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Review Article

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Updated Review of Proximal Gastrectomy for Gastric Cancer or Cancer of the Gastroesophageal Junction

Tomoyuki Irino, Manabu Ohashi, Masaru Hayami, Rie Makuuchi, Motonari Ri, Takeshi Sano, Toshiharu Yamaguchi, Souya Nunobe

Department of Gastroenterological Surgery, Cancer Institute Hospital Ariake, Tokyo, Japan

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Correspondence to
Souya Nunobe
Department of Gastroenterological Surgery, Cancer Institute Hospital Ariake, 3-8-31, Ariake, Koto-ku,, Tokyo 135-8550, Japan.
Email: souya.nunobe@jfcr.or.jp

ORCID iDs
Tomoyuki Irino
https://orcid.org/0000-0002-2056-0721
Manabu Ohashi
https://orcid.org/0000-0001-7417-3682
Masaru Hayami
https://orcid.org/0000-0003-3460-3785
Rie Makuuchi
https://orcid.org/0000-0002-7186-6181
Motonari Ri
https://orcid.org/0000-0001-8103-9721
Souya Nunobe
https://orcid.org/0000-0003-3012-5632

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ABSTRACT

Proximal gastrectomy (PG) has reemerged as a viable surgical option for managing proximal gastric cancer and gastroesophageal junction cancer, particularly for early-stage tumors, offering potential advantages over total gastrectomy (TG). This review examines the evolution of PG, emphasizing surgical techniques and outcomes. Although PG was initially abandoned due to postoperative complications such as reflux esophagitis, advances in reconstruction methods, such as the double-flap technique and double-tract reconstruction, have significantly improved patient quality of life and reduced complications. Modern techniques focus on preserving gastric function, enhancing postoperative nutritional status, and minimizing morbidity, especially compared to TG. However, debates persist regarding the optimal extent of lymphadenectomy, oncological safety, and the risk of metachronous gastric cancer after surgery. Various international guidelines support PG for specific cases, particularly where lymph node involvement is limited, and functional preservation is prioritized. Despite promising survival and quality-of-life outcomes, certain risks, such as anastomotic stenosis and metachronous cancer, remain. The role of PG in treating cancer of the gastroesophageal junction continues to be investigated, with ongoing studies further clarifying its effectiveness. The evolving techniques and increased focus on patient-centered outcomes suggest a renewed role of PG in the surgical management of gastric cancer.

Keywords: Gastrectomy; Gastric cancer; Techniques; Quality of life

INTRODUCTION

Gastric cancer remains one of the leading causes of cancer-related deaths worldwide, with surgical resection serving as the primary curative treatment [1]. Total gastrectomy (TG) has been considered the standard surgical approach for proximal gastric cancer. However, this extensive procedure is associated with significant postoperative morbidity and impaired quality of life (QOL) [2]. The concept of proximal gastrectomy (PG) as a function-preserving alternative for proximal gastric cancer emerged in the early 20th century. In 1908, Voelcker [3] reported the first successful case of resection of the cardia for carcinoma with immediate end-to-end esophagogastric anastomosis. This pioneering work laid the foundation for further development of PG techniques.

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Author Contributions

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Despite initial enthusiasm, PG has fallen out of favor in subsequent decades due to concerns about oncological adequacy and postoperative complications, particularly reflux esophagitis. In 1983, Maruyama et al. [4] reported a high incidence of reflux symptoms and esophagitis following PG with direct esophagogastrostomy (EG). These findings has led many surgeons to abandon PG in favor of TG. However, advances in surgical techniques and a better understanding of gastric cancer biology in recent years have rekindled the interest in PG as a function-preserving option for selected patients with proximal gastric cancer.

The optimal extent of gastric resection and reconstruction methods following PG remains a subject of debate. Various reconstruction techniques have been proposed to prevent reflux, including jejunal interposition, double-tract reconstruction (DTR), and novel valvuloplasty; however, the most effective approach remains unclear. Additionally, the oncological adequacy of PG compared with TG, particularly in terms of lymph node dissection, has been questioned. These unresolved issues highlight the need for a comprehensive review of the existing evidence on PG for gastric cancer.

This review aimed to critically evaluate the current literature on PG for gastric cancer, focusing on surgical techniques, short- and long-term outcomes, oncological adequacy, and QOL. By synthesizing the available evidence, we aimed to provide an updated perspective on the role of PG in the modern era of gastric cancer surgery and to identify areas requiring further investigation. This review is particularly timely, given the growing emphasis on organ-preserving strategies in oncological surgery and the potential for PG to improve postoperative outcomes without compromising cancer control in appropriately selected patients.

INDICATIONS FOR PG

What clinical guidelines say

The indications for PG or gastric cancer vary slightly across international guidelines, reflecting regional practices and evidence-based adaptations. According to Japanese guidelines, PG is recommended for proximal tumors where more than half of the distal stomach can be preserved, particularly for T1N0 tumors with appropriate margin considerations [5]. It is especially suitable for early-stage proximal gastric cancers that do not involve extensive lymph node metastasis and where functional preservation is advantageous. The Korean guidelines also emphasize PG for early-stage proximal gastric cancers, suggesting it as an alternative to TG when lymph node involvement is limited, with substantial potential benefits in maintaining nutritional status and QOL [6]. Similarly, Chinese guidelines recommend PG for tumors ≤4 cm in diameter at the esophagogastric junction, particularly when lymph node metastasis is not detected at critical locations, thereby enabling partial stomach preservation and reducing postoperative complications [7]. The ESMO guidelines align with these views, advocating for PG in cases where a satisfactory proximal resection margin can be obtained and when it offers a balance between oncological safety and functional preservation [8].

Issues open to debate

Early gastric cancers: PG or distal gastrectomy?

Laparoscopic subtotal gastrectomy (LsTG) and laparoscopic proximal gastrectomy (LPG) are viable options for early gastric cancer in the upper third of the stomach, each with its own advantages and disadvantages. In this context, LsTG is defined as laparoscopic distal

