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Original

A New Device Facilitating Intracorporeal Purse-string Suture during Endoscopic Surgery

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Abstract: Standard laparoscopic colorectal surgery requires additional incision or enlargement of the trocar incision for the retrieval of the surgical specimen. A natural orifice specimen extraction (NOSE) procedure, in which the specimen is retrieved through the anus or vagina without any additional skin incision, requires purse-string suture (PSS) of the rostral intestinal segment in order to fix the anvil head of the stapler and perform extracorporeal mechanical anastomosis. Colorectal surgery has a limited NOSE in cases where the end of the rostral segment could be pulled through the anus. Broader application of NOSE depends on intracorporeal PSS. We developed a new forceps for intracorporeal PSS during NOSE and evaluated its efficacy. The PSS instrument was refined to pass through a 12-mm trocar in an intracorporeal PSS and achieve anastomosis using double stapling. In trials utilizing an endoscopic practice box, regular spacing of stitches during PSS were consistent (n=10), and tight intracorporeal anastomosis of the porcine colon was successfully performed (n=2). We then confirmed efficacy through an operation on a pig. Our novel PSS device will help us perform NOSE not only in laparoscopic colorectal surgery but also in any operation requiring intracorporeal PSS, which should contribute to further advances in endoscopic digestive surgery.

Key words: purse-string suturing, new instruments, natural orifice specimen extraction (NOSE), laparoscopic surgery

Introduction

Recently, laparoscopic colorectal resection has been commonly performed worldwide, yielding outcomes comparable to those of open surgery[1)]. However, standard laparoscopic colorectal resection requires extraction of the surgical specimen from the abdominal cavity through an additional incision, such as Pfannenstiel incision, or through an enlargement of one of the

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trocar incisions. The extension of an incision increases the risk of wound complications, such as persistent wound pain and abdominal incisional hernia. Natural orifice transluminal endoscopic surgery avoids such issues; however, it has not achieved popularity, owing mainly to the difficulty of the technique and the incomplete state of development of the required new devices. One specimen extraction method suitable for conventional laparoscopic surgery without additional or extended incisions is natural orifice specimen extraction (NOSE); the surgical specimen is retrieved via the anus or vagina (Figure 1), avoiding undue surgical stress. Generally, laparoscopic sigmoidectomy or proctectomy involves a circular stapler for anastomosis using a double-stapling technique (DST). The use of NOSE in sigmoidectomy or proctectomy requires traction of the colon through the anus for extracorporeal fixation of the anvil head of a circular stapler, restricting NOSE to cases where the colon can be drawn out in such manner. To broaden the applicability of NOSE, including all laparoscopic colectomy and proctectomy cases requiring purse-string suture (PSS) and not only NOSE where the colon is exteriorized for PSS, we invented a removable endoscopic instrument by which PSS can be performed intracorporeally, as illustrated in Figure 1.

Materials and methods

We collaborated with Senko Medical Instrument Manufacturing (Tokyo, Japan) in the development of a new forcep-like endoscopic instrument for PSS designed to make intracorporeal endoscopic suture as reliable and safe as that achieved extracorporeally. The device was made from Titanium Ti 6Al-4V ELI and SUS304-WPB. Because these metals meet

