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ORIGINAL ARTICLE

Side overlap esophagogastrostomy to prevent reflux after proximal gastrectomy

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Abstract
Background No optimal method of reconstruction for proximal gastrectomy has been established because of problems associated with postoperative reflux and anastomotic stenosis. It is also important that the reconstruction is easily performed laparoscopically because laparoscopic gastrectomy has become widely accepted in recent years.
Methods We have developed a new method of esophagogastrostomy, side overlap with fundoplication by Yamashita (SOFY). The remnant stomach is fixated to the diaphragmatic crus on the dorsal side of the esophagus. The esophagus and the remnant stomach are overlapped by a length of 5 cm. A linear stapler is inserted in two holes on the left side of the esophageal stump and the anterior gastric wall. The stapler is rotated counterclockwise on its axis and fired. The entry hole is closed, and the right side of the esophagus is fixated to the stomach so that the esophagus sticks flat to the gastric wall. The surgical outcomes of the SOFY method were compared with those of esophagogastrectomy different from SOFY.
Results Thirteen of the 14 patients in the SOFY group were asymptomatic without a proton pump inhibitor, but reflux esophagitis was observed in 5 of the 16 patients in the non-SOFY group and anastomotic stenosis was observed in 3 patients. Contrast enhancement findings in the SOFY group showed inflow of Gastrografin to the remnant stomach was extremely good, and no reflux into the esophagus was observed even with patients in the head-down tilt position.
Conclusions SOFY can be easily performed laparoscopically and may overcome the problems of postoperative reflux and stenosis.

Keywords Laparoscopic gastrectomy · Proximal gastrectomy · Esophagogastrostomy

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Introduction

Proximal gastrectomy is indicated for early gastric cancer in the upper third of the stomach in which at least half of the remnant stomach can be preserved. Compared with total gastrectomies, proximal gastrectomies have been reported to offer advantages in terms of reducing postoperative weight loss and lower rates of gastric symptoms and malabsorption of vitamin B_{12} that are caused by gastrectomy [1]. However, esophagogastrostomy, which is one of the simplest reconstructions after proximal gastrectomy, sometimes causes severe reflux esophagitis; therefore, total gastrectomy is often selected instead of proximal gastrectomy. Attempts to add a valve-like mechanism to prevent reflux after esophagogastrostomy have been reported since 1964 [2, 3]. However, despite the many reports that have been published on this topic [4–10], no optimal method of anastomosis has come into wide use because of problems associated with the reliability of reflux prevention, the occurrence of anastomotic stenosis, and technical difficulties.

We have devised, and report here, a new method of esophagogastrostomy, called side overlap with

fundoplication by Yamashita (SOFY), that can be relatively easily performed with laparoscopic surgery and may overcome the problems of postoperative reflux and anastomotic stenosis. The surgical outcomes of the SOFY method were compared with those of esophagogastrectomy different from SOFY.

Patients and methods

Patients

Proximal gastrectomy with esophagogastrostomy was performed for patients with early gastric cancer localized in the upper stomach in which at least two thirds of the stomach can be preserved after proximal gastrectomy, and the abdominal esophagus can also be preserved.

Fourteen patients who met the aforementioned criteria underwent laparoscopic proximal gastrectomy with the new method of esophagogastrostomy (SOFY) at Osaka City General Hospital between January 2014 and March 2016. All procedures were performed by SOFY after it was developed. Sixteen patients who met the aforementioned criteria underwent laparoscopic proximal gastrectomy with esophagogastrostomy different from SOFY (non-SOFY) between January 2007 and December 2013. Clinical stage IA gastric cancer was diagnosed in all patients according to the 7th edition of the TNM classification of the Union for International Cancer Control [11] by preoperative diagnosis.

