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ORIGINAL ARTICLE

Optimal Roux-en-Y reconstruction after distal gastrectomy for early gastric cancer as assessed using the newly developed PGSAS-45 scale

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Abstract
Purpose The optimal surgical procedure for distal gastrectomy with Roux-en-Y reconstruction (DGRY) remains to be determined. Recently, a self-report assessment instrument, the Postgastrectomy Syndrome Assessment Scale-45 (PGSAS-45), was compiled to evaluate symptoms, the living status and the quality of life of patients who have undergone gastrectomy. We used this scale to evaluate procedures used for DGRY.
Methods The subjects included 475 patients who underwent DGRY for stage IA/IB gastric cancer. We evaluated whether the size of the remnant stomach, length of the Roux limb, reconstruction route and anastomotic procedure affected the patients' symptoms, living status and quality of life assessed using the PGSAS-45.
Results Patients with a residual stomach of more than half had significantly worse esophageal reflux scores than the patients with a smaller residual stomach ($P = 0.0462$); a residual stomach of one-third or one-fourth was favorable. A shorter length of the Roux limb was shown to be preferable to a longer Roux limb based on the results of the PGSAS-45. In addition, antecolic reconstruction and the anastomotic procedure using a linear stapler were found to be more favorable.
Conclusions The size of the remnant stomach and the length and route of the Roux limb significantly influence the patient-reported DGRY outcomes.

Keywords Gastrectomy · Roux-en-Y · Postgastrectomy syndrome

Introduction

Distal gastrectomy (DG) is performed in patients with gastric cancer located in the lower two-thirds of the stomach.

For the Japan Postgastrectomy Syndrome Working Party.

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Reconstruction after DG is usually performed according to the Billroth I or II (B-I or B-II) method (especially in Japan and Korea) or the Roux-en-Y (RY) method (especially in Western countries) [1, 2]. An increasing number of surgeons are turning to RY reconstruction following DG (DGRY) due to the decreased incidence of anastomotic leakage and attenuated risk of remnant gastritis and esophagitis resulting from reflux of the duodenal contents [3–7]. However, patients who have undergone DGRY sometimes experience so-called RY syndrome, which is characterized by abdominal pain, nausea and vomiting. Therefore, some surgeons are reluctant to perform RY reconstruction [8, 9].

Due to the widespread use of screening programs and improvements in diagnostic techniques, an increasing proportion of gastric cancers in Asia are being diagnosed at the early stage, leading to improved cancer-specific survival. Therefore, developing an optimal method of reconstruction is now more important than ever, as increasingly more patients would benefit in the long term. The quality of life (QOL) associated with the various types of reconstruction should thus be evaluated comprehensively and scientifically to determine the benefits for those expected to survive for a long time after undergoing surgery.

Recently, the Japan Postgastrectomy Syndrome Working Party developed and validated an assessment scale, the Postgastrectomy Syndrome Assessment Scale-45 (PGSAS-45), a self-report questionnaire that can be used to comprehensively evaluate the outcomes of patients who have undergone surgery for gastric cancer. In the present multi-institutional study, we examined the characteristics of various types of RY reconstruction using the PGSAS-45 questionnaire. Our primary objective was to determine how factors such as size of the residual stomach, length of the Roux limb, reconstruction route and anastomotic procedure affect the patient's symptoms, living status and QOL among Japanese subjects who have undergone DGRY. Our ultimate aim was to determine the optimum type of RY reconstruction after DG, as, to date, this question has not been adequately addressed.

Patients and methods

Patients

The study patients were recruited between July 2009 and December 2010 from 52 institutions (25 university hospitals, eight cancer centers and 19 community hospitals) in Japan that presently make up the core Japan Postgastrectomy Syndrome Working Party. All gastrectomy procedures were performed at least 1 year prior to the current study, with no signs of recurrence detected at the time of the evaluation. The criteria for inclusion in this study comprised the following items: age, 20–75 years; ECOG Performance Status, 0 or 1; open or laparoscopic gastrectomy performed with curative intent; no resection of other organs with co-resection equivalent to choelecystectomy being the exception; a postoperative pathological diagnosis of stage IA or IB gastric cancer according to the Japanese Classification of Gastric Carcinoma, 13th edition; and no pre- or postoperative chemotherapy or radiotherapy. Informed consent was also required. The patients were followed up at their institution's outpatient clinic on a regular basis and underwent various examinations aimed to detect disease recurrence.