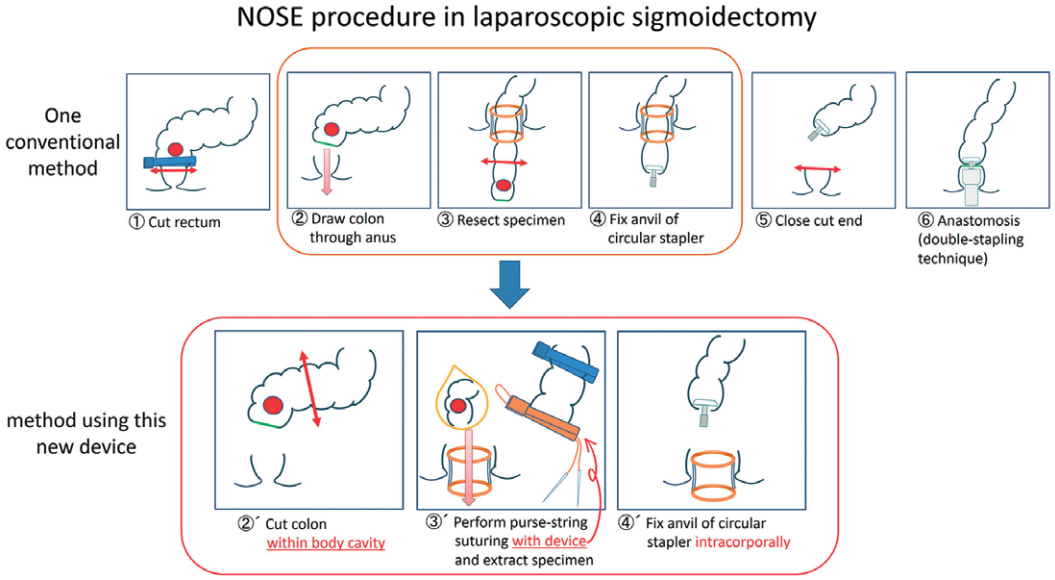

Fig. 1. Scheme of a natural orifice specimen extraction (NOSE) procedure. The conventional method requires traction to bring the sigmoid colon out through the anus and permit fixation of the anvil head of a circular stapler during anastomosis using a double-stapling technique. Our novel purse-string suture (PSS) instrument permits intracorporeal fixation of the anvil head and suturing.

a biological assessment based on Japanese Industrial Standards T 0993-1, we identified them as raw materials.

Results

The PSS device, which is 7.5 cm long and hinged (Figure 2a and b), can be passed through and out of the peritoneal cavity via a 12-mm trocar (Figure 2c and d). The device, whose jaws have nine and ten indentations, respectively, is used to grasp and hold the colon across its open end by commonly used laparoscopic forceps with a shaft 5 mm in diameter (Figure 2e and f). The suture needle and thread are passed through a channel in the device, smoothly penetrating the tissue.

