



Single-balloon enteroscopy in management of small-bowel disorders

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Abstract

Background Device-assisted enteroscopy including single-balloon enteroscopy (SBE) allows direct visualization of the small bowel and has good safety and efficacy in experienced hands. Our study is aimed to share our single-centre experience of SBE in diagnosing and treating small-bowel disorders.

Methods We reviewed the prospectively collected data (from December 2016 to December 2019) of 180 consecutive antero- and/or retrograde procedures. Analysis of baseline characteristics, endoscopic findings, and diagnostic and therapeutic rates was done.

Results SBE was done in 158 patients with a median age of 55 years (range, 13–94 years) for suspected small-bowel lesions. Dual enteroscopy (anterograde plus retrograde) was done in 22 patients (13.92%). The indication for the procedure was obscure gastrointestinal bleeding in 129 (71.66%), chronic unexplained abdominal pain in 20 (11.11%), suspected small-bowel abnormality in the form of narrowing and/or mass on imaging in 10 (5.5%), chronic diarrhea in 9 (5%), unexplained iron deficiency anemia in 9 (5%), and retained capsule in 2 (1.11%). The most common finding was ulcer, which was noted in 45 (25%) patients followed by stricture in 8 (4.44%) and both ulcers and strictures in 6 (3.33%) patients. SBE was normal in 61 (33.88%) patients. SBE gave a diagnosis in 66.11% while in 28.43% cases, therapeutic intervention was done. Minor complications like bleeding were noted in 3 patients and mild acute pancreatitis in 2 patients. Jejunal perforation requiring surgical intervention was noted in 1 patient.

Conclusion SBE is a safe and effective procedure in diagnosing and treating small-bowel diseases.

Keywords Antegrade enteroscopy · Capsule endoscopy · Iron deficiency anemia · Obscure gastrointestinal bleed · Retrograde enteroscopy · Single-balloon enteroscopy · Small bowel · Spirus enteroscopy

Introduction

Endoscopic observation of the entire small intestine and subsequent management without surgery have been possible since the discovery of double-balloon enteroscopy (DBE) by Yamamoto et al. [1]. In 2007, Olympus Medical Systems (Tokyo, Japan) launched the single-balloon enteroscopy (SBE) as an alternative to DBE [2–4]. The preparation and procedure time somewhat shortened by the application of one instead of two balloons. Direct visualization of the whole small intestinal mucosa became

possible in 2001 with the introduction of capsule endoscopy [5]. However, tissue sampling and therapeutic interventions are major limitations with capsule endoscopy.

The data on the safety and efficacy of balloon-assisted enteroscopy has been analyzed and published regularly since its introduction. But the most data are obtained from studies using DBE, and data obtained using SBE are limited [6–8]. More studies are therefore required to evaluate the safety and efficacy of the SBE in the diagnosis and management of small-bowel disorders. The aim of this study was to assess the indications, diagnostic rate, need for therapeutic interventions, and complications of SBE (both antero- and retrograde) in a tertiary medical centre in India.

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Methods

The present study conducted an analysis of the data obtained from patients who were admitted to a high-volume

Bullet points of the study highlights

What is already known?

- Single balloon enteroscopy (SBE) is a novel procedure for diagnosis and treatment of small bowel disorders.
- Incomplete visualization of the small bowel is still the major limitation.

What is new in this study?

- Diagnostic utility of SBE dominates over its therapeutic potential to manage a small bowel disease which further improves if appropriate radiological imaging is done prior to the enteroscopy.

What are the future clinical and research implications of the study findings?

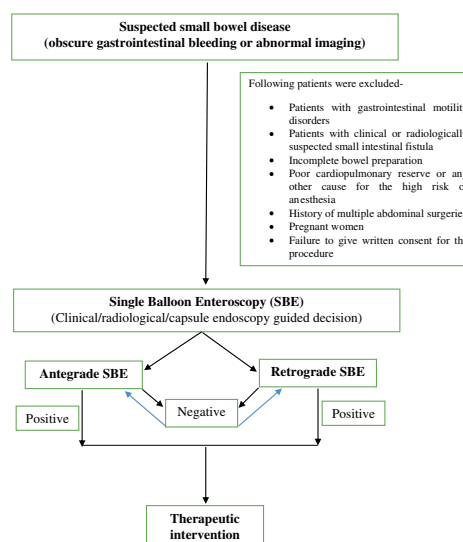
- Large multi-centre studies are needed to assess the safety and efficacy of single balloon enteroscopy especially in the era of motorized spirus enteroscopy.

