 cm of small bowel was examined. Once 10 cm was reached, a new reference point (eg, another circumferential fold) was monitored as the enteroscope was withdrawn another estimated 10 cm. This process was repeated until the ligament of Treitz was reached for the antegrade approach and the ileocecal valve was reached for the retrograde approach, and the final distance was hence calculated and recorded.

Ethical considerations

All patients provided written consent before undergoing NMSE after the procedure and adverse events were explained to them. In addition, informed consent was taken from all patients undergoing therapeutic enteroscopy, including argon plasma coagulation (APC) and polypectomy. Patients undergoing dilatation therapy were informed that surgical laparotomy with intraoperative enteroscopy or small-bowel resection was the standard approach. The study was approved by the institutional review board.

Statistics

The database was created with Microsoft Excel (Microsoft, Seattle, Wash, USA). Data entry was verified by a physician. Statistical analyses were carried out using SPSS version 25 (IBM Corp., Armonk, NY, USA). Continuous measures were expressed with sample size, mean (standard deviation), median (range), as and when required. Categorical measures were presented as number of patients and percentage. The 95% confidence interval was calculated using exact Clopper-Pearson for diagnostic yield and TER.

TABLE 2. Baseline characteristics of study population (n = 61)

Characteristic	Value
Mean age, y (standard deviation)	45.6 (15.3)
Male gender	43 (70.4)
Indications	
Obscure GI bleed	32 (52.4)
Unexplained abdominal pain with indeterminate radiologic findings	24 (39.3)
Chronic diarrhea	5 (8.1)
Route of enteroscopy	
Antegrade	34 (55.7)
Retrograde	5 (8.1)
Combined	22 (36.0)
Technical success	
Antegrade	52/56 (92.8)
Retrograde	27/27 (100)

Values are n (%) unless otherwise defined.

RESULTS

Ninety-two patients with suspected small-bowel diseases presented to our center during the study period (Fig. 1). Thirty-one patients were excluded from the study because of previous abdominal surgery (n = 14), American Society of Anesthesiologists class > 3 (n = 10), chronic liver disease with large esophageal varices (n = 3), and difficult airway (n = 2). SBE was preferred in these clinical situations. Overall, 61 patients who underwent NMSE were analyzed in this study (43 men and 18 women), with a mean age of 45.67 ± 15.37 years (Table 2). Fifty-seven NMSE procedures were successful, and antegrade enteroscopy was unsuccessful in 4 patients (6.55%): 1 patient had a difficult esophagus to negotiate, and in 3 patients the enteroscope could not be negotiated beyond the duodenojejunal flexure, possibly because of sharp angulation.

TER was possible in 37 of 61 patients (60.6%): 31.1% using the antegrade approach only and 29.5% using a combined antegrade plus retrograde approach. Partial enteroscopy was done in 20 patients (29.5%). In these cases, the enteroscopy was stopped either because the lesion of interest was reached (18/20) or there was nonadvancement of the enteroscope (2/20).The technical success rate was 92.8% by the antegrade approach and 100% by the retrograde approach. No enteroscopy-associated major adverse events such as pancreatitis, perforation, or bleeding were observed. Minor adverse events were observed in 15 procedures (24.5%) in the form of superficial mucosal injury and throat discomfort. Other details are given in Table 3.

Diagnostic yield and therapeutic success

The diagnostic yield was 65.5% (95% confidence interval, 52.31-77.27) in the overall population and 70.1% (95% confidence interval, 56.60-81.57) in the technically successful enteroscopy group (Table 3). Fourteen patients (23%) underwent therapeutic procedures, including APC and endoscopic hemoclipping, stricture dilatation, and capsule retrieval. For those who underwent successful enteroscopy (n = 57), the enteroscopic lesions were classified into 4 groups: inflammatory lesions (ulcers and/or stricture; 25 [41%]), vascular lesions (10 [16.4%]), mass lesions (4 [6.6%]), or other (worm infestation; n = 1) (Table 4). NMSE was normal in 17 patients (27.9%).