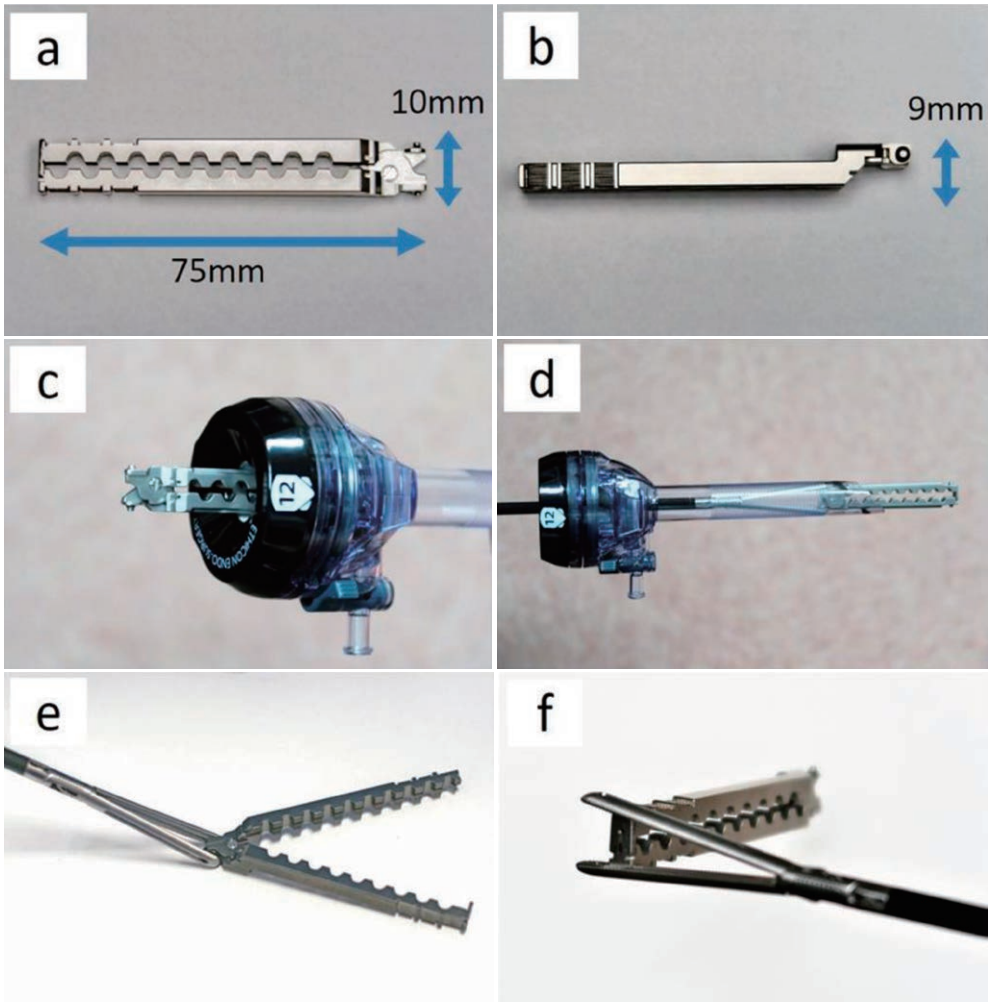

Fig. 2. Our new PSS instrument. Panels a and b show full-length views (length, 75 mm; width, up to 10 mm). The instrument can be inserted and withdrawn from the peritoneal cavity through a trocar 12 mm in internal diameter (c and d). The device can be grasped by forceps with a 5 mm in diameter shaft (e and f).

Our PSS device was tested and refined in three stages, as follows.

Assessment of manipulations using the device in a practice box

We first tested the performance of manipulations by using the device with a mock intestine in a practice box for laparoscopy. At first, the needle failed to pass smoothly through the channel of the device due to the oblique orientation of the needle toward the channel. We altered the needle insertion site to ensure straight and smooth passage.