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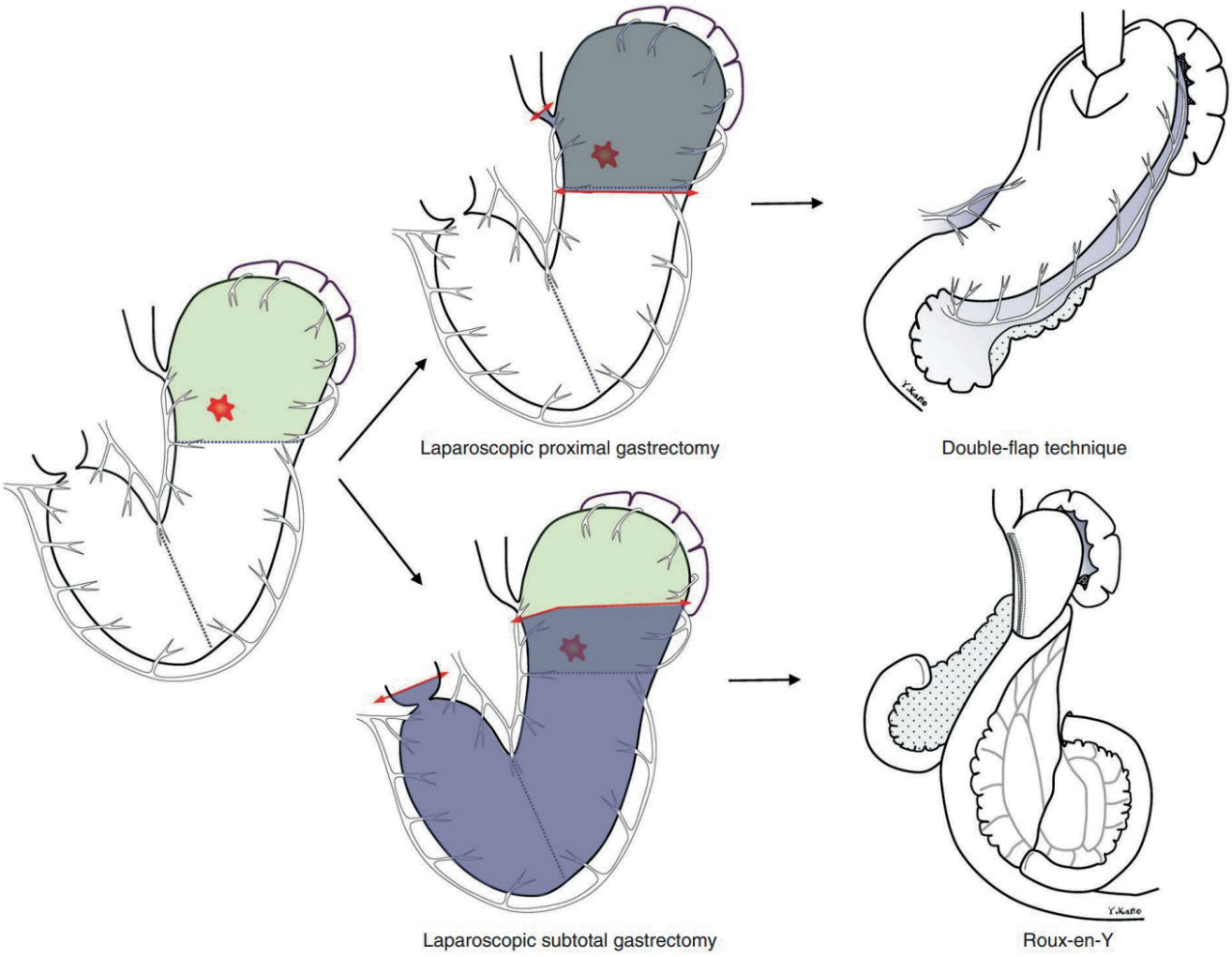

Fig. 1. Resection and reconstruction in laparoscopic subtotal and laparoscopic proximal gastrectomies using the double-flap technique.
Adapted from 'Laparoscopic proximal gastrectomy with double-flap technique versus laparoscopic subtotal gastrectomy for proximal early gastric cancer' by Kano et al. [9], published in *BJS Open*, Volume 4, Pages 252–259, 2020, DOI: 10.1002/bjs5.50241. This work was licensed under a Creative Commons Attribution-NonCommercial License (CC BY-NC), which permits non-commercial use with proper attribution.

gastrectomy for tumors located in the upper third of the stomach or tumor invading this area (**Fig. 1**) [9].

In terms of oncological outcomes, Kano et al. [10] found no significant differences in the 3-year overall survival (98.4% for LsTG vs. 98.6% for LPG) or relapse-free survival (98.4% vs. 97.0%) between the procedures. Both procedures showed very low rates of lymph node metastasis, with no metastases detected at stations 2 or 4sa for either procedure.

Another study by Kano et al. [9] highlighted better outcomes for the LPG double flap technique (DFT) regarding better outcomes in terms of postoperative hospital stay, reflux esophagitis, and postoperative nutritional status. The study reported that LPG-DFT resulted in higher hemoglobin concentrations compared to LsTG at 24 months (13.4 vs. 12.8 g/dL) and 36 months (13.5 vs. 12.8 g/dL) after surgery.

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LsTG is technically easier but has certain disadvantages, whereas LPG has some oncological advantages [10]. Specifically, LPG showed lower conversion rates to other procedures compared with LsTG (9.8% vs. 10.7%), partly because LPG allows for a longer proximal margin (median, 25 vs. 15 mm for LsTG). However, the operation time for LPG-DFT is significantly longer than that for LsTG (404 vs. 289 min) [9].

Thus, both procedures appear oncologically sound, with LsTG potentially offering some technical ease and LPG-DFT potentially offering better long-term hemoglobin levels. Therefore, the choice between procedures should be based on individual patient factors, surgeon's experience, and careful consideration of the potential benefits and risks associated with each approach.

Locally-advanced gastric cancer

PG has been investigated as a potential alternative to TG in patients with locally advanced gastric cancer in the upper third of the stomach. This approach aims to preserve stomach function by maintaining a greater portion of the gastric structure, potentially leading to improved postoperative nutritional status and QOL without compromising oncological radicality (**Table 1**) [11-14].

Ri et al. [11] examined patients with clinically advanced T2-T4 gastric cancer who underwent TG and revealed that the incidence of key distal lymph node metastasis, which denotes metastasis to stations 4d, 5, 6, and 12a, was either absent or very low for tumors located in the cardia and fornix and did not extend to the M region. These findings suggest that PG might be oncologically feasible for such patients [11]. Imai et al. [12] examined 71 patients with locally advanced upper-third gastric cancer and reported that the analysis of lymph node station 3, which was divided into 3a and 3b, revealed a high metastatic rate (32.7%) for station 3a, and a low metastatic rate for station 3b (3.8%).

Haruta et al. [13] provided further insights through their analysis of 385 patients with tumors in the upper third of the stomach. For advanced tumors with the distal border ending in the upper third (UE/U), the metastatic rate to station 3b was only 2.2%, which was significantly lower than that for tumors extending to the middle third (19.6%). The therapeutic index for station 3b in UE/U tumors was merely 1.1. Notably, all four UE/U tumors with 3b metastasis measured >40 mm in diameter and were T3 or T4 in depth. Supporting these findings, Yura et al. [14] analyzed 202 patients with pathological T2/T3 proximal gastric cancer and reported very low metastatic rates (0%–0.99%) to key distal lymph node stations (4d, 5, 6, 12a). Therefore, it was concluded that PG could be oncologically safe for T2/T3 proximal gastric cancer, potentially offering an alternative to TG in selected cases.

Table 1. Lymph node metastasis and therapeutic index in locally-advanced gastric cancer in the upper third of the stomach

Author	Year	Subjects	No.	T	Lymph node metastasis				Therapeutic index			
					#4d	#5	#6	#12a	#4d	#5	#6	#12a
Haruta et al. [13]	2016	Pathological T1–T4	385	T2–T4	3.3%	0.5%	1.6%	0%	0.6	0.6	0	0
Yura et al. [14]	2019	Pathological T2–T3	202	T2	0%	0%	0%	0%	0	0	0	0
				T3	1.6%	0%	0%	0.9%	0	0	0	0
Ri et al. [11]	2021	Clinical T2–T4	167	T2	0%	0%	0%	0%	0	0	0	0
				T3–T4	5.9%	1.4%	1%	0%	1.0	1.4	0	0
Imai et al. [12]	2024	Pathological T2–T4	71	T2–T4	2.8%	0%	1.4%	0%	2.1	0	0	0

Therapeutic index is a measure used to evaluate the effectiveness of lymph node dissection in gastric cancer surgery calculated using the following formula: Therapeutic Index = Metastasis Rate × 5-Year Overall Survival Rate. It helps surgeons identify which lymph node stations are most critical to dissect.

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These findings collectively suggest that PG could be oncologically safe for select patients with locally advanced upper-third gastric cancer, particularly those with tumors confined to the upper third and <40 mm in size, where appropriate proximal and distal margins can be secured. However, careful patient selection and further studies are required to establish definitive guidelines for the use of PG in advanced gastric cancer.

