〈Regular Article〉

Evaluating the accuracy of the sandwich method in colonic stent placement

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ABSTRACT　To enhance the accuracy of stent placement in obstructive colorectal cancer, we evaluated the efficacy of the “sandwich method”, a technique developed at our institution. This retrospective observational study included 28 patients who underwent endoscopic colonic stent placement followed by surgical resection between April 2022 and August 2024. The degree of misalignment between the center of the stent and the center of the tumor was assessed using resected specimens.

The mean deviation was 4.37 mm, with 71.4% of cases exhibiting a displacement of less than 5 mm. Technical success was achieved in all cases (100%), and clinical success was observed in 92.8% of patients. No procedure-related adverse events were reported.

The sandwich method, which involves partial stent deployment followed by endoscopic compression to secure positioning, enables precise placement even in anatomically challenging cases such as rectal lesions. It also allows for the use of shorter stents, potentially reducing the risk of complications such as delayed perforation and contributing to improved surgical outcomes. These findings suggest that the sandwich method is a safe and effective technique for colonic stent placement, particularly in cases requiring accurate positioning. Further studies are warranted to validate its applicability in other institutions and clinical settings.

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Key words：Colon cancer, Malignant colorectal obstruction, SEMS, Sandwich method

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INTRODUCTION

Obstructive colorectal cancer occurs in approximately 10-15% of all colorectal cancer cases[1]. Delayed decompression can result in colonic perforation and subsequent peritonitis, potentially leading to fatal outcomes. Timely decompression is thus essential for avoiding serious complications. Currently available decompression methods include stoma creation, transanal ileus tube placement, and self-expandable metal stent (SEMS) placement.

The first report of colonic SEMS placement was published by Dohmoto *et al*. in 1991 using a repurposed esophageal stent[2], followed by the development of dedicated colonic stents reported by Spinelli *et al*. in 1992[3]. Since then, the technique and devices have been refined, with recent studies reporting technical success rates of 95-98.1%, clinical success rates of 92.1-96%, and complication rates of 2.0-8.5%[4-7]. In addition to effective decompression, SEMS placement helps preserve activities of daily living and quality of life, and its use has been increasing.

Nevertheless, adverse events such as bleeding, perforation, and stent migration remain a concern, with perforation often requiring surgical intervention. Precise stent deployment with minimal misalignment is essential to achieve clinical success without complications. Various strategies have been proposed to improve placement accuracy, including the use of endoscopic clips and proximally deployed stents[8-10].

At our institution, we utilize a technique referred to as the "sandwich method", where the partially deployed stent is stabilized by gently compressing the stricture between the stent and the endoscope. We hypothesize that this approach would enable more accurate stent placement.

This study aimed to evaluate the accuracy of colonic SEMS placement at our institution by measuring stent misalignment and assessing the utility of the sandwich method.

MATERIALS AND METHODS

This study was approved by the Ethics Committee of Kawasaki Medical School (approval number: 6100-01).

Patients

This retrospective study included 28 patients who underwent endoscopic colorectal stent placement followed by surgical resection for bowel obstruction due to primary colorectal cancer at the Kawasaki University General Medical Center between April 2022 and August 2024. The exclusion criteria included patients under 18 years, pregnant women, those who did not provide informed consent, and those whose obstruction was caused by conditions other than primary colorectal cancer.

Before endoscopic stent placement, preoperative evaluation included laboratory testing to assess the degree of anemia and inflammatory markers related to obstructive colitis. Contrast-enhanced computed tomography (CT) was performed to determine the site and cause of the obstruction, assess lymph node and liver metastases for staging purposes, and rule out complications.

Colonoscopy was then performed. When malignant stenosis, including colorectal cancer, was endoscopically suspected, SEMS was placed during the same session. Biopsy specimens were obtained using the same procedure as that used for histopathological confirmation.

In cases where the malignancy could not be clearly diagnosed endoscopically, a transanal ileal tube was placed first. After malignancy was confirmed by histological examination, elective stent placement was performed.

Stent placement was indicated in cases that met the following criteria:

(1) severe stenosis that precluded passage of the colonoscope,

(2) presence of obstructive symptoms, and

(3) absence of gastrointestinal perforation or fistula formation in adjacent organs.

The proximal extent of eligible lesions was defined as ranging from the ileocecal valve to the lower rectum (below the Houston valve). Tumors with the anal side located within this range were considered suitable for stenting.