The PGSAS-45 questionnaire was administered to each gastrectomy patient by a surgeon in charge of the patient at an outpatient visit and returned by the patient via postal mail to the data center. Each patient was asked to fill in the questionnaire and mail it to the data center. A total of 2,520 (86.2 %) completed or nearly completed questionnaires were received at the data center. The surgeons were not given access to the individual questionnaires, and all data were analyzed at the data center [10]. Of the patients who returned the questionnaire, 475 had undergone DGRY, and their questionnaires were considered for the analysis. Of these 475 subjects, 318 were males, 154 were females and three did not indicate their sex. The average age was 62.0 ± 9.1 years. Three hundred and twenty of the patients underwent open surgery, 152 underwent laparoscopic surgery and the records did not indicate which type of surgery in three cases.

The following clinical data were reported to the data center by the various surgeons in charge using Case Report Forms designed specifically for the current study: extent of lymphatic dissection, whether the celiac branch of the vagus nerve was preserved, whether any other organs were resected, size of the residual stomach (more than half, approximately one-third, approximately one-fourth or less than one-fifth of the original size), length of the Roux limb defined as the distance from the gastrojejunostomy to the jejunojejunostomy, route of the Roux limb (antecolic or retrocolic) and anastomotic procedure for gastrojejunostomy (hand-sewn or reconstruction using a circular or linear stapler). All PGSAS-45 responses were matched to the individual patient data collected via the Case Report Forms.

The study protocol was approved by the institutional review board of each participating institution and registered with the University Hospital Medical Information Network's Clinical Trials Registry (registration number, 000002116). All patients provided their written informed consent for the confidential use of their information in the data analysis, in compliance with institutional guidelines.

Postoperative follow-up with the PGSAS-45

The PGSAS-45 consists of 45 items, including all eight items from the Short Form General Health Survey (SF-8),

all 15 items from the GSRS Gastrointestinal Symptom Rating Scale (GSRS) and 22 newly added items that cover various factors reflecting the patient's well-being [10–13]. The following 19 outcome measures were evaluated, each consisting of a single item or combination of related items from the PGSAS-45: physical component summary (PCS), mental component summary (MCS), esophageal reflux, abdominal pain, meal-related distress, indigestion, diarrhea, constipation, dumping, total symptoms, amount of food ingested per meal, quality of ingestion, need for additional meals, ability to work, dissatisfaction with symptoms, dissatisfaction at meals, dissatisfaction at work and dissatisfaction for daily life. Changes in body weight (a decrease in body weight/preoperative weight reported as the percentage) were also assessed as an outcome measure (Table 1). These 19 outcome measures were scored and classified into three domains: the QOL domain, the symptom domain and the living status domain. Higher scores denote better outcomes for the items of PCS, MCS, amount of food ingested per meal, quality of ingestion and changes in body weight, whereas lower scores denote better outcomes for the other 14 measures.

Statistical analysis

The values are shown as the mean ± SD or median and range. Two-group differences in the mean values were analyzed using an unpaired *t* test, and multiple-group differences were analyzed using a one-way analysis of variance (ANOVA). The Bonferroni-Dunn test was used when the ANOVA yielded a *P* value of <0.1. Generally, a *P* value of <0.05 on the *t* test or ANOVA was considered to be statistically significant. For Bonferroni/Dunn multiple comparisons, a *P* value of <0.05 divided by the number of comparisons was considered to be statistically significant. When the *P* value was less than twice the significance level, Cohen's *d* was calculated to determine the effect size. The value of Cohen's *d* reflects the effect of each causal variable, with 0.2 to <0.5 denoting a small but clinically meaningful effect and 0.5 to <0.8 and ≥0.8 denoting medium and large effects, respectively. All statistical analyses were performed with the StatView for Windows software program, ver. 5.0 (SAS Institute, Cary, NC, USA).

Results

Patient characteristics, surgical details and decrease in body weight

Of the original 475 DRGY patients who returned their questionnaires in this study, the case report form was missing for three patients. The study group, therefore, comprised 472 patients, including 318 males and 154 females, with a median age of 63 years (range 24–75 years). A total 320 open gastrectomy procedures and 152 laparsoscopic gastrectomy procedures were performed. D2 lymphadenectomy was performed in 163 patients; D1 lymphadenectomy plus nodes 7, 8a and 9 was performed in 246 patients; D1 lymphadenectomy plus node 7 was performed in 60 patients and D1 or partial D1 lymphadenectomy was performed in three patients. The celiac branch of the vagus nerve was preserved in 28 patients and resected in 442 patients; information pertaining to the vagus nerve was not provided in three cases. Gastrectomy with cholecystectomy was performed in 51 patients. The median follow-up time was 30 months (range 12–143 months). The median body mass index (BMI) was 22.9 kg/m^2 (range 15.1–33.0 kg/m^2) before surgery and 20.8 kg/m^2 (range 15.1–30.7 kg/m^2) after surgery.