PG for cancer of the gastroesophageal junction

PG is increasingly considered an alternative to TG for gastroesophageal junction (GEJ) cancers, particularly those classified as Siewert type II. A meta-analysis by Chen et al. [15] showed no significant difference in 5-year overall survival rate (odds ratio [OR], 0.95; 95% confidence interval [CI], 0.64–1.40) or recurrence rate (OR, 3.79; 95% CI, 0.37–38.46) between PG and TG. Similarly, Hipp et al. [16] reported that overall survival after PG was not inferior to that after TG, although they noted potential biases due to imbalanced tumor stages between the groups. Both reviews highlighted the nutritional benefits of PG. Chen et al. [15] found that PG patients had significantly higher serum hemoglobin, albumin, total protein, and cholesterol levels at 2–3 years follow-up. Hipp et al. [16] also reported less postoperative body weight loss (mean difference [MD], 3.56%; 95% CI, 1.32–5.79) and higher hemoglobin levels (MD, 3.73%; 95% CI, 1.59–5.88) at 12 months in PG patients compared to TG patients. However, both reviews observed a higher incidence of anastomotic strictures with PG. Chen et al. [15] found significantly more anastomotic stricture after PG (OR, 3.18; 95% CI, 1.46–6.92), whereas Hipp et al. [16] reported no significant difference in reflux symptoms between the 2 procedures. Overall, these reviews suggest that PG may be feasible for selected patients with GEJ cancer, potentially offering nutritional advantages without compromising oncological outcomes; however, careful patient selection and management of anastomotic complications are important considerations.

Adequate lymphadenectomy is critical for both staging and potential therapeutic benefit in GEJ cancer surgery. Lymph node dissection for GEJ cancer should focus on stations 1, 2, 3a, and 7, which had the highest rates of metastasis. Kurokawa et al. [17] reported metastasis rates of 47.1% at station 1, 23.5% at station 2, 39.2% at station 3a, and 23.5% at station 7, classifying these as Category 1 nodes, which are strongly recommended for dissection. Station 3b showed a lower metastasis rate (7.8%) and was classified as Category 2, with a weaker recommendation for dissection. Sato et al. [18] corroborated these findings by showing high metastasis rates at stations 1 (47.1%), 2 (23.5%), 3a (39.2%), and 7 (23.5%). Importantly, neither study found metastases at stations 4d, 5, or 6, suggesting that these can be omitted from the dissection. For tumors with esophageal involvement exceeding 2 cm, dissection of the lower mediastinal station 110 is recommended due to a metastasis rate exceeding 10%. Additionally, for tumors with esophageal involvement >4 cm, dissection of the upper mediastinal station 106recR should be considered, as the metastasis rate exceeds 10% in these cases.

Obtaining an adequate proximal margin is critical when performing PG for GEJ cancer. Koterazawa et al. [19] conducted a retrospective study on 289 patients who underwent PG or TG for gastric cancer with esophageal invasion or GEJ cancer. The study found that a gross proximal margin of 25 mm was required to ensure a pathologically negative margin in all the cases. However, shorter margins could be sufficient in certain subgroups: 15 mm for tumors ≤40 mm or superficial growth type, and 20 mm for expansive growth type. A larger tumor size (>40 mm), infiltrative growth, and undifferentiated histology were independently associated with the need for longer margins. The authors recommended tailoring the

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proximal resection length based on these tumor characteristics, with intraoperative frozen section analysis to confirm negative margins.

RECONSTRUCTION VARIATIONS AND SURGICAL OUTCOMES IN PG

DFT

The DFT involves the creation of double seromuscular flaps (typically 2.5 cm wide×3.5 cm high) at the anterior wall of the gastric remnant [20-22]. An incision is made at the inferior end of the mucosal window, and the esophagus is fixed at the superior edge of the mucosal window. Posterior wall anastomosis is performed between the full-thickness esophagus and the gastric mucosa/submucosa using running sutures. The anterior wall is then anastomosed using layer-to-layer running or interrupted Gambee sutures [22,23]. Finally, the anastomosis is fully covered by suturing the seromuscular flaps into a Y-shape. This creates a "new cardia" with the esophagus buried in the gastric wall, providing an anti-reflux mechanism.

Studies have demonstrated favorable QOL outcomes after DFT compared with other reconstruction techniques. Hayami et al. [20] reported significantly better scores on the Postgastrectomy Syndrome Assessment Scale-45 (PGSAS-45) questionnaire for esophageal reflux symptoms, dumping symptoms, and mental health component summary at 1 year postoperatively compared with TG. Kumamoto et al. [22] also observed lower rates of postoperative digestive symptoms (27% vs. 53%) and reflux/meal-related symptoms (18% vs. 35%) with DFT than with jejunal interposition at 1 year.

The incidence of reflux esophagitis after DFT has consistently been low across studies. Shoji et al. [21] reported reflux esophagitis ≥grade B in 4.2% of patients at 1 year. Kumamoto et al. [22] found only one patient (9%) with grade B reflux at 1 year. Saze et al. [23] reported no cases of reflux esophagitis in their DFT group. These rates are much lower than those observed with conventional EG techniques.

Anastomotic strictures requiring dilation occurs in 5%–10% of patients after DFT, according to a recent large series. Shoji et al. [21] reported an 8.3% stricture rate requiring balloon dilation. Kumamoto et al. [22] found a 5.3% anastomotic stricture rate. Kuroda et al. [24] reported a stricture rate of 4.7% in a multicenter study. Although present, these rates are lower than those of several conventional reconstruction techniques after PG.

Robotic surgery for PG has emerged as a promising alternative to laparoscopic surgery and offers potential advantages in terms of precision and dexterity. Hu et al. [25] compared robotic proximal gastrectomy with DFT (RPG-DFT) to LPG with DFT (LPG-DFT) for upper-third gastric and esophagogastric junction cancers in both unmatched and propensity-score matched patient cohorts. Their findings revealed that even during its introductory phase, RPG-DFT demonstrated comparable safety to the established LPG-DFT procedures, with severe postoperative complications (Clavien-Dindo grade ≥IIIa) occurring in only 2.8% of RPG-DFT patients compared to 9.9% in LPG-DFT patients in the propensity-score matched cohort.

Notably, RPG-DFT offers advantages in several key areas. The median reconstruction time for RPG-DFT was 100 (100) minutes, which was significantly shorter than the 120 (130) minutes for LPG-DFT. Intraoperative blood loss was also reduced in the RPG-DFT group, with a

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median of 45 (45) g, compared to 50 (70) g in the LPG-DFT group. Furthermore, patients undergoing RPG-DFT had shorter postoperative hospital stays, with a median of 8 (8) versus 10 (10) days for patients undergoing LPG-DFT. However, the study also highlighted a higher incidence of anastomotic stenosis in the RPG-DFT group (25.0%) than in the LPG-DFT group (12.1%), although this complication showed a decreasing trend over time, falling from 37.5% in 2019 to 17.6% in 2022, as surgeons gained experience with the robotic technique.

Although the initial learning curve may pose challenges, such as a higher rate of anastomotic stenosis, the benefits of shorter reconstruction time, reduced blood loss, and shorter hospital stays suggest that with increased experience and refinement, RPG-DFT could become the preferred surgical approach for these types of cancers.