Surgical procedure

Proximal gastrectomy

Patients were positioned with the legs open on a negative-pressure fixation device. The first port was placed in the umbilical region by the open method. A 10-mm flexible endoscope was inserted from the first port, and four ports were added as shown in Fig. 1. The surgeon stood on the right side of the patient and performed a D1+ lymphadenectomy in accordance with the Japanese gastric cancer treatment guidelines from 2010 (version 3) [12] or 2014 (version 4). The lesser omentum was released, and the anterior nerve branch was severed on the peripheral side where the hepatic branch diverged from the anterior vagus trunk in the cardiac region, exposing the abdominal esophagus. The perigastric vessels on the lesser curvature side were dissected at the arcade intersection of the left and right gastric arteries. To dissect no. 3a, the lesser curvature in the left gastric artery region was skeletonized to the planned gastric resection line. Next, the greater omentum on the left side was separated, and the left gastroepiploic artery was resected at the peripheral side where

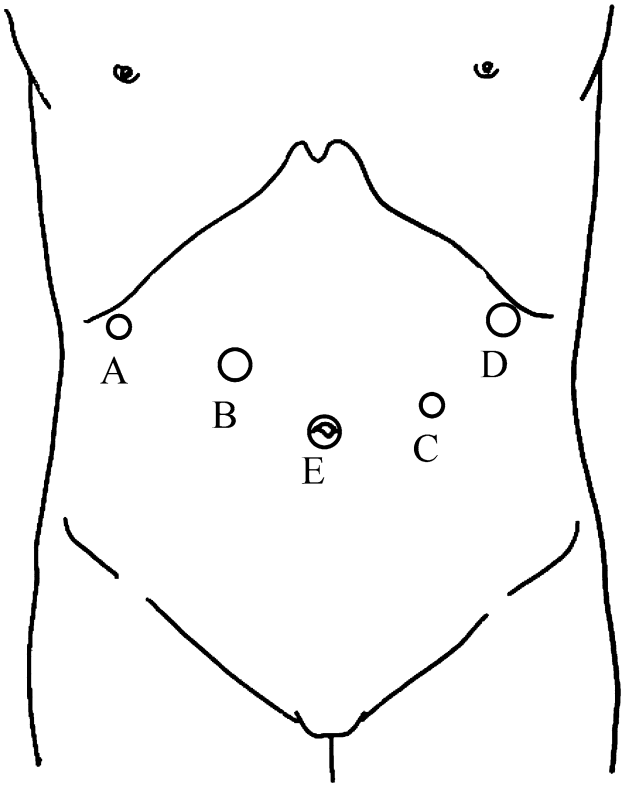

Fig. 1 Port sites for laparoscopic proximal gastrectomy. *A* 5 mm, *B* 12 mm, *C* 5 mm, *D* 12 mm, *E* laparoscope through the umbilicus

the epiploic branch diverged. To dissect no. 4sb, the greater curvature in the left gastroepiploic artery region was dissected toward the proximal side. The gastrosplenic ligament was then separated, and the short gastric vessels were resected at the base to dissect no. 4sa. The position of the tumor was confirmed via intraoperative endoscopy while the distal margins were secured, and the stomach was resected with a linear stapler. While the cardiac side of the stomach and the gastropancreatic fold were being pulled, no. 8a was dissected along the common hepatic artery, after which no. 7 was dissected, and the left gastric artery was resected. While the celiac branch of the vagus nerve was being preserved, no. 9 was dissected, and the crus of the diaphragm was sufficiently exposed. After the proximal part of the stomach had been separated from the retroperitoneum, the abdominal esophagus was completely isolated and resection was performed with a linear stapler, above the esophagogastric junction. No. 11p was dissected, and the posterior gastric artery was resected, completing the proximal gastrectomy. The specimen was picked up by the opening of the umbilical region wound.

Esophagogastrostomy: SOFY method

After the abdominal esophagus had been sufficiently exposed, the central apex of the remnant stomach stump was suture fixated to the crus of the diaphragm on the