Subgroup analysis

Inflammatory lesions (25 [41%]). NMSE findings were ulcerations with or without strictures (n = 25). Biopsy specimens were taken in all cases, and the final diagnosis was based collectively on clinical course, enteroscopic visual impression, imaging, and histopathologic findings. Final diagnoses of Crohn's disease (16/25, 64%), intestinal tuberculosis (4/25, 16%) (Fig. 4), cryptogenic multifocal ulcerous stenosing enteritis (2/25, 8%), and nonspecific enteritis (3/25, 12%) were made. Endoscopic stricture dilatation was performed in 3 patients, and in 1 of these patients along with stricture dilatation the retained capsule was removed. Sixty-eight percent of inflammatory lesions were located in the ileum. Cryptogenic multifocal ulcerous stenosing enteritis was differentiated from Crohn's disease by the presence of multiple short strictures and/or shallow ulcers of the small intestine (mainly ileum) without significant bowel obstruction and absence of biologic signs of systemic inflammation, with histology showing small intestinal epithelial mucosa having extensive infiltration of plasmacytic cells and lymphocytes.

Vascular lesions (10 [16.4%]). Of the 10 patients, 7 patients had angioectasias and were treated using APC (Fig. 5). Two patients had Dieulafoy's lesion, and hemostasis was achieved using endoscopic hemoclipping. One patient had both angioectasias and Dieulafoy's lesion and was treated using APC and hemoclips.

Mass lesions (4 [6.6%]). Two patients had mucosal growth, which on histopathologic examination and immunohistochemistry showed jejunal adenocarcinoma and ileal GI stromal tumor (Fig. 6). One patient had ulcerated subepithelial lesion in the ileum, which on the biopsy sample showed neuroendocrine tumor (Fig. 7). All 3 patients underwent surgical treatment with resection and anastomosis. Polypectomy was done in 1 patient with a known case of Peutz-Jeghers syndrome having multiple jejunal and ileal polyps.

DISCUSSION

This is the first study to evaluate the role of NMSE in a real-world scenario in patients with suspected small-bowel

TABLE 3. Procedure details

	With technical success (n = 57)	All patients (n = 61)
Extent of enteroscopy		
Total enteroscopy	37 (64.9) (95% CI, 51.13-77.09)	37(60.6) (95% CI, 47.31-72.93)
Antegrade	19 (33.3)	19 (31.1)
Retrograde	0	0
Combined	18 (31.5)	18 (29.5)
Partial enteroscopy	20 (35.0)	20 (32.7)
Depth of maximum insertion, cm		
Median (range)		
Antegrade	465 (100-650)	
Retrograde	140 (50-200)	
Total procedural time, min		
Median (range)		
Antegrade	40 (25-60)	
Retrograde	35 (30-60)	
Diagnostic yield	40 (70.1) (95% CI, 56.60-81.57)	40 (65.5) (95% CI, 52.31-77.27)
Therapeutic interventions	14 (24.6)	14 (23)
Biopsy	31 (54.3)	31 (50.8)
Adverse events		
Major	0	0
Minor	13 (22.8)	15 (24.5)

Values are n (%) unless otherwise defined. *CI*, Confidence interval.

TABLE 4. Diagnostic and therapeutic interventions (n = 57)

Findings	Subtypes	Pathology	Therapeutic intervention
Inflammatory (n = 25, 41%)	Ulcerations with or without strictures (25)	Crohn's disease (16) Tuberculosis (4) Cryptogenic multifocal ulcerous stenosing enteritis (2) Nonspecific inflammation (3)	Retained capsule retrieval (1) Endoscopic stricture dilatation (3)
Vascular lesions (n = 10, 16.4%)	Angioectasias (8) Dieulafoy's lesion (3)		Argon plasma coagulation (8) Hemoclip application (3)
Mass lesion (n = 4, 6.6%)	Growth (2) Subepithelial Lesion (1) Polyposis (1)	Adenocarcinoma (1) GI stromal tumor (1) Neuroendocrine tumor (1) Peutz-Jeghers syndrome (1)	Polypectomy (1)
Others (n = 1)	Worm infestation (1)	Ascariasis	

disorders using both antegrade and retrograde routes. The results suggest that this technique is promising and could achieve high diagnostic yield (65%), a higher number of panenteroscopy (60%), and could provide stable enteroscope position to perform therapeutic procedures.