Acceptable displacement range

As the colon is tortuous and curved, choosing a longer stent may result in poor coaxial alignment between the stent lumen and the colonic lumen due to the relationship between the stent ends and colonic flexures. In this study, the mean tumor length was 38.7 mm, and the distance from the center to each end of the tumor was less than 2 cm. Therefore, when a 6-cm stent was used, it could be placed such that the ends extended slightly beyond the tumor margins, achieving near-coaxial alignment. In such cases, if displacement exceeds 10 mm, the difference from the center to each end becomes greater than 2 cm, meaning the stent cannot adequately cover the entire tumor length, which may result in insufficient relief of obstruction or a higher risk of early re-obstruction. Thus, the goal of maintaining displacement was set to within ≤ 5 mm.

Procedure

Scope insertion and identification of the stenosis

The CF-HQ290 or PCF-H290 colonoscope (Olympus, Tokyo, Japan) was used. For flexural stenoses with limited frontal access, an upper GI scope (GIF-H290T) was used. The scope was advanced to directly visualize the obstruction.

Crossing the stricture

After identifying the stenosis, a guidewire was advanced to the oral side using an endoscopic retrograde cholangiopancreatography catheter (Fig. 1A). Since the tumor mucosa is often fragile, the procedure was carefully performed under fluoroscopy to avoid submucosal or extraluminal passage, with frequent checks for abnormal guidewire movement or air leakage.

Measurement of stricture length

After the catheter crossed the stenosis, contrast was then injected to confirm intraluminal placement by visualizing the colonic haustra. If confirmed, additional contrast was used to assess the stricture length (Fig. 1B). As fluoroscopy may distort length owing to its 2D nature, CT evaluation and patient repositioning were used to improve accuracy.

An uneven double lumen cannula (UDC, PIOLAX Inc., Kanagawa, Japan) with 0.025-inch and 0.035-inch lumens and 30-mm radiopaque markers was used. These, along with the 50-mm radiopaque guidewire tip, aided in estimating the stricture length (Fig. 2).

Stent

The stents used were the **HANAROSTENT®** (Boston Scientific Corporation, Marlborough, MA, USA; manufactured by PIOLAX Inc., Kanagawa, Japan), **Niti-S® Colonic Stent MD** (manufactured by Taewoong Medical Co., Ltd., Gimpo, Korea; distributed by Century Medical Inc., Tokyo, Japan), **JENTLLY® Colonic Stent** (Japan Lifeline Co., Ltd., Tokyo, Japan), and **NEXENT® Colonic Stent** (CREATE MEDICAL Co., Ltd., Kanagawa, Japan) (all 22 mm in diameter; length, 6-12 cm). All strains were hook and cross-typed. For flexural stenoses, JENTLLY® and Niti-S® were preferred for better conformity. In cases with anticipated placement difficulty, a re-sheathable HANAROSTENT® was used. Stent length was defined as stricture length plus 10-20 mm. Shorter stents were used when appropriate to reduce the risks of delayed perforation or re-obstruction.

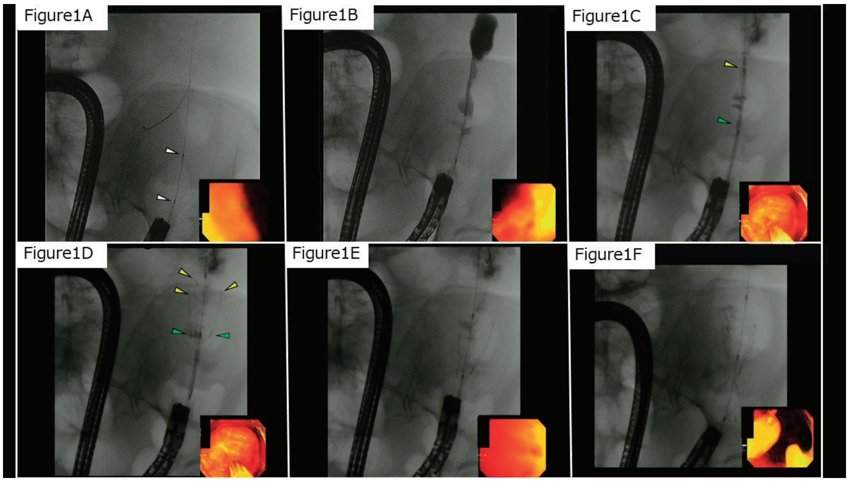

Fig. 1. Fluoroscopic images of colonic stent placement using the sandwich method
A. The stricture is traversed using an endoscopic retrograde cholangiopancreatography guidewire and catheter. Radiopaque marker of the catheter (white arrowhead).
B. Contrast is injected through the catheter to assess the length of the stricture.
C. The stent is advanced until its center passes beyond the midpoint of the stricture. Oral side marker of the stent (yellow arrowhead) and central marker of the stent (green arrowhead).
D. The stent is partially deployed until slightly before its midpoint. Oral side marker of the stent (yellow arrowhead) and central marker of the stent (green arrowhead).
E. The delivery system is retracted to align the center of the stent with the center of the stricture. At this point, the deployed portion of the stent and the endoscope sandwich the stricture.
F. The remaining portion of the stent is deployed within the delivery catheter.