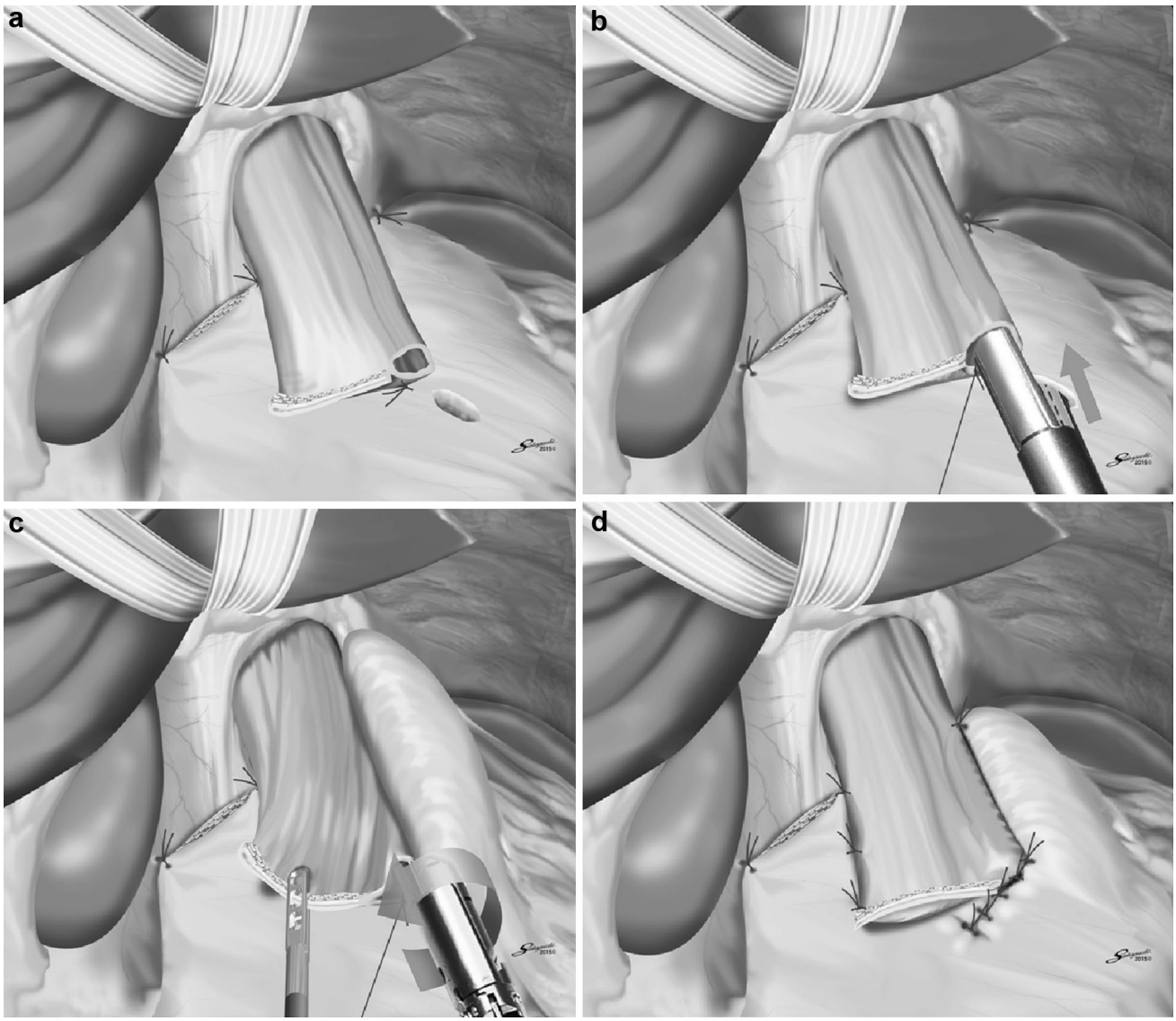

Fig. 2 Side overlap esophagogastrostomy. **a** A small incision was made in the center of the anterior gastric wall, which coincides with the left side of the esophageal stump. **b** Forks of a 45-mm linear stapler were inserted into the esophagus and stomach. **c** The linear stapler was rotated counterclockwise on its axis, suturing the gastric wall to the left side of the esophagus. **d** The entry hole was closed by approximately eight stitches of 4-0 absorbable sutures