NMSE is the latest addition to the armamentarium to achieve deep enteroscopy and offers multiple features including self-propulsion and a separate channel with an integrated water jet, which provides better irrigation and keeps the view clear. A shorter enteroscope with a larger channel of 3.2 mm compared with BAE (channel diameter of 2.8 mm) makes diagnostic and therapeutic enteroscopy much easier. The drawback of this procedure is that patients require general anesthesia and intubation for antegrade procedures. Moreover, it is contraindicated in patients with large esophageal varices, diseases with poor esophageal compliance like eosinophilic esophagitis, and pediatric patients, especially infants and toddlers. At our institute we prefer SBE over NMSE in postoperative patients with adhesions; however, more data are needed to

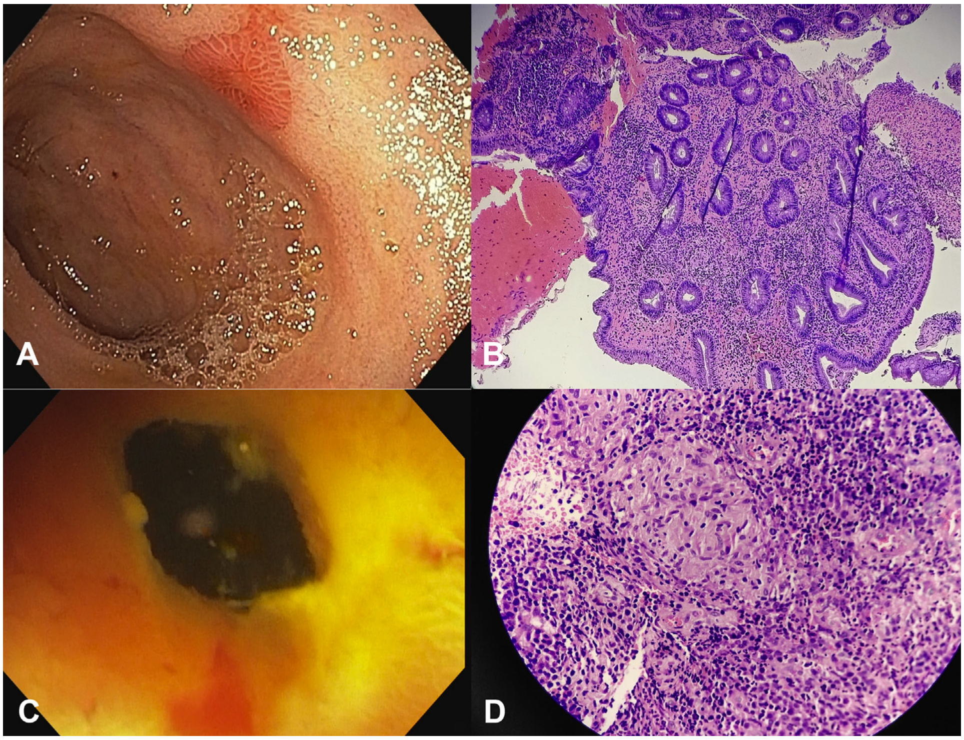

Figure 4. A, Novel motorized spiral enteroscopy (NMSE) image showing ulceration and mucosal edema in the jejunum. **B,** Architecture distortion with disarray and microgranulomas (Crohn's disease) (H&E, orig. mag. ×10). **C,** NMSE image of a jejunal ulceration with stricture. **D,** Large well-defined granuloma consisting of epithelioid histiocytes rimmed by lymphocytes (tuberculosis) (H&E, orig. mag. ×40).