endoscopy centre of a large corporate hospital in Kolkata, who underwent single-balloon enteroscopy from December 2016 to December 2019. Approval from the ethical committee of our institution was taken for this study. A total of 180 anterograde (through oral route) or retrograde (through rectal route) procedures were done in 158 patients for suspected small-bowel lesions. Dual enteroscopy (anterograde plus retrograde) was done in 22 of these patients. Patient's demographic data, clinical indication for enteroscopy, indications and findings of prior radiological imaging (abdominal ultrasonography, computed tomography [CT] of the abdomen or CT angiography/CT enteroclysis/magnetic resonance enteroclysis), esophagogastroduodenoscopy (EGD), colonoscopy, procedural data, findings, and complications were recorded. All patients provided written consent prior to the procedure. All procedures were done using SIF-Q180, Olympus scope (Olympus Medical Systems, Hachioji-shi, Tokyo, Japan) of length 200 cm and 2.8-mm working channel diameter, and overtube with length of 140 cm, inner diameter of 11 mm, and outer diameter of 13.2 mm.

Patients who met any of the following criteria were included in the present study:

1. Non conclusive EGD and colonoscopy with suspected small-bowel disease
2. Localization of small-bowel pathology by capsule endoscopy or imaging studies (CT angiography, CT or magnetic resonance [MR] enteroclysis)
3. Suspected small-bowel bleed

Study flow chart



Procedure

Patients were kept fasting for at least 6–8 h prior to the procedure. Retrograde procedure was carried out after bowel preparation with 2 L of polyethylene glycol with electrolyte solution (one sachet containing 118 g of polyethylene glycol was dissolved in 2 L of water). All the procedures were carried out under sedation using propofol or midazolam by an

anesthetist. The depth of insertion was measured by counting the amount of small bowel traversed on withdrawal in 5- to 10-cm increments. The route of insertion (antegrade or retrograde) was guided either by radiological imaging or wireless capsule endoscopy. In patients in whom no lesion was identified by the antegrade approach, the subsequent retrograde approach was performed and vice versa. Depending on the findings of enteroscopy, therapeutic procedures were performed as and when necessary. In clinically appropriate situations, tissue sampling was performed and samples were sent for histopathological analysis.

Statistical analysis

All statistical analyses were performed using Statistical Package for Social Science (SPSS; version 09.0 for Windows, SPSS Inc., Chicago, IL., US). For categorical data, Chi-square or Fisher's exact tests were used, and for continuous variables, Student's *t* test was used. Differences with $p < 0.05$ were considered statistically significant.

Results

A total of 180 diagnostic and/or therapeutic SBE procedures were performed in 158 patients. Dual enteroscopy (antegrade plus retrograde) was performed in 22 (13.92%) patients, and

136 (86.07%) underwent either antegrade SBE or retrograde SBE. The median age of the patients (94 males and 64 females) was 55 years (range, 13–94 years). There was no statistical difference between age and gender distribution between the antegrade and retrograde groups of patients. Out of 180 SBE procedures, 114 (63.33%) were performed by antegrade approach and 66 (36.66%) were performed by retrograde approach (Table 1). Indications for the single-balloon enteroscopy were as follows: obscure gastrointestinal (GI) bleeding in 129 (71.66%) procedures, chronic unexplained abdominal pain in 20 (11.11%), suspected small-bowel abnormality in the form of narrowing and/or mass on imaging in 10 (5.5%), chronic diarrhea in 9 (5%), unexplained iron deficiency anemia in 9 (5%), retained capsule in 2 (1.11%), and suspected small-bowel tumor in 1 (0.55). The enteroscopy was normal in 61 (33.88%) patients. In patients with obscure GI bleeding, chronic diarrhea, and anemia, the retrograde approach was more common than the antegrade approach. A total of 9 patients had chronic diarrhea as the predominant symptom. Among them, 5 underwent SBE through the antegrade approach and the remaining 4 through the retrograde approach. No lesion was identified in 3 patients, jejunal erosions and ulcerations were noted in 2 patients whose biopsies revealed non-specific inflammation, ileal ulcers and narrowing were noted in 2 and 1 patients, respectively, and their biopsies revealed features of Crohn's disease. The remaining one patient had ileal erosions whose biopsy showed non-specific inflammation. Among the 20 patients