dorsal side of the esophagus. The left and right edges of the remnant stomach stump were also suture fixated to the crus of the diaphragm. This fixation allowed the stomach to firmly press the abdominal esophagus from the back side, which plays an important role in reflux prevention. The abdominal esophagus was pulled enough to the caudal side, and the most proximal dorsal side of the esophagus was suture fixated to the apex of the remnant stomach stump so that the esophagus was not pulled into the thoracic cavity. This caused the abdominal esophagus and the remnant stomach to overlap by approximately 5 cm. A small incision was made in the center of the anterior gastric wall, which coincides with the left side of the esophageal stump (Fig. 2a), and a 45-mm linear stapler was inserted through the patient's upper left port. The forks of the linear stapler were inserted into the esophagus and stomach (Fig. 2b) and rotated counterclockwise on its axis, suturing the gastric wall to the left side of the wall of the esophagus (Fig. 2c). The entry hole was closed by approximately eight stitches of 4-0 absorbable sutures. However, the closure with a linear stapler has been done recently to shorten the procedure time. The right side of the esophagus was suture fixated to the gastric wall with two stitches so that the esophagus stuck flat to the gastric wall (Fig. 2d).

Esophagogastrostomy: non-SOFY method

As for all cases in non-SOFY methods, esophagogastrostomy by a 25-mm circular stapler was performed. After the abdominal esophagus had been sufficiently exposed, the anvil head of the circular stapler was inserted in the esophagus with purse-string suture anastomosis. An incision of approximately 3 cm was made in the anterior wall of the remnant stomach, and the circular stapler was inserted through the umbilical wound. Airtightness was maintained by gloves being attached to the circular stapler, and esophagogastrostomy was performed endoscopically. The remnant stomach was sewed on the esophagus and/or the crus diaphragm before or after esophagogastrostomy. However, the location of the esophagogastrostomy and how to sew the remnant stomach differed according to the surgeons and the operation date.

Results

The surgical outcomes of 14 patients who underwent SOFY (SOFY group) were compared with those of 16 patients who underwent laparoscopic proximal gastrectomy with esophagogastrectomy different from SOFY (non-SOFY group). The clinicopathological features of these groups are shown in Table 1. All patients in the SOFY group had early gastric cancer of the upper stomach, and the depth of wall invasion was T1a in 3 patients and T1b in 11 patients. Final pathological diagnosis showed no lymph node metastasis in any patient in the SOFY group, whereas in non-SOFY group, three patients had tumor invasion depths of T2 and one patient had a lymph node metastasis. The surgical outcomes of the patients in SOFY and non-SOFY groups are shown in Table 2. The mean operation time for the SOFY group was 330 min (range 273–361 min), and the mean time for reconstruction was 38 min (range 30–55 min); no significant differences were noted between the two groups. Estimated blood loss was significantly less in the SOFY group (17.0 g in the SOFY group and 61.0 g in the non-SOFY group). Twenty-seven lymph nodes (range 6–60) were harvested in the SOFY group and 25 (range 10–57) were harvested in the non-SOFY group, indicating no significant difference. No intraoperative complications and no cases of conversion to open surgery were observed in both groups. In the non-SOFY group, anastomotic leakage was observed in two patients and anastomotic stenosis was observed in three patients. However, no postoperative complications, including anastomotic leakage and stenosis, were observed in the SOFY group. Patients started drinking water on postoperative day 3 and eating meals on postoperative day 4 in both groups. Thirteen of the 14 patients in the SOFY group were asymptomatic without a proton pump inhibitor (PPI) nor H_2 blockers. One patient reported a mild reflux symptom, but the symptom disappeared by the dosage of the PPI. Endoscopic examination showed incomplete flattening of the abdominal esophagus and reflux esophagitis of Los Angeles classification grade B in this patient. On the other hand, reflux esophagitis was observed in five patients in the non-SOFY group, and a PPI was prescribed for seven patients. The rate of weight loss at 1 year after surgery in the SOFY group was lower than that in the non-SOFY group (7.4% for the SOFY group and 15.0% for the non-SOFY group).