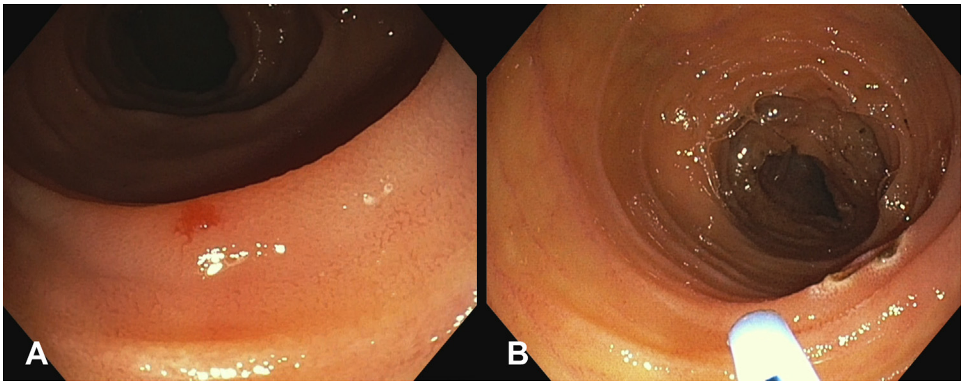

Figure 5. A, Novel motorized spiral enteroscopy image showing jejunal angioectasias. **B,** Treated with argon plasma coagulation.

know the efficacy and safety of NMSE in this subset of patients.

In comparison with BAE, NMSE works on a different principle. This is a self-propulsive motorized version of the spiral enteroscope that uses the technique of "pulling" the bowel toward itself by rotation of the shaft. This rotation of a spiral overtube at the distal end of the enteroscope converts the rotational energy into linear energy that pleats the intestine onto the enteroscope, whereas BAE is a push and pull technique, wherein with every push and pull cycle the bowel is pleated behind the balloon of an overtube. Although there was no head-to-head comparison between these 2 technologies, in this study the median time to complete the NMSE procedure was relatively short. The antegrade and retrograde procedures were completed in 40 and 35 minutes, respectively. The principle of pulling rather than pushing the endoscope into the bowel is advantageous and makes the procedure quicker; moreover, the rotation of spiral fins fixes the bowel and provides stability to perform therapeutic procedures even in deeper positions. The power spiral control unit allows gradual and controlled withdrawal of