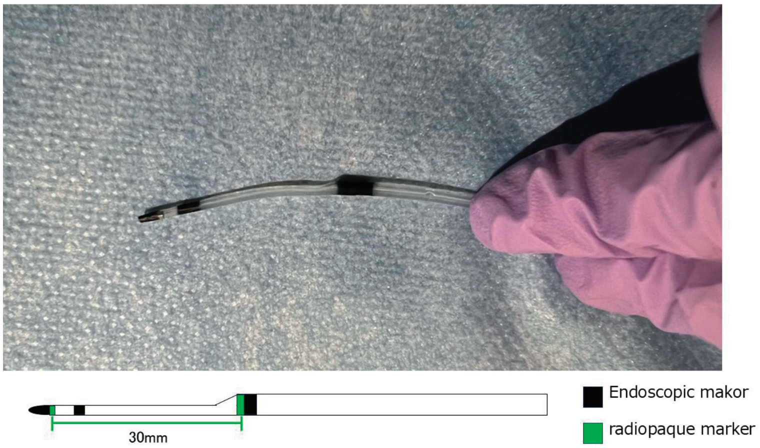

Fig. 2. Endoscopic retrograde cholangiopancreatography catheter.
An uneven double-lumen cannula (PIOLAX, Inc.) was used. It contains two lumens compatible with 0.025-inch and 0.035-inch guidewires and is equipped with a 30-mm radiopaque marker.

Stent insertion

The stent was inserted using the through-the-scope technique. The selected stent was advanced over the guidewire using an endoscope (Fig. 1C). Since reaction forces occur between the stent and stenosis during insertion, they tend to push the endoscope backward. Therefore, frequent adjustments of the scope position and manual fixation by an assistant

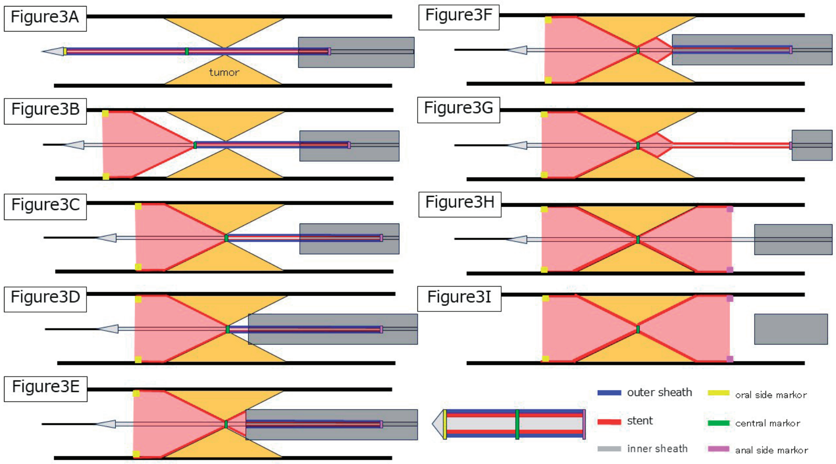

Fig. 3. Schematic illustration of the sandwich method
A. The stent is advanced until its center passes beyond the midpoint of the stricture.
B. The stent is partially deployed until just before its midpoint.
C. The shaft is pulled back until the center of the stent aligns with the center of the stricture.
D. Slight retraction of the shaft causes the stent to catch on the stricture, allowing the endoscope to approach the lesion. At this stage, the tumor is sandwiched between the deployed stent and the endoscope.
E. Deployment of the stent continues.
F. The deployed stent, extending from the tumor to the endoscope, secures positioning. Deployment is completed within the delivery system.
G. Release the stent from within the endoscope channel
H. The stent expands to relieve the obstruction.
I. The introducer and guidewire are removed to complete the procedure.

were necessary.