Table 1 Patients' backgrounds

Clinical parameters	SOFY group ($n = 14$)	Non-SOFY group ($n = 16$)
Sex		
Male	11	11
Female	3	5
Age (years)		
Mean	59	66
Range	44–86	44–86
BMI (kg/m^2)		
Mean	22.8	21.8
Range	17.8–29.6	16.8–28.4
Depth of wall invasion		
T1a	3	3
T1b	11	10
T2	0	3
Lymph node metastasis		
N0	14	15
N1	0	1
Stage		
IA	14	12
IB	0	4

BMI body mass index, *SOFY* side overlap with fundoplication by Yamashita

Figure 3 shows contrast enhancement findings with Gastrografin 4 days after proximal gastrectomy with SOFY. Inflow of Gastrografin from the esophagus to the remnant stomach was extremely good, and no reflux of Gastrografin into the esophagus was observed even with the patient in the head-down tilt position. Endoscopic examination 6–12 months after proximal gastrectomy with SOFY was been performed in 10 of the 14 patients, and indicated that the lumen of the abdominal esophagus was closed flat because of pressure from the remnant stomach on the dorsal side, but was easily expanded by air supply (Fig. 4a, b). The anastomosis was observed on the left side of the esophageal wall and the gastroscope was smoothly inserted through the anastomosis (Fig. 4c). Observation of

Table 2 Surgical outcomes

Surgical outcomes	SOFY group ($n = 14$)	Non-SOFY group ($n = 16$)
Operation time (min)		
Mean	330	337
Range	273–361	241–452
Time for reconstruction (min)		
Mean	38	40
Range	30–55	20–85
Estimated blood loss (g)		
Mean	17.0	61.0
Range	10–40	10–290
Harvested lymph nodes		
Mean	27	25
Range	6–60	6–57
Postoperative complications		
Anastomotic leakage	0	2
Anastomotic stenosis	0	3
Deaths	0	0
Postoperative hospital stay (days)		
Mean	10	16 days
Range	8–20	8–20
Postoperative endoscopic findings	($n = 10$)	($n = 16$)
Esophagitis	1 (LA grade B)	5
Saburra	2	7
Use of PPI	1	7
Rate of weight loss at 1 year after surgery (%)		
Mean	7.4	15.0
Range	3.1–19.4	8.8–31.4

LA Los Angeles, *PPI* proton pump inhibitor, *SOFY* side overlap with fundoplication by Yamashita

the stomach revealed the angle of His and that a pseudofornix had formed (Fig. 4d).

Discussion

From the viewpoint of performing an optimal lymphadenectomy, it is not necessary to perform a total gastrectomy for early gastric cancer of the upper stomach, and a proximal gastrectomy is an appropriate operative procedure [13]. There are a number of advantages to preserving the pylorus side of the stomach. These include the following: (1) retention and mixing of food; (2) reduced severity of digestion and absorption disorders of proteins and fat and postoperative anemia as compared with those for total gastrectomy; and (3) preservation of gastrin and secretin secretion [1]. However, proximal gastrectomies have previously often been avoided because of various problems associated with the method of reconstruction. The simplest method of reconstruction for proximal gastrectomy is an esophagogastrostomy. However, if the anastomosis is simply performed without any modifications, reflux esophagitis frequently occurs [14]. The double-tract and jejunal interposition methods are used to prevent reflux esophagitis, but despite the complicated nature of these techniques, compared with total gastrectomy their benefits are less likely in terms of postoperative problems and nutrition. Observation of the remnant stomach, in which there is a risk of malignancy, is also often difficult after such procedures.

A number of esophagogastrostomy techniques have been reported to prevent reflux. The principal ideas behind these techniques include valvuloplasty and fundoplication [1–5, 9, 10, 15, 16]. Valvuloplasty has been sporadically reported dating from the 1950s. This technique attempts to prevent reflux by use of intragastric pressure to flatten the lower end of the esophagus into a valvate shape, but the high level of technical difficulty has prevented this technique from becoming widely used. Fundoplication involves sewing the remnant stomach on the lower esophagus and/or diaphragm to form the angle of His. However, this method offers a low level of reliability and cannot completely