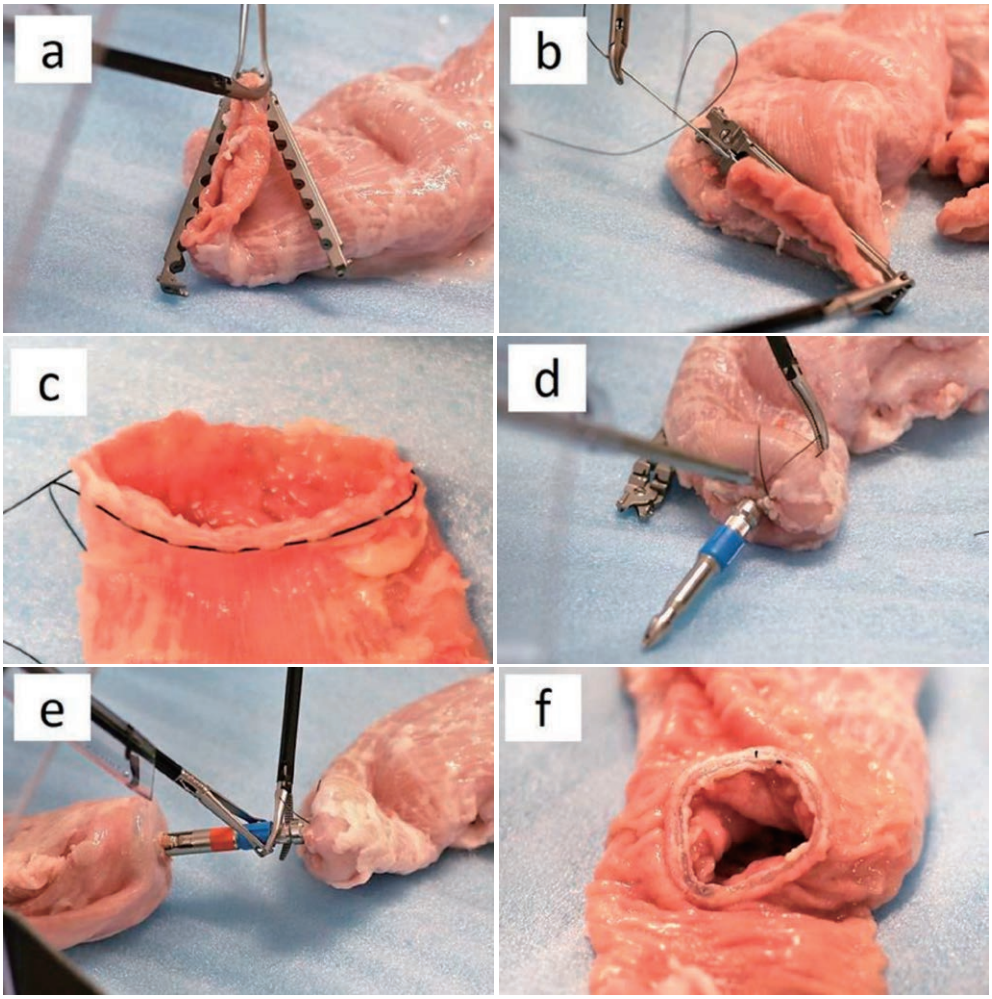

Fig. 3. Manipulations within a laparoscopy practice box. The device grasps a cadaveric porcine colon segment (a). A needle is passed smoothly through the channel of the device (b). Stitching for PSS was performed reliably (c). The anvil head of a circular stapler was fixed to the end of the colon without difficulty (d). Complete anastomosis using a circular stapler was performed (e and f).

Assessment of accuracy of anastomosis with the device in the practice box

To determine whether the thread had completely passed, we compared the number of indentations on the jaw of the device grasping the cadaveric porcine colon segment 8 to 12 cm in circumference with the stitch count in the anastomosed colon (Figure 3a to c). Accurate and uniform placement of purse-string sutures in the colon was verified in each of ten trials, with a consistent 1.0 ratio of indentations to stitch count. We then anastomosed the porcine colon using the circular stapler in two trials and confirmed the tightness of the anastomosis in both (Figure 3d to f).