Stent deployment using the "sandwich technique"

We used the "sandwich technique" for stent deployment. First, the stent was advanced until its midpoint passed beyond the midpoint of the stenosis (Fig. 3A), and deployment was initiated. The stent was expanded up to just before the midpoint (Fig. 1D and 3B). While maintaining this semi-expanded state, the stent shaft was withdrawn slightly to align the stent midpoint with the center of the stricture (Fig. 3C). At this point, the endoscope was advanced toward the tumor (Fig. 3D), effectively "sandwiching" the tumor between the semi-deployed stent and endoscope tip. Further expansion (Fig. 3E) led to stable anchoring between the stricture and scope (Fig. 1E, 3F). The remaining portion of the stent was deployed within the scope channel (Fig. 3G) and fully released (Fig. 1F and 3H). Finally, the introducer and the guidewire were removed to complete the procedure (Fig. 3I).

Post-stenting assessment

Stent expansion was assessed based on clinical signs (stool or flatus) and abdominal radiography the following day. If expansion and obstruction relief were confirmed, the oral intake was resumed. Complications such as bleeding or obstructive colitis were monitored using serial blood tests, including hemoglobin, white blood cells, and C-reactive protein levels.

Outcomes

The primary outcome was the degree of

misalignment between the center of the stent and the tumor assessed after resection. The surgical team opened the specimen to expose the stent and tumor, and the offset was measured by an attending gastroenterologist (Fig. 3). Technical success was defined as successful stent placement without complications (e.g., bleeding, perforation, or misplacement) and confirmed decompression on post-procedure imaging. Clinical success was defined as symptom relief (e.g., nausea, pain, bloating) and resumption of oral intake. The Colorectal Obstruction Scoring System (CROSS) classification, proposed by the Japanese Colorectal Stenting Technical Study Group, was used to evaluate clinical symptoms related to obstruction (Table 1). Obstructive symptoms were defined as abdominal pain, bloating, nausea, vomiting, constipation, or diarrhea triggered by food intake.

Statistical analyses

For statistical analyses, continuous variables were expressed as mean ± standard deviation and compared using the Mann-Whitney U test. Categorical variables are presented as frequencies (percentages) and compared using the chi-square test. All statistical analyses were performed using SPSS version 29 software (IBM Corp., Armonk, NY, USA). Statistical significance was set at $p < 0.05$.

RESULTS

Patient characteristics (Table 2)

Twenty-eight patients were included in this study. The cohort comprised 15 males and 13 females with a mean age of 72.8 years. Patients' characteristics are shown in Table 2. Regarding laboratory findings, the mean hemoglobin level was 11.65 g/dL (range: 6.1-16.0), and some patients presented with anemia, likely associated with tumor bleeding. The CROSS score improved from 1.39 before treatment to 3.89 after treatment, enabling the patients to resume oral intake.

Misalignment between stent and tumor centers; Sandwich technique

The mean misalignment distance between the center of the stent and the center of the tumor was 4.37 mm (range: 0-40 mm), and 4.37 mm (range: 0-40 mm), respectively, and 26 cases (71.4%) showed a displacement of < 5 mm. Among the 17 patients with displacement, the stent was displaced toward the anal side in nine patients and toward the oral side in eight patients.

No damage to the endoscope or stent occurred in any of the cases.

Endoscopic treatment outcomes (Table 3)

The average tumor length was 38.7 mm (range, 10-56 mm), and 24 stents were 6 cm long, making this the most frequently used tumor size.

Table 1. CROSS (Colonic Obstruction Scoring System)

Level of oral intake	Score
Requiring continuous decompressive procedure	0
No oral intake	1
Liquid or enteral nutrient	2
Soft solids, low-residue, and full diet with symptoms of stricture†	3
Soft solids, low-residue, and full diet without symptoms of stricture†	4

† Symptoms of stricture contain abdominal pain/cramps, abdominal distension, nausea, vomiting, constipation, and diarrhea which are related to gastrointestinal transit.

A scoring system proposed by the Japanese Colonic Stent Safe Placement Study Group that reflects the severity of obstruction based primarily on clinical symptoms.