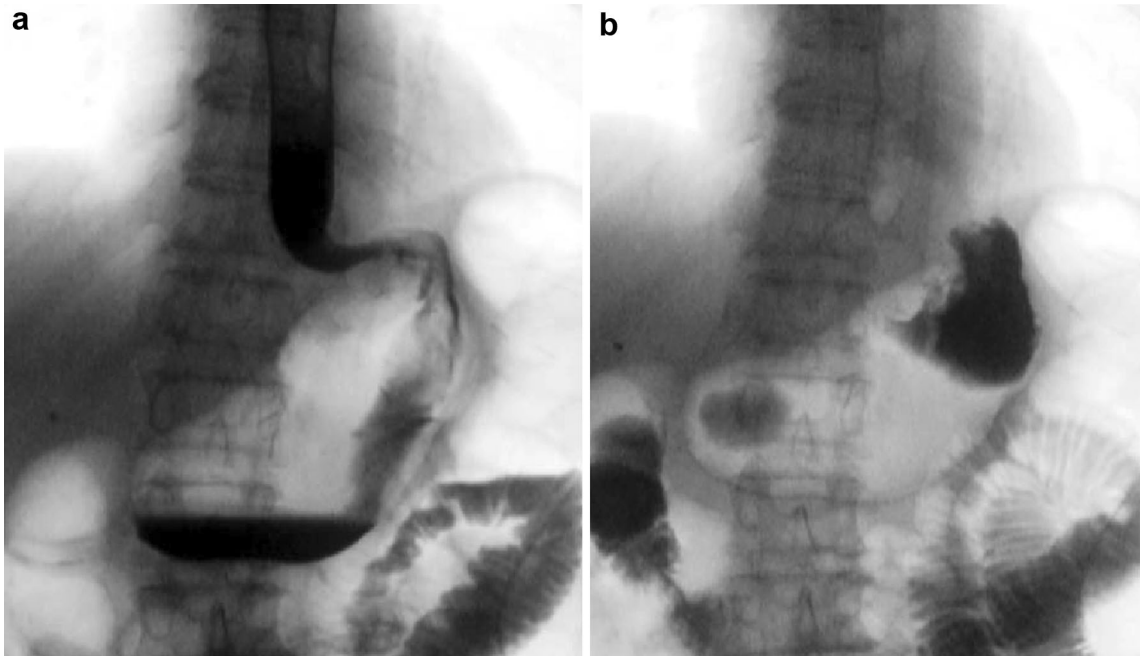

Fig. 3 Contrast enhancement findings with Gastrografin 4 days after proximal gastrectomy with side overlap with fundoplication by Yamashita. **a** Inflow of contrast medium from the esophagus to the remnant stomach was extremely good. **b** No reflux of contrast medium into the esophagus was observed even with the patient in the head-down tilt position

prevent reflux esophagitis. Wrapping the remnant stomach around the lower esophagus increases reflux prevention, but obstructions may occur. Thus, at present, there is no optimal method of reconstruction for proximal gastrectomy. In recent years, laparoscopic gastrectomy for early gastric cancer has become widely accepted throughout Asia. Therefore, it is also important that the reconstruction after proximal gastrectomy is easily performed laparoscopically. Many methods previously reported for open surgery have been extremely difficult to perform laparoscopically. Previous reports of endoscopic esophagogastrostomies have described the use of a linear stapler to perform side-to-side esophagogastrostomy on the anterior wall of the stomach and dorsal side of the esophagus [7, 8]. Although this method is very simple, it breaks the antireflux, high-pressure zone in the lower end of the esophagus. Okabe et al. [10] first fixated the esophagus onto the anterior wall of the stomach with a knifeless linear stapler and then performed end-to-side anastomosis by hand suture. Intracorporal anastomosis is difficult to perform by hand suture and is likely the cause of anastomotic stenosis.