Overlap anastomosis with a linear stapler

Several techniques for esophagogastric anastomosis using linear staplers have been described in recent literature. One such method, the side overlap with fundoplication using Yamashita (SOFY) technique involves making small incisions on the right side of the esophageal stump and anterior gastric wall, inserting the forks of a 45-mm linear stapler, rotating the esophagus 90° counterclockwise, and stapling to create a side-to-side anastomosis. The entry hole is then closed using barbed sutures. A modified version (mSOFY) makes the anastomosis on the right side of the esophagus instead of the left, inserts the stapler from the patient's right side, and uses single-layer closure of the entry hole [26]. The conical remnant gastroesophageal side-overlap fundoplication (CGEO) technique uses a similar side-to-side stapling approach but shapes the gastric remnant into a conical form [27]. The right-sided overlap and single-flap valvuloplasty (ROSF) method creates a single left-sided seromuscular flap on the remnant stomach, performs side-to-side stapling of the right esophageal wall to the gastric mucosal window, and covers the anastomosis with the flap [28]. The EG with placement of the remnant stomach into the lower mediastinum (EG-PRIME) technique involves creating a pseudo-fornix and lozenge-shaped gastric conduit, inserting it into the esophageal hiatus, and performing an overlapping anastomosis [29].

Common technical considerations across these methods include the adequate mobilization of the esophagus and remnant stomach to allow tension-free anastomosis, precise placement of a linear stapler to create an appropriately sized anastomosis, and meticulous closure of the common entry hole. Barbed sutures are frequently used for the closure to simplify this step. Some techniques, such as ROSF and EG-PRIME, incorporate additional antireflux mechanisms, such as flap creation or positioning of the remnant stomach. The choice of stapler size (typically 45 mm) and cartridge color (cartridge with 3.5–4 mm height staples) is relatively consistent across techniques.

The incidence of reflux esophagitis varies across these methods, ranging from 0%–17.9%. The SOFY and mSOFY techniques reported reflux rates of 7.1%–17.8%. The CGEO technique reported no reflux symptoms in four patients at 6 months follow-up. In the ROSF method, only 1 of 20 patients (5%) had mild reflux symptoms, and 1 patient (5%) had endoscopic evidence of reflux esophagitis at 1 year. The EG-PRIME study reported no reflux symptoms in three patients, with 24-hour pH monitoring showing a fraction time of pH <4 ranging from 0.3%–9.0%.

Anastomotic stenosis rates were generally low for these overlapping anastomoses. The SOFY and mSOFY methods have reported stenosis rates of 0%–2.8%. No stenosis was observed in the initial CGEO, EG-PRIME, and ROSF cases. These rates compare favorably to the higher stenosis rates (4.7%–29.1%) reported for other reconstruction techniques, such as DFT.

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DTR

DTR after PG involves three key anastomoses: esophagojejunostomy (EJ), gastrojejunostomy (GJ), and jejunojejunostomy (JJ). For the EJ, both circular and linear stapling techniques have been described [30,31]. Circular stapling methods include direct anvil insertion, reverse puncture, and transoral anvil insertion (OrVil™). Linear stapling approaches such as overlap and π-shaped anastomoses have also been reported. The GJ is typically performed 15–20 cm distal to the EJ using either circular or linear staplers, whereas the JJ is usually created 20 cm distal to the GJ using a linear stapler.

A novel technique described by Tanaka et al. [32] involves twisting both the remnant stomach and jejunum during the GJ to create an "oblique jejunogastrostomy," which aims to facilitate food passage through the remnant stomach. Another proposed technical variation is ligation of the jejunum just distal to the GJ to create a "single tract," potentially improving nutritional outcomes, although this approach may increase glucose intolerance [33].

Studies have demonstrated favorable outcomes for DTR in terms of postoperative QOL, reflux symptoms, and anastomotic complications [30-32,34]. Tanaka et al. reported no anastomotic leakage or strictures in a series of 10 patients, with only two patients experiencing moderate reflux symptoms that resolved with proton pump inhibitor treatment. The average percentage body weight loss at 10 months postoperatively was 14.0%, and the average percentage decrease in hemoglobin at 12 months was 5.4%. A meta-analysis by Xu et al. [35] found that DTR was associated with a lower incidence of reflux esophagitis than EG after PG (0%–25% vs. 9.1%–35.3%). Tang et al. [31] summarized multiple studies showing low rates of reflux symptoms (0%–4.8%) and anastomotic complications after DTR. One comparative study they cited reported that only 13% (2/15) of patients who underwent oblique GJ had contrast directly entering the jejunum on fluoroscopy, compared to higher rates with traditional side-to-side GJ.

A multicenter randomized trial in Korea, KLASS-05, evaluated whether LPG with DTR (LPG-DTR) could effectively address the drawbacks of TG, such as poor QOL and nutritional deficits. The trial, which included 138 patients, found that LPG-DTR achieved results comparable to laparoscopic TG in terms of operative time (219.4 vs. 201.8 minutes), blood loss (76.0 vs. 66.1 mL), and overall morbidity (23.5% vs. 17.4%), with no mortality in either group. Most notably, despite common concerns about DTR's structural complexity and multiple anastomoses, there were no anastomosis-related complications, and postoperative symptoms, including reflux, were similar between the groups. The authors concluded that DTR successfully preserved gastric function while avoiding complications typically associated with PG, making it a viable alternative to TG for upper early gastric cancer. However, they emphasized the importance of proper patient selection through preoperative screening [36].

Jejunal interposition (JI)

JI after PG involves creating a 10–15 cm jejunal segment to interpose between the esophagus and remnant stomach. There are 2 main variations: DTR and single-tract jejunal interposition (STJI) [22,33,37]. In DTR, an end-to-side EJ is created, followed by a jejunogastrostomy 12–15 cm distal to it, and a JJ 30–50 cm further. STJI is similar but includes blocking the jejunal segment distal to the GJ. In the laparoscopic approach described by Kinoshita et al. [37], EJ and jejunogastrostomy were performed intracorporeally, whereas JI and JJ were performed via a 5 cm mini-laparotomy. A 25 mm circular stapler was used for EJ and a 60 mm linear stapler for jejunogastrostomy. JI was performed in an antecolic or retrocolic manner. Both open

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and laparoscopic techniques emphasize preserving blood supply to the interposed jejunal segment through careful mesenteric division.

With regard to postoperative reflux and stricture, a meta-analysis by Lu et al. [33] found no significant differences between DTR and STJI in terms of reflux esophagitis, anastomotic complications, or total complications. However, STJI was associated with longer operation times (P=0.04) and better postoperative nutritional outcomes, including a significantly higher body weight at 6 months postoperatively (P=0.02). Endoscopic evaluation revealed low rates of reflux esophagitis in both the DTR and STJI groups. According to Kinoshita et al. [37] and Kumamoto et al. [22], anastomotic stricture rates requiring endoscopic dilation were reported as 9.1% in laparoscopic cases, 5.9% in open cases, and 7% overall. Likewise, the anastomotic leakage rates were considerable, occurring in 9.1% of laparoscopic cases, 7.4% of open cases, and 7% overall. Despite these complications, all studies have concluded that jejunal interposition provides good anti-reflux outcomes after PG, with STJI potentially offering nutritional advantages over DTR. However, the authors emphasized the need for larger long-term studies to further evaluate these outcomes.

Other variations

Spade-shaped anastomosis (SPADE operation)

The SPADE operation can resolve the 3 physiological mechanisms that contribute to reflux: the His angle, fornix, and lower esophageal sphincter (**Fig. 2**) [38]. The key features include a double-suture technique to fix the distal part of the posterior esophageal wall to the proximal part of the anterior stomach wall, which creates an anti-reflux mechanism by producing a spade-shaped anastomosis. The study included 56 patients, 26 of whom underwent the SPADE operation. The key advantage is a significant reduction in reflux symptoms compared with conventional EG. Only 11.5% of patients who underwent SPADE experienced mild reflux symptoms compared with 43.3% of patients in the conventional EG group. Endoscopic findings showed lower rates of reflux esophagitis, bile reflux, and residual food in the SPADE group.