Table 1 Clinical characteristics of patients under study

Characteristics	Total SBE ($n = 180$)	Antegrade ($n = 114$)	Retrograde ($n = 66$)	<i>p</i>
Age in year, median (range)	55 (13–94)	55 (13–94)	61 (16–84)	0.15
Sex, M (%)	94 (59.49)	62 (54.38)	32 (48.48)	0.552
Comorbidities				
Diabetes mellitus, <i>n</i> (%)	45 (25%)	25 (21.92%)	20 (30.30%)	0.267
Hypertension, <i>n</i> (%)	35 (19.44%)	30 (26.31%)	05 (7.57%)	0.002
Ischemic heart disease, <i>n</i> (%)	10 (5.55%)	07 (6.14%)	03 (4.54%)	0.763
COPD, <i>n</i> (%)	02 (1.11%)	01 (0.87%)	01 (1.51%)	0.564
Abdominal surgery, <i>n</i> (%)	02 (1.11%)	01 (0.87%)	01 (1.51%)	0.564
Indications				
Obscure GI bleeding, <i>n</i> (%)	129 (71.66)	79 (69.29)	50 (75.75)	0.561
Chronic diarrhea, <i>n</i> (%)	09 (5.00)	05 (4.38)	04 (6.06)	0.527
Anemia, <i>n</i> (%)	09 (5.00)	06 (5.26)	03 (4.54)	0.739
Chronic abdominal pain, <i>n</i> (%)	20 (11.11)	10 (8.77)	10 (15.15)	0.221
Small-bowel tumor, <i>n</i> (%)	01 (0.55)	01 (0.87)	00	
Suspected small-bowel abnormality on imaging, <i>n</i> (%)	10 (5.55)	03 (2.63)	07 (10.6)	0.033
Foreign body, <i>n</i> (%)	02 (1.11)	02 (1.75)	00	
Intervention rate, <i>n</i> (%)	102 (56.66)	65 (57.01)	37 (56.06)	0.925
Diagnostic rate, <i>n</i> (%)	119 (66.11)	79 (69.29)	40 (60.60)	0.428

COPD chronic obstructive pulmonary disease, GI gastrointestinal, SBE single-balloon enteroscopy

who had chronic abdominal pain as the predominant symptom, enteroscopy was normal in 9 patients, Crohn's disease was diagnosed (after SBE-guided biopsy) in 7, tuberculosis in 2, and non-specific inflammation in the jejunum in the remaining 2 patients. The indication for SBE was unexplained iron deficiency in 9 patients. Among them, no lesion was identified in 5 patients, superficial jejunal ulcers were noted in 2 patients, tiny worms were noted in the ileum of one patient, and post-polypectomy ulcers were noted in the distal jejunum of one patient. The diagnostic rate of the antegrade approach was 69.29% and of retrograde approach was 60.60%. The overall diagnostic rate of SBE is 66.11%.

Findings The most common finding in SBE (Table 2) was ulcerations. It was noted in 45 (25%) patients (23 of these were found through antegrade SBE and 22 through retrograde approach). There was no significant difference between these two approaches ($p = 0.074$). Stricture was noted in 8 (4.44%) patients (2 on antegrade and 6 on retrograde SBE, $p = 0.035$). Both ulcers and strictures were noted in 6 (3.33%) patients. Small-bowel angiodysplasia and Dieulafoy's lesions were noted in 5 (2.77%) and 3 (1.66) patients, respectively through the antegrade SBE. Active bleeding source was identified in 14 (7.77%) patients with significantly more in antegrade SBE in comparison with retrograde SBE (antegrade 11.4% vs. retrograde 1.51%, $p = 0.013$). Eight (4.44%) patients had arteriovenous malformations (6 on antegrade and 2 on retrograde SBE, $p = 0.48$). Superficial erosions with no signs of active bleeding were noted in 19 (10.55%) patients (antegrade 13.15% vs. retrograde 6.06%, $p = 0.108$). Other findings like congestive enteropathy, diverticula, and non-specific lesions were noted in 3 (1.66%), 4 (2.22%), 1 (0.55%)

patients, respectively. One patient had 2 polyps in the terminal ileum, which required polypectomy during antegrade SBE, and the same patient was found to have an ulcero-proliferative mass in the mid-jejunum for which tattooing was done and was referred to surgery after marking the mass using a tattoo. Figure 1 shows tumor with clean-based ulcer over it in the jejunum (left image) and ulcer with edematous mucosa noted in the ileum (right image). The most common intervention was obtaining a biopsy from the lesions (Table 3). The rate of obtaining biopsy was significantly higher in retrograde SBE compared with that in antegrade SBE (91.89% vs. 60.31%, $p = 0.007$).