PGSAS-45-based evaluation of the DGRY procedures

The effects of the surgical procedure on the main PGSAS-45 outcome measurements were analyzed statistically.

Size of the residual stomach

The patients were classified into four groups according to the size of the residual stomach: those for whom the residual stomach was over half of the original size ($n = 10$), those for whom the residual stomach was approximately one-third of the original size ($n = 299$), those for whom the residual stomach was approximately one-fourth of the original size ($n = 139$) and those for whom the residual stomach was less than one-fifth of the original size ($n = 22$); two patients did not report size of their residual stomach. The esophageal reflux scores were significantly affected by the size of the residual stomach ($P = 0.0462$, Tables 2). That is, the scores were significantly higher (reflux was worse) in the group that retained over half of the stomach than in the groups with residual stomachs one-third and one-fourth of the original size (Table 3), and the size of the residual stomach (1/2 vs. 1/3 and 1/2 vs. 1/4) was shown to have a medium effect on the esophageal reflux subscale scores according to Cohen's *d* (Table 3).

Length of the Roux limb

The median length of the Roux limb was 30 cm (range 15–60 cm). The length of the Roux limb was reported in incremental units of 5 cm, and the corresponding numbers of patients are indicated in Table 4. The length of the Roux limb was not reported in 16 patients. We classified the limbs into three groups: 87 limbs were considered to be short (≤25 cm), 187 were considered to

Table 1 Overview of the PGSAS-45, including the main outcome measure

Domain	Subdomain	Items		Scoring[a]	Main outcome measure(s)
QOL	SF-8	1	Physical functioning	5 or 6-point Likert scale	Physical component summary (PCS) (items 1–8)
		2	Role physical		Mental component summary (MCS) (items 1–8)
		3	Bodily pain		
		4	General health		
		5	Vitality		
		6	Social functioning		
		7	Role emotional		
		8	Mental health		
Symptoms	Gastrointestinal Symptom Rating Scale (GSRS) items	9	Abdominal pain	7-point Likert scale (except items 29 and 32)	Esophageal reflux subscale (items 10, 11, 13, 24)
		10	Heartburn		Abdominal pain subscale (items 9, 12, 28)
		11	Acid regurgitation		Meal-related distress subscale (item s 25–27)
		12	Sucking sensation in the epigastrium		Indigestion subscale (items 14–17)
		13	Nausea and vomiting		Diarrhea subscale (items 19, 20, 22)
		14	Borborygmus		Constipation subscale (items 18, 21, 23)
		15	Abdominal distension		Dumping subscale (items 30, 31, 33)
		16	Nausea and vomiting		Total symptom scale (summary of the 7 symptom domain subscales)
		17	Increased flatus		
		18	Decreased passage of stools		
		19	Increased passage of stools		
		20	Loose stools		
		21	Hard stools		
		22	Urgent need for defecation		
		23	Feeling of incomplete evacuation		
	PGSAS-specific items	24	Bile regurgitation		
		25	Sense of food sticking		
		26	Postprandial fullness		
		27	Early satiation		
		28	Lower abdominal pain		
		29	Number and type of early dumping symptoms		
		30	Early dumping general symptoms		
		31	Early dumping abdominal symptoms		
		32	Number and type of late dumping symptoms		
		33	Late dumping symptoms		
Living status	Meals (amount)	34	Amount of food ingested per meal[a]		Amount of food ingested per meal[a] (item 34)
		35	Amount of food ingested per day[a]		
		36	Frequency of main meals		
		37	Frequency of additional meals		
	Meals (quality)	38	Appetite[a]	5-point Likert scale	Quality of ingestion subscale[a] (item s 38–40)
		39	Hunger[a]		
		40	Satiety[a]		
	Additional meals (amount)	41	Need for additional meals		Need for additional meals
	Social activity	42	Ability to work		Ability to work
QOL	Dissatisfaction	43	Dissatisfaction with symptoms		Dissatisfaction with symptoms
		44	Dissatisfaction at the meals		Dissatisfaction at meals
		45	Dissatisfaction at working		Dissatisfaction at work
					Dissatisfaction for daily life subscale (items 43–45)
Living status			Change in body weight (%)		Change in body weight[a]

[a] For items 1–8, 38–40, the higher the score, the better the condition; for items 9–28, 30, 31, 33, 41–45, the higher the score the poorer the condition; items 29, 32, 34–37 and the change in body weight are reported as actual values

Table 2 Patient scores for the 19 main outcome measure according to the size of the residual stomach