Double ligation method

Takayama et al. [39] introduced a novel technique for intracorporeal circular EJ (**Fig. 3**). The method involves a handsewn purse-string suture on the esophagus, followed by a double-ligation process to secure the anvil. In this study involving 202 patients, this technique demonstrated low rates of anastomotic complications, with only 2% of patients experiencing leakage and 6% developing stenosis. The main advantages of this method are its simplicity and safety as it requires only 1 absorbable thread and no specialized devices for anvil fixation.

Esophagogastric asymmetric anastomosis

This technique involves creating an asymmetric anastomosis between the esophagus and the remnant stomach (**Fig. 4**) [40]. Key features include an oblique cut of the lower esophagus, asymmetry between the esophageal diameter and the gastric incision, 90-degree torsion of the esophagus, and asymmetric suturing to create a valve-like structure. In this study, which enrolled 13 patients, only 2 developed mild reflux esophagitis postoperatively. The main advantage of this method is the creation of an effective anti-reflux mechanism without the need for complex reconstruction procedures.

Gastric tube reconstruction with stapled pseudo-fornix

Hosogi et al. [41] presented a technique that uses a gastric tube (35 mm wide) for reconstruction after LPG. A key step is the use of a no-knife linear stapler to create a

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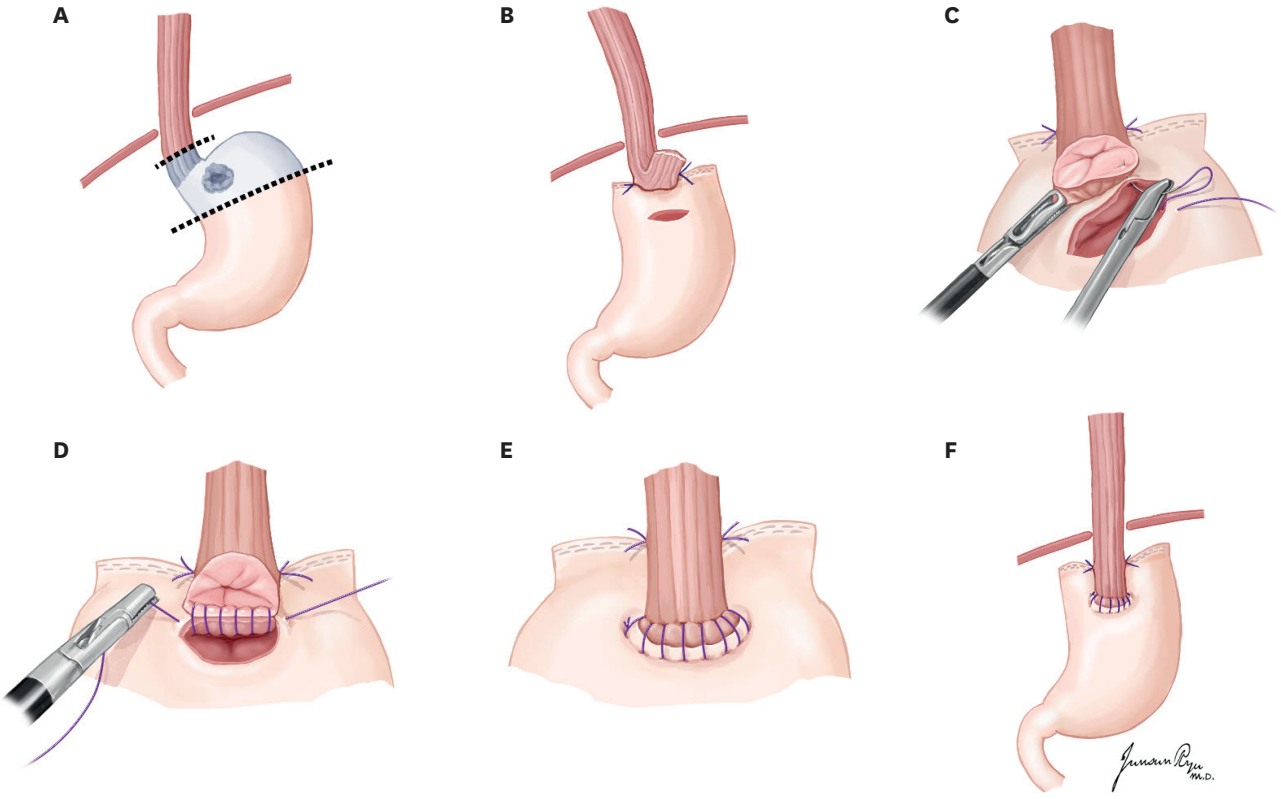

Fig. 2. Illustration of SPADE operation. (A) Laparoscopy assisted or totally laparoscopic D1+ proximal gastrectomy was conducted. (B) Both the distal part of the posterior wall of the esophagus and the proximal part of the anterior wall of the stomach were sutured with an interrupted stitch. (C) After an opening was made, one stitch was placed at the left corner of the esophagus posterior wall and the stomach anterior wall. (D) Anastomosis was performed using 2 continuous sutures (V-Loc™ or Stratafix™), each starting from the left corner moving in the opposite direction. (E) After completion of the posterior wall anastomosis, the anterior wall anastomosis was performed from both ends toward the middle. (F) After completing the anastomosis, a spade shape was formed, with an artificial His angle and pseudo-fornix created with a sphincter and intraabdominal anastomosis.
Adapted from 'Spade-shaped anastomosis following a proximal gastrectomy using a double suture to fix the posterior esophageal wall to the anterior gastric wall (SPADE operation): case-control study of early outcomes' by Han et al. [38], published in *J Gastric Cancer*, Volume 20, Pages 72–80, 2020, DOI: 10.5230/jgc.2020.20.e5. This work is licensed under a Creative Commons Attribution-NonCommercial License (CC BY-NC), which permits use for non-commercial purposes with proper attribution.

"pseudo-fornix" at the anastomotic site. This procedure was feasible in 15 patients, with low complication rates. Its main advantage is that it allows tension-free anastomosis, even for bulky tumors requiring lower esophagectomy, owing to the long gastric tube used.

Gastric tube reconstruction

This technique creates a narrow gastric tube from the greater curvature for anastomosis to the esophagus [42]. In this study of 41 patients, manometry demonstrated the recovery of gastric tube motility over time, which correlated with decreased reflux. Its key advantage is the preservation of gastric function while providing a simple, single-anastomosis technique. The study showed that the incidence of reflux esophagitis decreased from 19.5% at 1 month to 12.1% at 1-year post-surgery, correlating with improved gastric tube motility.

COMPARISONS AMONG VARIOUS RECONSTRUCTION METHODS

PG has become an increasingly common procedure for upper third gastric cancer, and various reconstruction techniques have been developed to improve postoperative outcomes.