In our study, four children belonging to the age group between 13 and 18 years underwent SBE. Indications in three of them were obscure GI bleeding who on enteroscopy were found to have ileal ulcers in one child, jejunal submucosal lesion suspicious of GI stromal tumor in another child, and a normal finding in the third child. The indication of SBE in the fourth child in our study was chronic diarrhea with suspected small-bowel Crohn's disease, whose enteroscopy revealed jejunal ulceration, nodularity, and stricture. In all the four children, propofol was used as an anesthetic agent and was monitored by a skilled anesthetist during the procedure.

Therapeutic interventions Therapeutic procedures were carried out in 28 patients (Table 3). Among them, 19 required argon plasma coagulation (APC), 2 required adrenaline injection, 4 underwent stricture dilatation, 1 underwent polypectomy, and 2 underwent capsule removal. The most common mode of achieving hemostasis was APC, which was used in 19 patients with the majority (18) being done by

Table 2 Single-balloon enteroscopy findings

Enteroscopy findings	Total SBE ($n = 180$) (%)	Antegrade ($n = 114$) (%)	Retrograde ($n = 66$) (%)	p
Ulcer	45 (25)	23 (20.17)	22 (33.33)	0.074
Stricture	08 (4.44)	02 (1.75)	06 (9.09)	0.035
Ulcer and stricture	06 (3.33)	04 (3.5)	02 (3.03)	0.705
Angiodysplasia	05 (2.77)	05 (4.38)	00	
Dieulafoy's lesion	03 (1.66)	03 (2.63)	00	
Bleeding	14 (7.77)	13 (11.4)	01 (1.51)	0.013
Growth/mass	01 (0.55)	01 (0.87)	00	
Erosions	19 (10.55)	15 (13.15)	04 (6.06)	0.108
Retained VCE	02 (1.11)	02 (1.75)	00	
AVM	08 (4.44)	06 (5.26)	02 (3.03)	0.48
Congestive enteropathy	03 (1.66)	03 (2.63)	00	
Diverticula	04 (2.22)	02 (1.75)	02 (3.03)	0.655
Non-specific lesions	01 (0.55)	00	01 (1.51)	
Negative/normal	61 (33.88)	35 (30.70)	26 (39.39)	0.339

AVM arteriovenous malformations, SBE single-balloon enteroscopy, VCE video capsule endoscopy

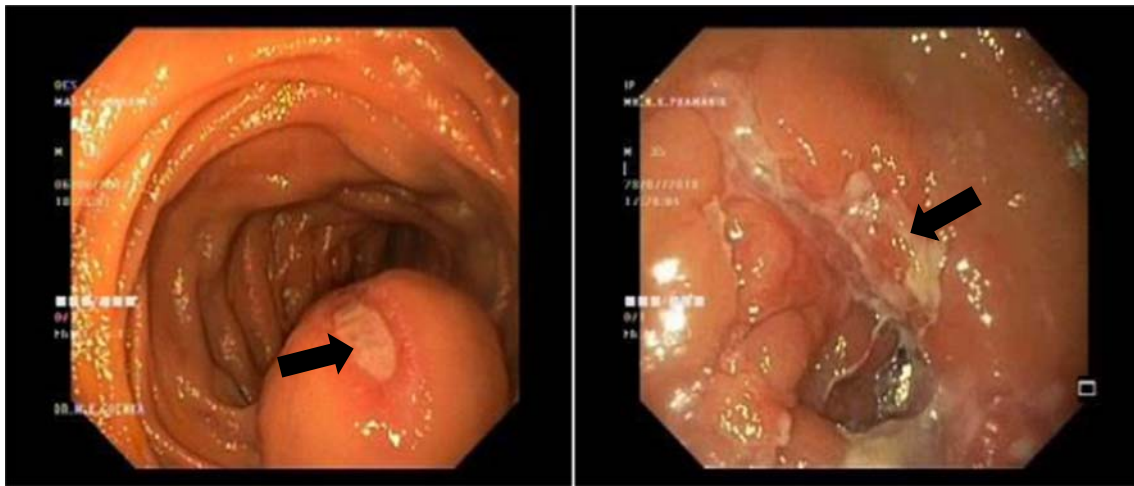


Fig. 1 Tumor with clean-based ulcer over it in the jejunum (left image) and ulcer with edematous mucosa noted in the ileum (right image)