Main outcome measures	Size of the residual stomach				
	Over half ($n = 10$)	Around one-third ($n = 299$)	Around one-fourth ($n = 139$)	Less than one-fifth ($n = 22$)	*P* value (ANOVA)
Esophageal reflux subscale	2.0 ± 1.3	1.5 ± 0.6	1.5 ± 0.7	1.6 ± 0.6	0.0462
Abdominal pain subscale	2.1 ± 1.6	1.6 ± 0.7	1.6 ± 0.8	1.9 ± 1.2	>0.1
Meal-related distress subscale	2.3 ± 1.1	2.1 ± 0.8	2.1 ± 0.9	2.3 ± 1.2	>0.1
Indigestion subscale	2.5 ± 1.2	2.0 ± 0.8	2.1 ± 0.9	2.0 ± 0.9	>0.1
Diarrhea subscale	2.3 ± 0.8	2.1 ± 1.1	2.0 ± 1.0	2.5 ± 1.6	>0.1
Constipation subscale	2.1 ± 0.9	2.1 ± 1.1	2.1 ± 0.9	2.0 ± 0.9	>0.1
Dumping subscale	2.5 ± 1.5	2.0 ± 1.0	1.9 ± 0.9	1.8 ± 1.1	>0.1
Total symptom scale	2.0 ± 0.8	1.9 ± 0.7	1.9 ± 0.7	2.0 ± 0.8	>0.1
Change in body weight (%)[a]	−8.9 ± 4.9	−9.0 ± 6.6	−8.6 ± 6.8	−9.5 ± 6.2	>0.1
Amount of food ingested per meal[a]	7.4 ± 1.5	7.4 ± 1.9	7.0 ± 2.1	6.7 ± 1.9	>0.1
Need for additional meals	1.8 ± 0.6	1.9 ± 0.8	1.9 ± 0.8	2.0 ± 0.7	>0.1
Quality of ingestion[a]	3.8 ± 0.7	3.8 ± 0.9	3.6 ± 1.0	3.6 ± 1.0	>0.1
Ability to work	2.0 ± 1.0	1.9 ± 0.9	1.8 ± 0.8	1.7 ± 0.7	>0.1
Dissatisfaction with symptoms	2.2 ± 1.2	1.8 ± 0.9	1.8 ± 0.9	1.6 ± 0.7	>0.1
Dissatisfaction at meals	2.5 ± 1.1	2.1 ± 1.1	2.2 ± 1.1	2.3 ± 1.1	>0.1
Dissatisfaction at work	2.0 ± 1.2	1.7 ± 1.0	1.7 ± 0.9	1.5 ± 0.8	>0.1
Dissatisfaction for daily life	2.2 ± 1.0	1.9 ± 0.9	1.9 ± 0.9	1.8 ± 0.8	>0.1
Physical component summary[a]	47.0 ± 13.1	50.8 ± 5.4	51.1 ± 5.2	50.3 ± 5.9	>0.1
Mental component summary[a]	50.2 ± 5.5	49.9 ± 5.4	50.1 ± 6.2	49.6 ± 4.6	>0.1

[a] The higher the score or value, the better the condition; otherwise (items without letter a), the higher the score, the poorer the condition

be average (30 cm) and 181 were considered to be long (≥35 cm), as shown in Table 5. The MCS scores were higher (indicating better mental health) in the short limb group than in the long limb group ($P = 0.0012$, Cohen's $d = 0.44$) and in the average limb group than in the long limb group ($P = 0.0162$, Cohen's $d = 0.25$); the quality of ingestion scores was higher in the average limb group than that in the long limb group ($P = 0.0135$, Cohen's $d = 0.27$). The scores for esophageal reflux (short vs. long: $P = 0.0086$, Cohen's $d = 0.32$; average vs. long: $P = 0.0123$, Cohen's $d = 0.25$), abdominal pain (short vs. long: $P = 0.0123$, Cohen's $d = 0.25$; average vs. long: $P = 0.0287$, Cohen's $d = 0.26$), indigestion (short vs. long: $P = 0.0043$, Cohen's $d = 0.37$), diarrhea (average vs. long: $P = 0.0138$, Cohen's $d = 0.27$), constipation (average vs. long: $P = 0.0077$, Cohen's $d = 0.28$), total symptoms (average vs. long: $P = 0.0141$, Cohen's $d = 0.28$), the ability to work (short vs. long: $P = 0.0028$, Cohen's $d = 0.39$; average vs. long: $P = 0.0065$, Cohen's $d = 0.28$), dissatisfaction at work (short vs. long: $P = 0.0120$, Cohen's $d = 0.31$; average vs. long: $P = 0.0026$, Cohen's $d = 0.32$) and dissatisfaction with daily life (short vs. long: $P = 0.0294$, Cohen's $d = 0.28$; average vs. long: $P = 0.0168$, Cohen's $d = 0.25$) were significantly lower (i.e., better) in the short and/or average Roux limb group than in the long Roux limb group ($P < 0.05$, t test). The finding of a Cohen's d value of >0.2 showed that the length of the Roux limb had a small but meaningful effect on the items of esophageal reflux, abdominal pain, indigestion, ability to work, dissatisfaction at work, dissatisfaction with daily life and MCS scores between the short limb group and the long limb group and the items of esophageal reflux, abdominal pain, diarrhea, constipation, quality of ingestion, ability to work, dissatisfaction at work, dissatisfaction with daily life and MCS scores between the average limb group and the long-limb group. However, there were no statistically significant differences between the short-limb group and the average limb group.