We searched for a method of laparoscopic esophagogastrostomy that would reliably prevent reflux, not cause anastomotic stenosis, and be relatively easy to perform laparoscopically. Previously, we had fixated the remnant stomach to the crus of the diaphragm after anastomosing the anterior wall of the stomach and the esophagus with a circular stapler. However, it was difficult to firmly support the remnant stomach on the dorsal side of the esophagus with this method, and it sometimes caused reflux esophagitis. Next, we had fixated the remnant stomach to the crus of the diaphragm and then anastomosed the anterior wall of the stomach and the esophagus using a circular stapler. Although this method offered reliable reflux prevention, it complicated the anastomosis with a circular stapler more because the remnant stomach was fixed. Moreover, esophagogastrostomy with a circular stapler sometimes results in anastomotic stenosis. Therefore, we decided to perform the anastomosis with a linear stapler. Performing side-to-side esophagogastrostomy on the dorsal side of the esophagus breaks the antireflux, high-pressure zone of the lower end of the esophagus. Therefore, we proposed using a method that creates an anastomosis on the left side of the esophageal wall. First, it is very important that the abdominal esophagus and the remnant stomach overlap by approximately 5 cm. We anastomosed the left side of the esophageal wall to the anterior gastric wall and stuck the right side of the esophageal wall to the gastric wall, so as to flatten the esophagus. This caused the preserved dorsal esophageal wall to be pressed and flatten into a valvate shape by pressure from the artificial fundus so as to form the reflux prevention mechanism (Fig. 5). This was confirmed by endoscopic examination and a contrast study. This reflux prevention mechanism is considered to be a consequence of the combination of valvuloplasty and fundoplication. Furthermore, it is a significant advantage that this can be performed laparoscopically with little stress. Theoretically, SOFY might be applicable to