antegrade SBE and only one done by the retrograde route. Major reason for doing APC was jejunal arteriovenous malformation in 8 patients (among them 2 patients had Dieulafoy's lesion with ooze in the mid-jejunum and 3 had jejunal angiodysplasia). In 8 patients, bleeding jejunal ulcer required APC to control the bleeding. Other reasons for doing APC were radiation enteritis in 2 patients and portal hypertensive enteropathy in one patient. Adrenaline injection was used in 2 patients. One patient had congestive enteropathy in the distal jejunum and the other had jejunal angiodysplasia who needed adrenaline injection to control the bleeding. Stricture dilatation was done in 4 patients (2 by antegrade SBE and 2 by retrograde SBE). During retrograde SBE, 6 patients had strictures in the ileum. Among them, 2 were follow-up cases of stricturing Crohn's disease who were subjected to SBE for stricture dilatation. The remaining 4 patients were found to have mild narrowing (scope was easily negotiated through the stricture) in the ileum, which did not require dilatation, and hence, only biopsies were obtained from these strictures. The locations of strictures requiring dilatation were ileum in 2 patients, jejunum in one, and hepaticojejunostomy site in

one patient. Enteroscope could be negotiated after dilatation in all four patients. Patients improved symptomatically 3 to 4 days following the procedure. Capsule was retained in 2 patients with jejunal stricture, which required removal with the help of SBE (antegrade). One patient required tattooing of the small-bowel lesion prior to surgery. Therapeutic success was achieved in stricture dilatation, polypectomy, and capsule removal. However, among the 19 patients who underwent APC for bleeding control, 4 had rebleeding within 24 h requiring angioembolization. Therefore, therapeutic success was achieved in 25 out of 29 patients (86.20%). Suspected small-bowel abnormality on imaging (CT enterography) was the indication for SBE in 10 patients. Imaging prior to enteroscopy helped in deciding the approach (antegrade or retrograde) and on enteroscopy all these patients had the lesions (strictures, ulcers, bleeding, etc.) consistent with the imaging. CT angiography prior to SBE was done in 20 patients out of whom 5 underwent angioembolization of the bleeding vessels, while SBE-guided endotherapy was done in the remaining 15 patients. In this way, CT angiography done prior to SBE made the job of localizing the bleeding source easier.

Table 3 Diagnostic and therapeutic endoscopic interventions

Intervention	SBE with interventions (<i>n</i> = 100) (%)	Antegrade (<i>n</i> = 63) (%)	Retrograde (<i>n</i> = 37) (%)	<i>p</i>
Diagnostic				
Biopsy	72 (72)	38 (60.31)	34 (91.89)	0.007
Therapeutic				
Hemostasis				
1. APC	19 (19)	18 (28.57)	01 (2.7)	<0.0001
2. Injection adrenaline	02 (2)	02 (3.17)	00	
Stricture dilatation	04 (4)	02 (3.17)	02 (5.4)	0.48
Polypectomy	01 (1)	01 (1.58)	00	
Removal of foreign body	02 (2)	02 (3.17)	00	

SBE single-balloon enteroscopy, APC argon photo coagulation

Table 4 Indication of enteroscopy in those patients with negative/normal study

Indication	Negative SBE (<i>n</i> = 61) (%)	Antegrade (<i>n</i> = 35) (%)	Retrograde (<i>n</i> = 26) (%)	<i>p</i>
GI bleed	43 (70.49)	23 (65.71)	20 (76.29)	0.401
Abdominal pain	09 (14.7)	04 (11.42)	05 (19.23)	0.144
Diarrhea	03 (04.91)	03 (8.57)	00	
Anemia	06 (9.83)	05 (14.28)	01 (3.84)	0.018