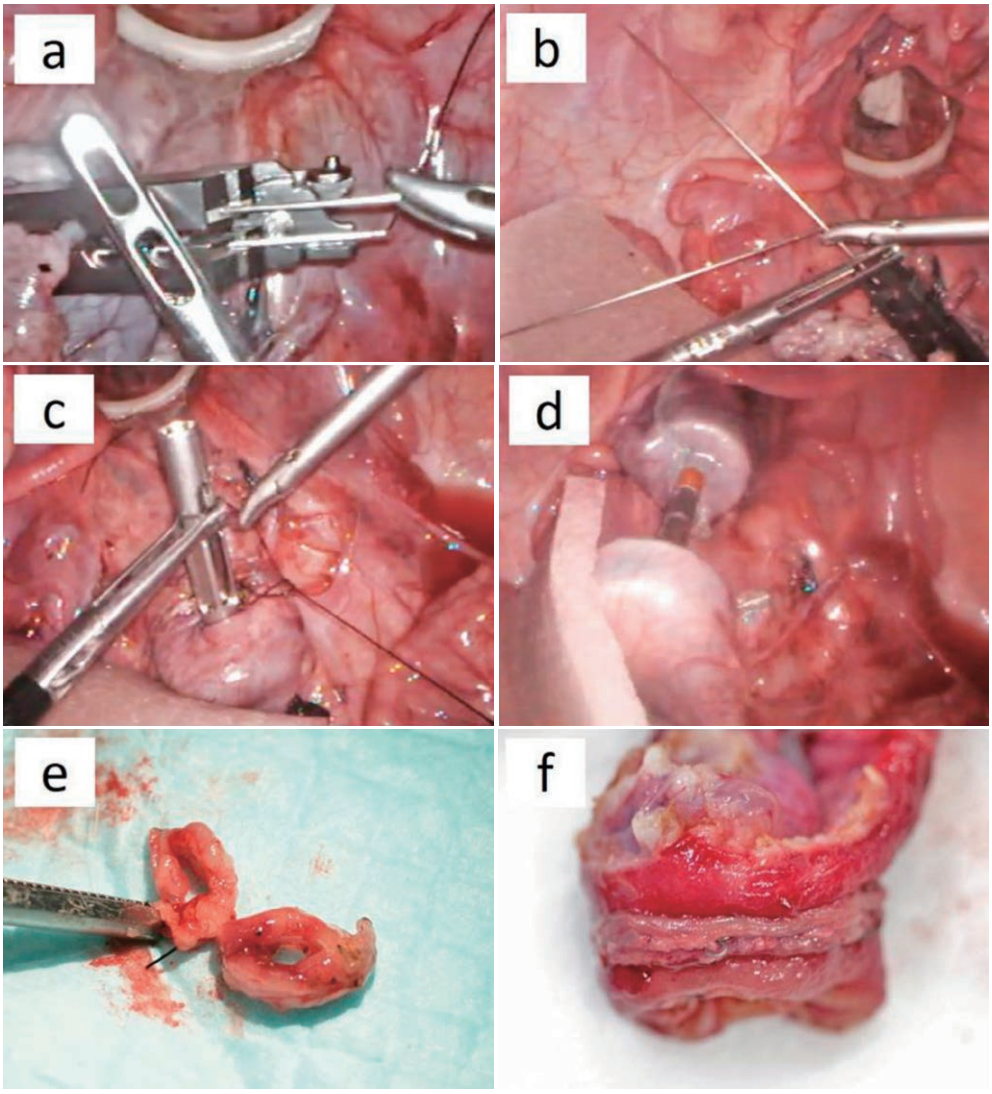

Fig. 4. Operation on a pig. We achieved anastomosis without difficulty by double stapling using a circular stapler. PSS at the end of the porcine colon by could be performed without difficulty (a and b). An anvil head for a circular stapler was fixed by intracorporeal suture (c). Intracorporeal stapling was performed (d). The two cut ends of the intestine were completely encircled by double stapling (e). After successfully completing the anastomosis, the anastomotic site was retrieved for careful gross inspection (f).

Operation on a pig

Finally, we performed an operation on a pig to test the device's intraoperative performance. During the operation, we successfully completed anastomosis without any difficulty applying a DST with circular staplers with diameters 21 and 25 mm (Figure 4a to d). We determined the completeness of the suture line with a laparoscopic monitor and fixed the anvil head through intracorporeal ligation. The tissue "doughnuts" dissected by the circular stapler demonstrated complete circles (Figure 4e). We then confirmed the completeness of the anastomosis through an air leakage test. Finally, we removed the anastomosed segment for careful gross examination, which confirmed completeness of the colorectal anastomosis (Figure 4f). To sum up, DST with this device was securely and safely performed.

Discussion

Laparoscopic colorectal surgery is less invasive compared to open surgery. However, enlargement of the incision is often needed for specimen extraction. Since 1993, NOSE procedures have been reported[2–5] to render incision enlargement necessary in retrieving specimens through natural orifices, such as the anus and vagina. In addition to sigmoidectomy and proctectomy, NOSE has been utilized in right colectomy[6] and total colectomy[7]. Functional end-to-end anastomosis can be performed using linear stapling devices in laparoscopic right colectomy. However, sigmoidectomy or proctectomy requires anastomosis with DST using a circular stapler. Nonetheless, one needs to fix the stapler anvil head at the end of the colon for anastomosis with DST. Therefore, our device is particularly useful in performing intracorporeal PSS in laparoscopic sigmoidectomy or proctectomy. In the present study, our newly developed device permitted safe and simple intracorporeal PSS during endoscopic surgery on a pig. The larger peritoneal cavity in human adults should make this method easier.

Performing intracorporeal PSS allows unrestricted application of the NOSE procedure. Moreover, we believe that the device will be useful not only for colectomy but also for other digestive operations that will require PSS. We, therefore, expect that the availability of the device will contribute to the progress of endoscopic surgery.

This is a preliminarily study done in animals. The next step would be to use this device in clinical practice.

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Disclosure of Potential Conflicts of Interest

The authors declare that they have no conflicts of interest.

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