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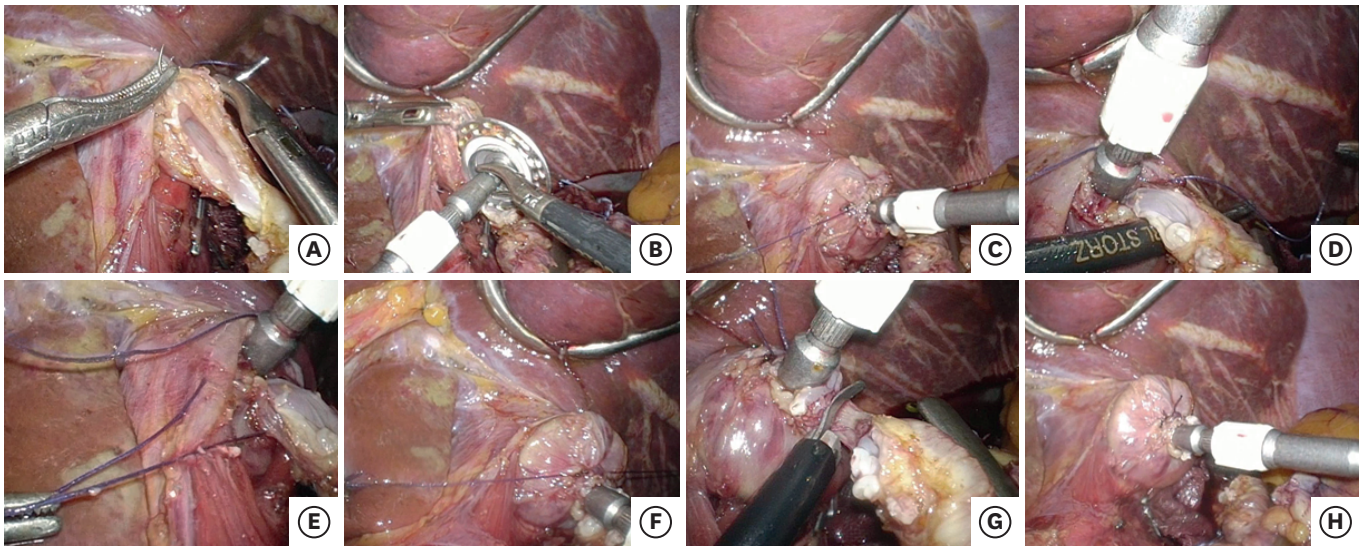

Fig. 3. Anvil fixation technique. (A) After incising 3/4 of the esophageal wall, a laparoscopic handsewn purse-string suture was performed. (B) An anvil rim was introduced into the esophageal lumen by sliding it on the posterior wall of the esophagus. (C) The purse-string suture was ligated. (D) Kelly forceps were passed through the posterior wall of the esophagus to grasp the ligated thread. (E) The ligated thread was turned through the posterior wall of the esophagus. (F) The turned thread was ligated again. (G) The remnant esophageal wall was incised. (H) The anvil fixation was completed.
Adapted from 'A novel technique of hand-sewn purse-string suturing by double ligation method (DLM) for intracorporeal circular esophagojejunostomy' by Takayama et al. [39], published in *J Gastric Cancer*, Volume 19, Pages 290–300, 2019, DOI: 10.5230/jgc.2019.19.e26. This work is licensed under a Creative Commons Attribution-NonCommercial License (CC BY-NC), which permits non-commercial use with proper attribution.

Several studies have compared the surgical outcomes between different reconstruction methods after PG, providing valuable insights into their relative advantages and disadvantages (**Table 2**) [20-24,26,30,34,35,37,38,43,44].

Kumamoto et al. [22] compared DFT to JI and found no significant differences in operation time (228 vs. 246 minutes, P=0.377) or incidence of anastomotic complications (7% vs. 0%, P=0.412). However, the DFT group showed significantly lesser blood loss than the JI group (250 vs. 435 mL, P=0.015). Chen et al. [43] expanded their comparison to include EG, gastric tube reconstruction, and DTR. They reported that the mean operative time was significantly longer in the DTR group than in the EG and gastric tube groups (163 vs. 139 vs. 141 minutes, respectively; P=0.001), although blood loss did not differ significantly between the three groups. Xu et al. [35] compared DTR to tube-like stomach reconstruction (TLR) and found no significant differences in operation time, blood loss, or postoperative hospital stay.

A key consideration in reconstruction after PG is prevention of reflux symptoms and esophagitis. Kumamoto et al. [22] found only one patient (9%) in the DFT group who experienced reflux esophagitis (≥grade B) compared with zero patients in the JI group. Chen et al. [43] reported significant differences in postoperative reflux symptoms (P=0.042) and reflux esophagitis (P=0.040) among the EG, GT, and DTR groups. The DTR group had the lowest rates, with 19.4% of patients experiencing reflux symptoms and 13.9% having reflux esophagitis on endoscopy, which were markedly lower than those in the EG (45.1% and 37.3%, respectively) and GT groups (39.0% and 23.4%, respectively). Xu et al. [35] found no significant difference in the incidence of reflux esophagitis between the DTR and TLR groups (10.9% vs. 18.2%, P=0.279). Nishimura et al. [44] reported reflux esophagitis rates of 22.2% for EG, 10% for DF, and 0% for DTR 1 year after surgery.

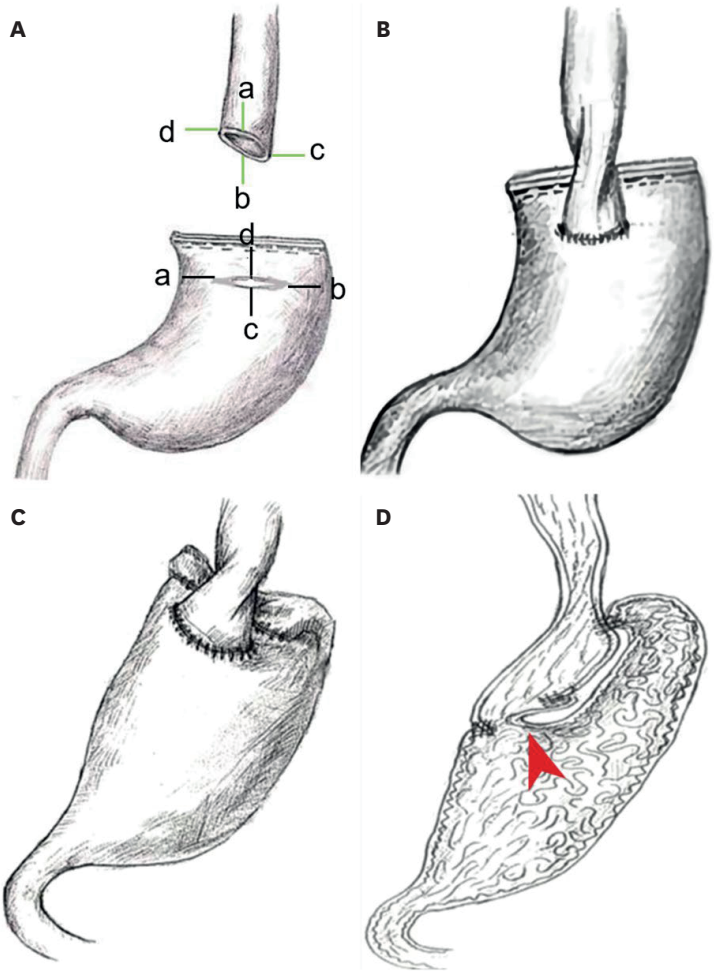

Fig. 4. Critical design features of the esophagogastric asymmetric anastomosis technique. (A) The diameter of the esophagus and the incision size of the residual gastric anterior wall were asymmetric; and the length of the two sides of the lower esophagus was asymmetrical; the points a/b/c/d shows the corresponding points of asymmetric anastomosis between the esophagus and the residual stomach. (B) Asymmetry of the longitudinal section (or sagittal surface) of the esophagus and residual stomach after anastomosis. (C) After anastomosis, the seromuscular layer of the residual stomach and esophagus was asymmetrically sutured. (D) The sagittal plane of esophagogastric asymmetric anastomosis: showing the suture point of the asymmetric anastomosis; the red arrow indicates a flap structure formed by the folded gastric wall in the gastric cavity.
Adapted from 'Anti-reflux effects of a novel esophagogastric asymmetric anastomosis technique after laparoscopic proximal gastrectomy' by Pang et al. [40], published in *World J Gastrointest Surg*, Volume 15, Issue 8, Pages 1761–1773, 2023, DOI: 10.4240/wjgs.v15.i8.1761. This work is licensed under a Creative Commons Attribution-NonCommercial License (CC BY-NC), which permits use for non-commercial purposes with proper attribution.