SBE single-balloon enteroscopy, GI gastrointestinal

SBE was not diagnostic or yielded negative result in 61 (33.88%) patients (Table 4). Among the negative SBE, the most common indications were obscure GI bleeding in 43 patients, abdominal pain in 9, diarrhea in 3, and anemia in 6 patients. Among these 4 indications, anemia was a significant indication for antegrade enteroscopy ($p = 0.018$). Procedure-related complications were noted in 6 patients in our study. Minor complications like bleeding were noted in 3 patients (2 during retrograde and 1 in antegrade SBE) and were managed conservatively. Mild acute pancreatitis was noted in 2 patients during antegrade SBE, which improved with symptomatic treatment. Jejunal perforation requiring surgical intervention was noted in one patient during retrograde SBE.

Discussion

SBE has a high intervention and diagnostic rate with very low rates of complications. In addition, SBE is convenient and easier to manipulate in comparison with DBE with experienced operators [9]. In this study, a variety of small-bowel lesions were diagnosed and treated using SBE. Though there are limitations in the study, the diagnostic yield ranges from 58% to 70% [7,10–15].

The diagnostic yield of SBE in our study was 66.11% and the therapeutic intervention rate (excluding biopsies) was 28.43%, which are similar to those of previous reports [10–12]. The general condition and comorbidities did not differ whether they were done by antegrade or retrograde SBE. The indications for SBE and the diagnostic yield in our study

did not differ by antegrade or retrograde SBE except that suspected small-bowel abnormality on imaging leading to SBE was done mainly through the retrograde approach (70%). In the present study, the most common indication was obscure GI bleeding, which was seen in 129 (71.66%) patients. Similar to the other reports from the eastern countries, the causes of bleeding in our study were predominantly inflammatory rather than vascular lesions.

Panenteroscopy (antegrade plus retrograde SBE using tattoo as a marker) was done in 5/22 (22.72%) patients. The rate of panenteroscopy (Table 5) is similar to the previous studies [16–20].

Endoscopists with different levels of experience may have reported inconsistent findings on the efficacy and safety of SBE, including diagnostic and complication rate in the previous studies. In our study, all the SBE procedures were carried out by one of two endoscopists with more than 5 years of clinical practice in small-bowel endoscopy such as push enteroscopy. Therefore, in our study, there was no performance bias of the operators on the results.

Drawback of the study was that it was a single-centre study. Larger multi-centre studies are required to validate these findings in detail.

In conclusion, SBE is a safe and effective procedure in diagnosing and treating small-bowel diseases. The diagnostic yield increases if the radiological imaging is done prior to the procedure and helps in deciding the approach (antegrade or retrograde). Though advanced imaging modalities in the form of video capsule endoscopy, CT enterography, nuclear scan, etc. are available for localizing the lesions, the definitive

Table 5 Rates of panenteroscopy using single-balloon enteroscopy

Year	Reference	Study design	No. of cases	Rate of panenteroscopy
–	Present study	Prospective	180 procedures in 158 patients	5/22 (22.72%)
2014	Li et al. [16]	RCT	106	37/106 (34.9%)
2011	Takano et al. [17]	RCT	14	0/14 (0%)
2011	Domagk et al. [18]	RCT	65	7/65 (11%)
2010	May et al. [19]	RCT	50	11/50 (22%)
2009	Ramchandani et al. [20]	Case series	131 procedures in 106 patients	5/20 (25%)

RCT randomized controlled trial

diagnosis and effective treatment can be possible only with the enteroscopy. In spite of meticulous evaluation and clinical expertise, SBE failed to yield the diagnosis in about one-third of the procedures, which required further evaluation with other imaging modalities.

Author contributions Mahesh Goenks made the study concept and protocol design. Shivaraj Afzalpurkar did the collection and analysis of data and prepared the initial draft of the manuscript. Vijay Rai, Rachit Agarwal, Bhavik Shah, Gajanan Rodge, Bhaerath Raj, and Usha Goenka did the critical review of the manuscript for intellectual content.

Compliance with ethical standards

Conflict of interest MKG, SA, VKR, RA, BBS, GAR, BR, and UG declare that they have no conflict of interest.

Ethics statement The study was performed conforming to the Helsinki declaration of 1975, as revised in 2000 and 2008 concerning human and animal rights, and the authors followed the policy concerning informed consent as shown on Springer.com. Approval from the ethical committee of our institution was taken for this study. All patients provided written consent prior to the procedure.

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