Table2. Patient characteristics

Characteristics	
patients	28
Sex (Male / Female)	15 / 13
Age (mean, range)	72.8 (39 - 93)
Symptoms (abdominal distension / pain / vomiting / hematochezia / others / none)	5 / 3 / 10 / 5 / 2 / 3
Location	
Ascending colon	3
Transverse colon	5
Descending colon	3
Sigmoid colon	7
Rectum (RS / Ra / Rb)	10 (6 / 3 / 1)
Stage (TNM, Ⅱ : Ⅲ : Ⅳ)	8 : 12 : 8
WBC (μL; mean, range)	7309 (710 - 12030)
Hb (g/dl; mean, range)	11.65 (6.1 - 16.0)
CRP (mg/dl; median, range)	0.51 (0.01 - 4.21)
CEA (ng/ml; median, range)	33.55 (1.8 - 420)
CA19-9 (U/ml; median, range)	115.0 (2.1 - 1360)
CROSS (before / after treatment, mean)	1.39 / 3.89

A total of 28 cases were included, with rectal lesions being the most common (n = 10). CROSS scores improved after treatment.

The average misalignment was 4.37 mm. The most frequently used stent length was 6 cm. Both technical and clinical success rates were high.

Table3. Endoscopic treatment outcomes

Endoscopic Outcomes	
Misalignment (mean, mm)	4.37 (0 - 40)
Direction of displacement (central / anal side / oral side)	11 / 9 / 8
Tumor length (mean, mm)	38.7 (10 - 56)
Stent	
HANARO (22 mm 6 cm)	10
HANARO (18 mm 6 cm)	1
HANARO (18 mm 9 cm)	1
JENTLLY (22 mm 6 cm)	9
JENTLLY (22 mm 8 cm)	1
Niti-S (22 mm 6 cm)	1
Niti-S (22 mm 8 cm)	1
Niti-S (22 mm 10 cm)	1
Niti-S (18 mm 6 cm)	1
NEXTENT (22 mm 6 cm)	2
Procedure time (mean, minutes)	22.9 (11 - 70)
Technical success rate (%)	100 (28 / 28)
Clinical success rate (%)	92.8 (26 / 28)
Complication rate (%)	0 (0 / 28)

The average misalignment was 4.37 mm. The most frequently used stent length was 6 cm. Both technical and clinical success rates were high.

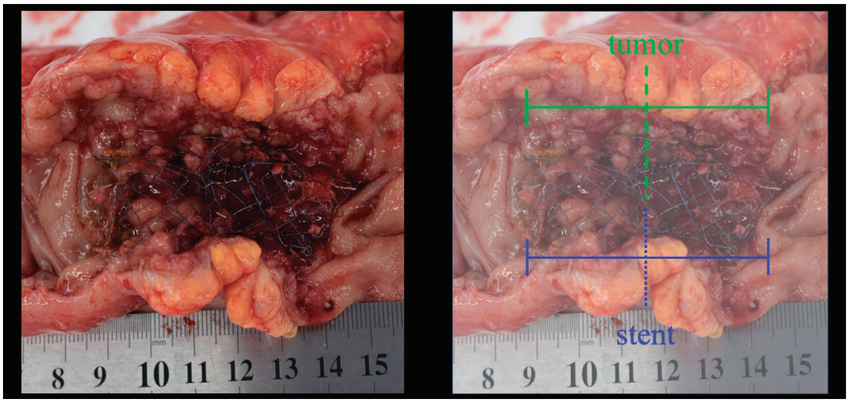

Fig. 4. Resected surgical specimen and measurement of misalignment
The misalignment between the center of the stent and the center of the tumor was measured from the resected specimen. In this case, there was minimal discrepancy, indicating accurate placement.

Table4. Surgical outcomes

Surgical Outcomes	
Waiting period until surgery (mean, days)	42.5 (7 - 228)
Surgical approach (open : laparoscopic : robotic)	
Right hemicolectomy	2 : 3 : 3
Left hemicolectomy	0 : 1 : 4
Sigmoid colectomy	1 : 0 : 1
High anterior resection	1 : 0 : 4
Low anterior resection	1 : 1 : 6
Operative time (mean, minutes)	251 (115 - 468)
Stoma creation rate (%)	21.4 (4 / 28)
Intraoperative complications (%)	0 (0 / 28)
Postoperative complications (%)	10.7 (3 / 28)
abdominal abscess	1 / 28
Peristomal skin infection	1 / 28
Pneumonia	1 / 28
Hospital stay (mean, days)	22.6 (11 - 57)

The interval to surgery was mostly within 2 to 4 weeks. There were no intraoperative complications, and postoperative complications were few. The rate of stoma creation was 21.4%.

The mean procedure time was 22.9 min. Technical success was achieved in 100% of cases, and clinical success was achieved in 92.8%.

In two cases of clinical failure, a transanal ileus tube was placed for decompression, followed by elective surgery. No procedural complications occurred.