Postoperative nutritional status is another important factor in the evaluation of reconstruction techniques. Kumamoto et al. [22] found that the DFT group had significantly less body weight loss at 1 year compared with the JI group (−8.1% vs. −16.1%, P=0.001). Total protein and albumin levels were also higher in the DFT group, although the differences were not statistically significant. Chen et al. [43] reported that the GT group had significantly higher reduction rates in total protein, albumin, and hemoglobin at 12 months postoperatively than the EG and DTR groups. The mean body weight loss at 1 year was also the highest in the GT group at 12.6%, compared to 9.8% in the EG group and 8.1% DTR group (P=0.021). Xu et al. [35] found that patients in the DTR group had significantly higher weight 1 year after surgery than those in the TLR group. They also reported that hemoglobin and albumin levels in both groups recovered to preoperative levels 1 year after surgery. Saze et al. [23] found that the DFT group had the most favorable body weight changes over 36 months postoperatively compared with the EG, JI, and DT reconstruction groups.

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Table 2. Surgical outcomes among various reconstruction methods after proximal gastrectomy

Author (year)	Reconstruction method	Surgical outcomes/Comparisons (%)		
		Reflux esophagitis	Reflux symptoms	Stenosis/stricture
Kinoshita et al. (2013) [37]	Laparoscopic JI (n=22)	n/a	0	9.1
	Open JI (n=68)	n/a	0	5.9
Hayami et al. (2017) [20]	PG-DFT (n=43)	2.3	4.7	n/a
	TG (n=47)	14.9	12.8	n/a
Shoji et al. (2019) [21]	PG-DFT (n=147)	4.2	n/a	8.3
Han et al. (2020) [38]	PG-SPADE (n=26)	15.3	11.5	0
	PG-conventional EG (n=30)	30	53.3	13.3
Hu et al. (2020) [30]	PG-DTR (circular) (n=15)	0	0	0
Kumamoto et al. (2021) [22]	PG-DFT (n=14)	9	n/a	0
	PG-JI (n=20)	0	n/a	0
Saze et al. (2021) [23]	PG-DFT (n=36)	0	n/a	8.3
	PG-DTR (n=14)	21.4	n/a	21.4
	PG-JI (n=10)	10	n/a	10
	PG-EG (n=9)	22.2	n/a	11.1
Nishimura et al. (2023) [44]	PG-EG (circular) (n=33)	24	n/a	n/a
	PG-DFT (n=35)	3	n/a	n/a
	PG-DTR (n=8)	n/a	n/a	n/a
Yamashita et al. (2022) [26]	PG-modified SOFY (n=36)	17.8	2.8	2.8
Chen et al. (2023) [43]	PG-EG (n=51)	37.3	45.1	2.0
	PG-gastric tube (n=77)	23.4	39.0	5.2
	PG-DTR (n=36)	13.9	19.4	5.6
Xu et al. (2023) [35]	PG-DTR (n=55)	10.9	n/a	5.5
	PG-TLR (n=55)	18.2	n/a	9.1
Zhang et al. (2023) [34]	PG-DTR (n=36)	8.3*	n/a	n/a
	PG-EG (n=37)	32.4*	n/a	n/a
Kuroda et al. (2019) [24]	PG-DFT (n=39)	5.3 (grade A/B)	n/a	5.3

JI = jejunal interposition; n/a = not assessed; PG = proximal gastrectomy; DFT = double flap technique; TG = total gastrectomy; EG = esophagogastrostomy; DTR = double-tract reconstruction; SOFY = side-overlap with fundoplication by Yamashita.
*Significant difference.

Nishimura et al. [44] provided a detailed comparison of changes in body composition among the EG-DFT, EG-circular stapler (CS), and DTR methods. They found that both subcutaneous adipose tissue (SAT) and visceral adipose tissue (VAT) were significantly better preserved in the EG than in the DTR ($P<0.01$ for SAT and $P=0.04$ for VAT). However, there were no significant differences in SAT and VAT preservation between CS and DFT. With regard to reflux, the DFT group showed a lower incidence of reflux esophagitis compared with the CS group. Specifically, only 3% of patients in the DFT group experienced reflux esophagitis, which was significantly lower than the rate of 24% observed in the CS group.

Although each reconstruction technique has specific advantages and disadvantages, the DFT appears to offer superior outcomes in terms of reflux prevention and postoperative nutritional status. However, this may be associated with longer operative times. The choice of reconstruction method should be tailored to individual patient factors and the surgeon's experience. Further large-scale prospective studies are required to definitively determine the optimal reconstruction method after PG.

QOL ASSESSMENT

QOL assessment after PG has become essential for evaluating the surgical outcomes in patients with upper-third gastric cancer. Various tools and methods have been employed to comprehensively assess the postoperative experience (**Table 3**) [44-47].

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Table 3. Comprehensive quality of life outcomes after PG

Aspect	PG	TG	PG-EG	PG-DTR	SRDG	Reference
Body weight loss	−12.0%	−14.3%	−11.4%	−13.0%	−10.9%	[44–47]
Need for additional meals	2.2	2.4	2.2	2.3	2.2	[44–46]
Ability to work	2.1	2.2	2.1	2.1	1.8	[44–46]
Constipation SS	2.4	2.2	2.5	2.1	2.1	[44–46]
Reflux esophagitis rate	n/a	n/a	27.3%	7.6%	n/a	[47]
Anastomotic stricture rate	n/a	n/a	12.5%	4.2%	n/a	[47]
Anastomotic leakage rate	n/a	n/a	2.2%	2.8%	n/a	[47]
Early complications rate	n/a	n/a	15.2%	18.2%	n/a	[47]
Esophageal reflux SS	2.0	2.1	1.9	2.1	1.5	[45,46]
Abdominal pain SS	1.7	1.7	1.7	1.8	1.5	[45,46]
Meal-related distress SS	2.6	2.6	2.6	2.7	2.1	[45,46]
Indigestion SS	2.2	2.2	2.1	2.2	2.1	[45,46]
Diarrhea SS	2.2	2.4	2.3	2.2	2.4	[45,46]
Dumping SS	2.1	2.2	2.2	2.1	1.9	[45,46]
Total symptom score	2.2	2.2	2.2	2.2	2.0	[45]
Ingested amount of food per meal	6.2	6.1	6.2	6.3	7.6	[45,46]
Quality of ingestion SS	3.6	3.6	3.6	3.7	3.8	[45,46]
Dissatisfaction with symptoms	2.0	2.0	2.0	2.0	1.7	[45,46]
Dissatisfaction at meal	2.6	2.7	2.6	2.7	2.1	[45,46]
Dissatisfaction at working	1.9	2.1	1.9	2.0	1.6	[45,46]
Dissatisfaction for daily life SS	2.2	2.3	2.2	2.2	1.8	[45,46]
PCS of SF-8	49.1	48.7	48.9	49.4	51.6	[45,46]
MCS of SF-8	49.7	49.4	49.6	49.5	51.1	[45,46]
EORTC QLQ-C30 Global QoL	n/a	n/a	Lower	Higher	n/a	[47]
EORTC QLQ-STO22 Dysphagia	n/a	n/a	N/S	N/S	n/a	[47]
EORTC QLQ-STO22 Pain	n/a	n/a	N/S	N/S	n/a	[47]
EORTC QLQ-STO22 Reflux	n/a	n/a	Higher	Lower	n/a	[47]
EORTC QLQ-STO22 Eating Restrictions	n/a	n/a	N/S	N/S	n/a	[47]