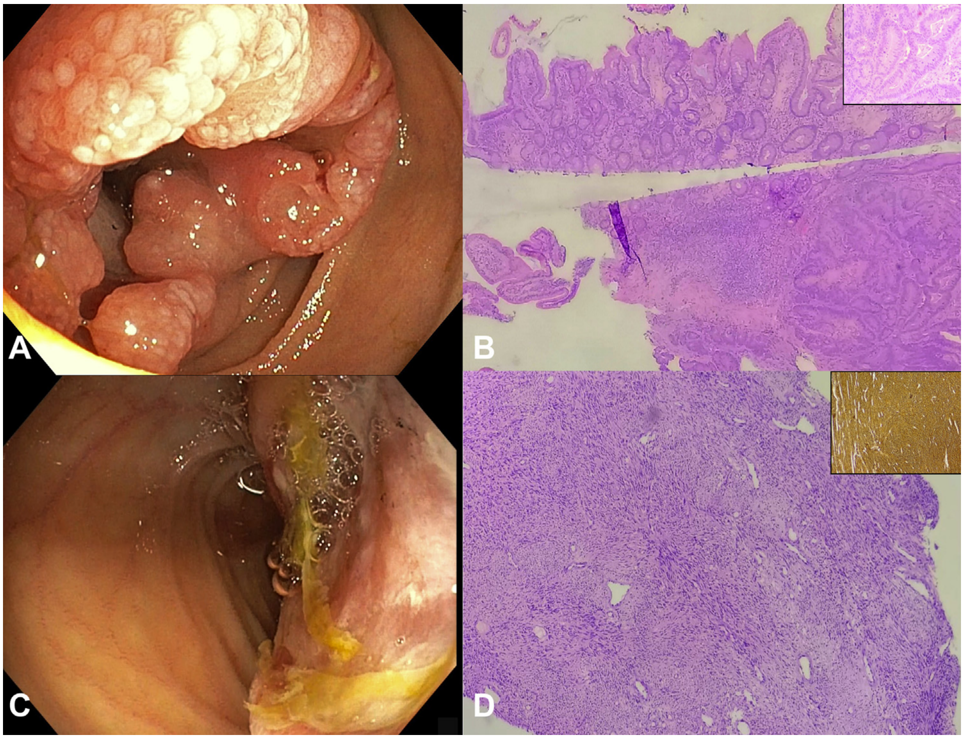

Figure 6. A, Novel motorized spiral enteroscopy (NMSE) image showing ulceroproliferative growth in the jejunum. **B,** Transition from benign jejunal mucosa to tumor in a glandular pattern infiltrating into the lamina propria and muscularis mucosa (H&E, orig. mag. ×4). Inset, Neoplastic glands (H&E, orig. mag. ×40). **C,** NMSE image showing an ulcerated mass with friability in distal ileum. **D,** Spindle cell tumor arising from the submucosa and extending into the mucosa (H&E, orig. mag. ×4). Inset, CD 117 showing cytoplasmic positivity in spindle cells (GI stromal tumor) (immunohistochemistry, orig. mag. ×40).

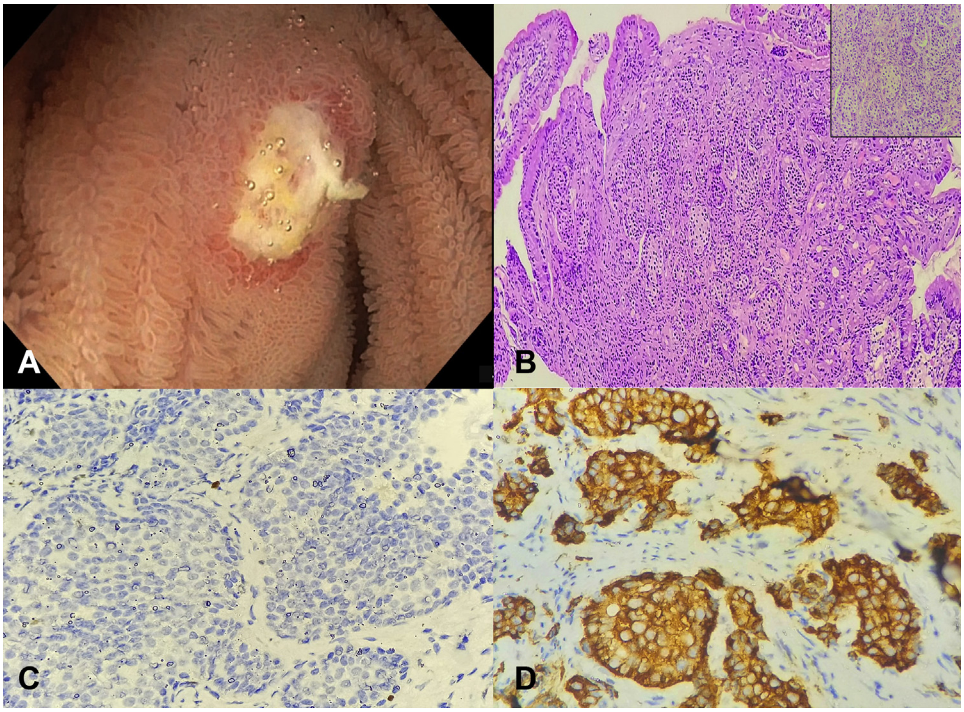

Figure 7. A, Novel motorized spiral enteroscopy image of the ileal mucosa showing an ulcerated subepithelial lesion. **B,** Expansion of the lamina propria and muscularis mucosa with nests of monomorphic round cells (H&E, orig. mag. ×4). Inset, Well-differentiated tumor in nests with monomorphic round cells with stippled chromatin (H&E, orig. mag. ×40). **C,** Ki67 positivity 1%, grade 1 neuroendocrine tumor (immunohistochemistry, orig. mag. ×40). **D,** Synaptophysin showing cytoplasmic positivity in tumor cells (immunohistochemistry, orig. mag. ×10).

the enteroscope without any slippage, thereby minimizing the chances of missing lesions and facilitates adequate evaluation of the small bowel and therapeutic procedures like clipping, APC, or polypectomy. All therapeutic procedures could be done with regular colonoscopic accessories without failures.