Surgical outcomes (Table 4)

The median waiting period between stent placement and surgery was 42.5 days (range, 7-228 days). The surgical approaches included open surgery (n = 4), laparoscopic surgery (n = 5), and robot-assisted surgery (n = 19), with the latter being the most frequently used.

The mean postoperative hospital stay was 22.6 days. A stoma was created in four cases (21.8%), likely due to the relatively high number of rectal lesions.

Postoperative complications occurred in three patients (10.7%).

DISCUSSION

The Colonic Stent Safe Procedure Study Group recommends adequate advancement of the guidewire, decompression of the colonic loops, and accurate measurement of stricture length. Although techniques such as anal-side clip placement have been proposed to assist in positioning, they do not contribute to stent stabilization during deployment. In our method, the stent and endoscope simultaneously "sandwiched" the lesion, minimizing misalignment during deployment. This study demonstrated favorable outcomes using this approach.

Generally, stent deployment is performed by advancing the stent out of the endoscopic channel while confirming the relative positions of the stricture and the stent under fluoroscopic guidance. However, with this method, the positions of the stent and the stricture are not completely fixed, and displacement can easily occur due to the simultaneous manipulation of the endoscope and introducer during deployment. Significant displacement may require the placement of an additional stent, resulting in increased costs. In contrast, the sandwich method involves fixing the stricture by "sandwiching" it between the partially deployed stent and the endoscope during deployment. As a result, misalignment is minimized, allowing for more accurate placement. In fact, in our study, no additional stents were required due to positional displacement.

Most procedures are performed using the sandwich method at our institution; thus, direct comparison with conventional techniques within our hospital was not possible. According to previous reports, the technical success rate of colonic stenting ranges from 95.5% to 100%, clinical success from 93% to 97.9%, and complication rates from 1.0% to 7.0%[4-7]. Compared with these general outcomes, the results of the sandwich method did not show a marked difference. However, this method offers additional advantages beyond the commonly evaluated parameters, such as preventing the need for additional stents due to displacement and enabling accurate placement even near the rectal Rb, making it a useful technique.

A mechanical understanding of stent behavior during deployment is essential for the implementation of this technique. When a stent is deployed from the anal side toward the stricture, the expanding stent exerts pressure against the wall, generating a forward force. By pulling back the introducer in opposition, the endoscope tip presses against the anal side of the stricture, thereby stabilizing the lesion between the stent and the scope. This method requires the use of a braided-type stent, because no laser-cut SEMS for colonic use is currently available or suitable for this technique.

The stent expands into a conical shape. The angle of this cone differs between the braided types; the cross-wire design produces a shallower angle and weaker radial force, whereas the hook-wire design creates a deeper angle and stronger force. Accordingly, the amount of traction required on the introducer varies depending on the stent design, which is a critical technical consideration.

With this technique, we avoided using unnecessarily long stents and frequently used shorter 6 cm stents. The average tumor length in our cohort was 38.7 mm, and the use of shorter stents helped minimize excessive resection and prevent contact between the stent edge and the bowel wall at flexures. Safe placement is achievable even for lesions near the rectum. In rectal tumors, using overly long stents may necessitate changes in the surgical approach, stoma creation, or cause discomfort when extending beyond the dentate line. Our technique allows precise adjustments, avoiding these adverse outcomes. Furthermore, the outcomes for rectal lesions were comparable with those previously reported using proximally deployed stents[8-10], supporting the effectiveness of the sandwich method.

This study had several limitations. This was a single-center, retrospective observational study.

In this study, displacement was set as the primary endpoint. Conventionally, failure is defined as the inability to achieve clinical success, that is, failure of decompression and persistence of obstructive symptoms. In our study, two cases failed to achieve clinical success, both involving strictures in the rectal RS region. In both cases, transanal ileus tubes were placed subsequently to achieve decompression, after which surgical treatment was performed. In these cases, the stricture was located at a flexure, and twisting during stent deployment may have prevented adequate expansion. Although controlling twisting is difficult with the sandwich method, improvement may be achieved by using stents with a higher expansion force and ensuring coverage of both the stricture and the flexure.

Additionally, implementation of the technique requires specific endoscopic maneuvers and a solid understanding of the underlying mechanics, which may pose challenges for reproducibility at other centers. Therefore, it is important to accumulate more cases and develop additional training methods to facilitate broader adoption.

Conclusion

The sandwich method for colonic SEMS placement in patients with malignant colonic obstruction is safe and effective. However, it requires technical expertise and an understanding of the deployment mechanics, underscoring the importance of adequate training for widespread implementation.

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