Scores were measured by Postgastrectomy Syndrome Assessment Scale-45 unless otherwise specified. Generally, for most symptom-related items and subscales, lower scores indicate better quality of life outcomes for the patient, whereas for some items related to physical functioning or food intake, higher scores may indicate better outcomes.
PG = proximal gastrectomy (including EG and DTR); TG = total gastrectomy; EG = esophagogastrostomy; DTR = double-tract reconstruction; SRDG = small remnant distal gastrectomy; SS = symptom subscale; n/a = not assessed; PCS = physical component summary; MCS = mental component summary; EORTC-QOL = European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire; N/S = not significant.

The PGSAS-45 has emerged as a valuable tool for assessing the QOL after gastric surgery. Developed by the Japan Postgastrectomy Syndrome Working Party, this questionnaire comprises 45 items, including questions from the 8-Item Short-Form Health Survey and Gastrointestinal Symptom Rating Scale [45,46,48]. The PGSAS-45 evaluates various aspects of postoperative life, including symptoms, living status, and overall QOL, providing a multidimensional assessment of patient outcomes.

In a large-scale study using the PGSAS-45, Kunisaki et al. [45] compared QOL outcomes between patients who underwent PG and TG. They found that PG patients experienced less body weight loss (−12.0% vs. −14.3%), had less need for additional meals, and reported a better ability to work than TG patients. However, PG patients reported more severe constipation than those who underwent TG. These findings suggest that PG may offer QOL advantages over TG, particularly in terms of nutritional outcomes and daily functioning.

The choice of reconstruction method after PG can significantly affect postoperative QOL. Ikeda et al. used the PGSAS-45 to compare QOL outcomes between the EG and DTR reconstruction methods [48]. Their study revealed that DTR promoted significantly better constipation subscale scores ($P<0.05$), whereas the EG tended to result in less body weight loss ($P<0.10$). Interestingly, when stratified by remnant stomach size, DTR showed advantages in several QOL measures for both 1/2 and 2/3 remnant stomach sizes.

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The importance of QOL assessment was further emphasized in a study by Nakada et al. [46] that compared QOL outcomes across various gastrectomy procedures. They found that small remnant distal gastrectomy and DG, which preserves part of the stomach, enhanced postoperative QOL compared to TG.

Fujisaki et al. [47] highlighted the impact of tumor location on postoperative QOL and found that among post-PG patients, those with upper third gastric cancer had better QOL in several measures than those with GEJ cancer. This underscores the importance of considering the tumor location when assessing and predicting postoperative QOL.

Beyond the PGSAS-45, other QOL assessment tools have been employed. Some studies utilized the European Organization for Research and Treatment of Cancer QLQ-C30 and QLQ-STO22 questionnaires [47,49]. These tools provide insights into global QOL and gastric cancer-specific symptoms. One study reported that DTR showed apparent advantages over the EG in terms of global QOL scores based on these measures.

Li et al.'s systematic review [49] and meta-analysis provided a comprehensive overview of QOL assessments across various reconstruction methods. They found that esophagojejunal anastomosis methods (including DTR) resulted in lower rates of reflux esophagitis (7.6% vs. 27.3%) and anastomotic stricture (4.2% vs. 12.5%) than the EG. However, EG were associated with less weight loss at 12 months postoperatively (MD, −1.25%; 95% CI, −2.11 to −0.39; P=0.004).

Assessing QOL after PG is crucial for understanding the full impact of surgery on patients' lives. The PGSAS-45 has proven to be a valuable tool for comprehensively evaluating postoperative outcomes. Although PG generally seems to offer QOL advantages over TG, the optimal reconstruction method and the impact of factors such as tumor location remain subjects of ongoing research. Future studies should focus on standardizing QOL assessments and conducting larger randomized trials to definitively determine the best surgical approach to maximize the postoperative QOL in patients undergoing PG.

GASTRIC STUMP CANCER AFTER PG

The incidence of metachronous gastric cancer (MGC) after PG varies among studies but appears to be higher than that of other gastrectomy procedures. Nunobe et al. [50] reported that the incidence of MGC was as low as 1.7%, particularly in males; however, long-term follow-up is recommended, as some cases develop more than 10 years postoperatively. In a large nationwide Japanese survey, the precise incidence of MGC after PG was 6.28%, which was significantly higher than that after distal gastrectomy (2.35%) (P<0.001) [51]. Another multicenter study in Japan reported an even higher incidence of 8.9% after PG with DFT, with cumulative 5- and 10-year incidence rates of 5.7% and 11.4%, respectively [52]. A South Korean single-center study found a slightly lower but still elevated incidence of 4.8% after PG [53]. The variation in the reported incidences may be due to differences in the follow-up duration and definitions of MGC between the studies.

Several risk factors have been identified for the development of MGC [50-53]. Age and sex appear to be significant factors, with female patients aged ≥60 years at a higher risk than younger male patients. The surgical method itself is also a risk factor because PG is

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associated with a higher incidence of MGC than other gastrectomy types, likely because of the larger amount of remnant gastric mucosa. Additionally, male sex and intestinal-type histology of the primary tumor have been suggested as potential risk factors. *Helicobacter pylori* infection status may also play a role, with untreated infections potentially increasing the risk of MGC. These factors highlight the importance of careful patient selection and postoperative management for patients undergoing PG.

Endoscopic submucosal dissection (ESD) has emerged as an important treatment option for MGC after PG. A Japanese nationwide survey found that 50.8% of MGC cases after PG were treated with ESD, which was significantly higher than the 31% ESD rate for MGC after distal gastrectomy ($P<0.001$) [51]. Similarly, a multicenter study of PG using DFT reported that 71% of MGC lesions were treated with ESD [52]. The higher rates of ESD after PG are likely due to the larger remnant stomach, which allows for easier endoscopic access and treatment. For more advanced MGC that are not amenable to ESD, completion TG is typically performed. A multicenter study found that 16% of MGC cases after PG required surgical resection. Overall, ESD appears to be the preferred first-line treatment when feasible, with surgery being reserved for more advanced lesions. This organ-preserving approach helps maintain QOL of patients by avoiding completion gastrectomy whenever possible.

CONCLUSIONS

Based on a comprehensive review of PG for gastric cancer, several key conclusions can be drawn. PG has emerged as a viable function-preserving alternative to TG for selected patients with proximal gastric cancer, offering improved postoperative QOL and nutritional outcomes. Various reconstruction techniques have been developed to address the challenges such as reflux and anastomotic complications, with DFT and DTR showing particularly promising results. However, the optimal reconstruction method remains the subject of debate and ongoing research. Although PG demonstrates oncological adequacy for early-stage cancers, careful patient selection is crucial, particularly for more advanced tumors. The higher incidence of MGC after PG underscores the importance of long-term endoscopic surveillance. Overall, PG represents a valuable option in the surgical management of proximal gastric cancer, balancing organ preservation with oncological principles; however, further large-scale, long-term studies are needed to definitively establish its role and refine patient selection criteria.

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