Very limited data are available on the efficacy of NMSE. One recent prospective study by Beyna et al[12] using NMSE for antegrade enteroscopy only showed a TER of 10.6% (14/132) and a technical success of 97%. Most patients (74.2%) underwent NMSE for suspected GI bleeding. Overall, the diagnostic yield was 74.2%, and endotherapy was done in 68.2% of patients. In our study, we found comparable technical success using both antegrade (92.85%) and retrograde (100%) routes. We had a greater TER of 60.6%, with the antegrade route showing 31.1%. In this study, bidirectional enteroscopy was done, and the variation in the panenteroscopy rate may also be because of a different population in 2 different geographic regions.

This real-world scenario analysis showed that the diagnostic yield of NMSE was 70% in those who successfully underwent enteroscopy, and therapeutic procedures were done in almost one-fourth of patients. In our study, most indications were inflammatory lesions, predominantly Crohn's disease. This probably explains the inclusion of a larger number of young men in this study[13] and the need for fewer therapeutic interventions as compared with the previous study[12] in which most cases were GI bleeding, wherein therapeutic procedures are required more frequently. Interestingly, we also found a larger number of patients with Crohn's disease as compared with small-intestinal tuberculosis in the Indian population as the predominant etiology of small-bowel ulceration with or without strictures. In tropical countries like India, Crohn's disease, intestinal tuberculosis, and other diseases[13-15] are important causes of small-bowel ulcers, and techniques like NMSE can immensely benefit in reaching to correct diagnosis by facilitating morphologic assessment of the lesion and tissue acquisition for histopathologic diagnosis.

No head-to-head studies compare BAE with NMSE or SE with NMSE. Randomized controlled studies comparing DBE versus SBE have shown the diagnostic yield for both groups ranged from 40% to 60%,[4,5] with an overall rate of adverse events of pancreatitis, bleeding, and perforation being 1.2% to 1.6%. There are limited data comparing DBE[16] and SBE[17] with SE. One prospective study of DBE versus SE by Rahmi et al[16] showed that SE appeared to be as safe as DBE for small-bowel exploration with a similar diagnostic and therapeutic yield. A small prospective study[18] compared DBE and SE in 26 patients, showing that DBE achieved complete enteroscopy in 92% of patients compared with only 8% in the SE group; however, the main drawback of DBE was significantly longer duration of procedure.

No major adverse events were noted in this study; however, minor adverse events including throat discomfort and superficial mucosal erosions were seen in approximately one-fourth of patients. This novel enteroscope is designed with some safety features. The most important is a feature of assessment of resistance, which becomes very important in the absence of having tactile feedback in motorized enteroscopy. If resistance beyond the preset safety limit is felt, the forward movement stops, preventing any major injury to the bowel. The flip side of having such a feature is that it is difficult to do this procedure in postoperative patients where the bowel may have adhesions, causing kinking of the bowel. All patients in this study underwent preemptive wire-guided bougie dilatation of 18 to 20 mm before the procedure. A larger diameter of overtube poses a challenge and causes a potential risk of esophageal injury because of unexpected stricture or reduced compliance. Reduced compliance of esophagus or angulation at the duodenojejunal flexure may put undue resistance and the forward rotation of machine can stop. In our study, in the 4 cases that were unsuccessful, the enteroscope could not be negotiated beyond the esophagus in 1 and beyond the duodenojejunal flexure in 3 patients.

Our study suggests that NMSE takes less time for the procedure and achieves total enteroscopy with minimal adverse events, hence making it an extremely exciting prospect for the future in the field of enteroscopy and in planning future comparative studies. Limitations of our study are that it is a retrospective study done in selective patients and no comparison was done with the presently available BAE. Randomized controlled trials should be done in the future for head-to-head comparisons between NMSE and BAE.

To conclude, this was a novel study to assess the efficacy of NMSE in patients with small-bowel disease. In our experience, NMSE is easy to perform with a high diagnostic yield and few adverse events and represents a promising alternative to the present BAE techniques.

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