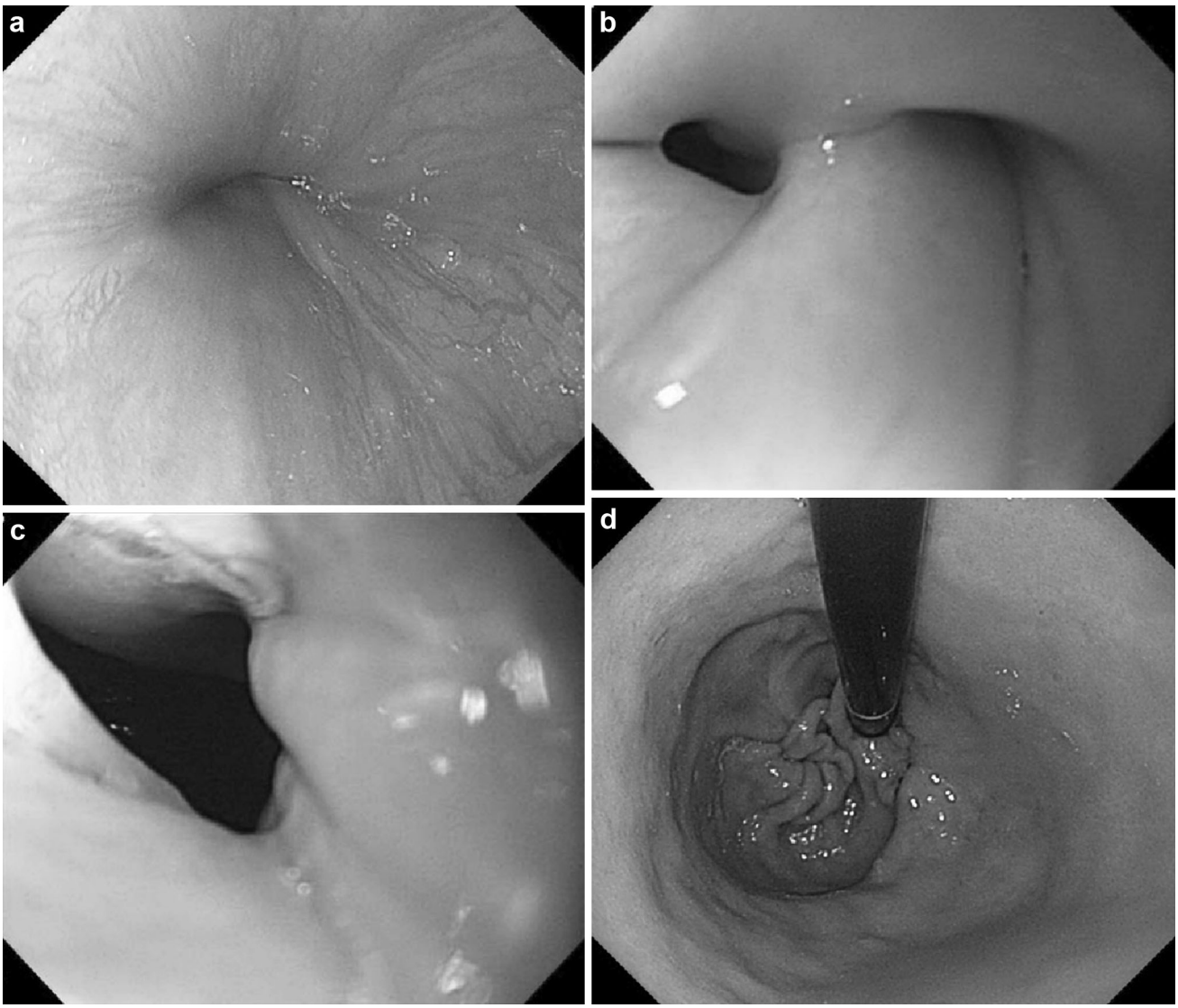

Fig. 4 Endoscopic findings 6 months after proximal gastrectomy with side overlap with fundoplication by Yamashita. **a** The lumen of the abdominal esophagus was closed flat because of pressure from the remnant stomach on the dorsal side. **b** The abdominal esophagus was easily expanded by air supply and the anastomosis was observed on the left side of the esophageal wall **c** A gastroscope was smoothly inserted through the anastomosis. **d** Observation of the stomach revealed the angle of His and that a pseudofornix had formed

esophagogastric junction tumor that requires the resection of the abdominal esophagus, but we have not tried this yet.

In this study, SOFY prevented reflux in 13 of 14 patients and prevented a stenosis in all patients. The results suggest that SOFY is a reliable procedure as the reconstruction after the proximal gastrectomy. One patient reported a mild reflux symptom due to reflux esophagitis of Los Angeles classification grade B. Endoscopic examination showed incomplete flattening of the abdominal esophagus in this patient. It was thought that this was caused by abdominal esophagus and the remnant stomach not overlapping enough, which is a technical problem. The rate of weight loss was reduced in comparison with previous methods for esophagogastrostomy as a result of prevention of reflux and stenosis.

In summary, we have developed and reported SOFY, a new method of esophagogastrostomy after proximal gastrectomy that can be relatively easily performed laparoscopically and may overcome the problems of postoperative reflux and anastomotic stenosis. In this method, the preserved dorsal esophageal wall is pressed and flatten into a valvate shape by pressure from the artificial fundus, which plays an important role in reflux prevention, and the overlap anastomosis created with linear stapler provides good passage without stenosis. Examination of more cases and longer follow-up are required to

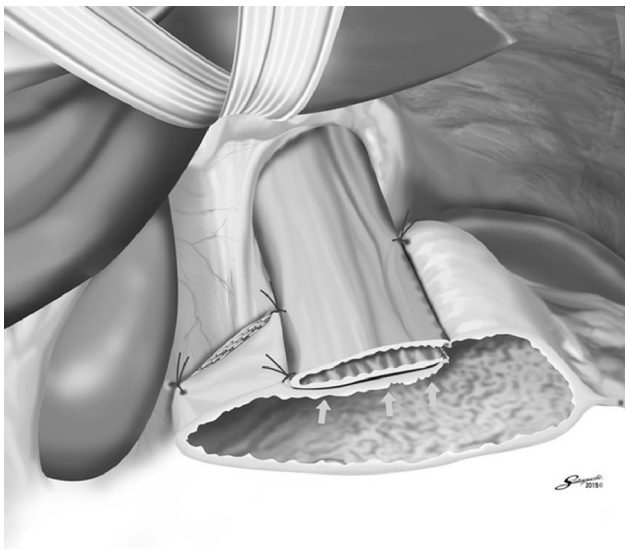

Fig. 5 The reflux prevention mechanism resulting from side overlap with fundoplication by Yamashita. The preserved dorsal esophageal wall is pressed and flatten into a valvate shape by pressure from the artificial fundus

determine the usefulness of SOFY because this is a retrospective small case-series study.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Human rights statement and informed consent All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later versions. Informed consent or substitute for it was obtained from all patients for their being included in the study.

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