Reconstruction route

The effect of the RY reconstruction route was analyzed in 292 patients in whom antecolic reconstruction was performed and 175 patients in whom retrocolic reconstruction was performed. The dissatisfaction with symptoms scores were significantly lower (i.e., better) in the antecolic group than in the retrocolic group, and a small effect was observed ($P = 0.028$, Cohen's $d = 0.21$) (Table 6).

Table 3 Effect of the size of the residual stomach on the esophageal reflux subscale score

Size of the residual stomach				
Over half ($n = 10$)	Around one-third ($n = 299$)	Around one-fourth ($n = 139$)	*P* value**	Cohen's *d*
Esophageal reflux subscale				
2.0 ± 1.3	1.5 ± 0.6	–	0.0100	0.53
2.0 ± 1.3	–	1.5 ± 0.7	0.0119	0.52

** $P < 0.0083$, according to Bonferroni/Dunn multiple comparisons

Table 4 Number of cases per RY limb length

Length of RY limb (cm)	15	20	25	30	35	40	45	50	60	Not described
Number ($n = 475$)	5	37	45	191	59	105	2	13	2	16

Anastomotic procedure for gastrojejunostomy

The effect of the anastomotic procedure was analyzed in 69 patients who underwent reconstruction with a circular stapler (CS), 267 patients who underwent reconstruction with a linear stapler (LS) and 105 patients in whom the anastomosis was hand-sewn. The dissatisfaction with symptom scores were significantly different for the esophageal reflux subscale ($P = 0.0298$, Table 7). That is, the scores were significantly higher (reflux-related symptoms were more severe) in the group in which LS was used than in the group in which CS was used (Table 8), and the anastomotic procedure (CS vs. LS) was shown to have a moderate effect on the esophageal reflux subscale scores according to Cohen's *d* (Table 8).

Discussion

The choice of reconstruction method after DG for gastric cancer remains controversial. The aim of this study was to determine the optimal method for DGRY reconstruction. The relatively low incidence of anastomotic leakage and infrequent occurrence of esophagitis and/or gastritis associated with reflux are considered advantages of DGRY, whereas the complexity of the procedure and possible occurrence of RY syndrome are considered to be disadvantages [8]. However, there are no previous detailed studies attempting to identify the optimal surgical procedure among the RY variants [3, 14–16].

Because the size of the residual stomach has been suggested to be a factor affecting health-related outcomes, we classified the current patients into four groups according to the size of the residual stomach and compared the outcomes between the groups. Consequently, a statistically significant difference in favor of a one-third or one-fourth residual stomach as opposed to a larger residual stomach was observed in relation to the esophageal reflux scores, although no differences were observed in any of the other 18 outcome measures evaluated. In addition, the Bonferroni/Dunn multiple comparisons analysis showed borderline significance, whereas the Cohen's *d* value indicated a moderate association between the esophageal reflux scores and the size of the residual stomach. These results point to a residual stomach of one-fourth to one-third as being the optimal size for DGRY. Fukuhara et al. [3] reported that the incidence of reflux correlates well with exposure of the residual stomach to bile. However, Nomura et al. [17] reported abandoning DGRY in patients with a large (half) residual stomach due to the unacceptable incidence of postoperative stasis, although the reservoir function of the residual stomach is preserved and the procedure is beneficial in patients with a large residual stomach undergoing B-I reconstruction. In the present study, we observed no statistically significant differences in the indigestion scores, possibly as a result of the small number of patients with a large residual stomach ($n = 10$).

In this study, the patients with a short Roux limb (≤25 cm) had superior scores for seven main outcome measurements (esophageal reflux, abdominal pain, ingestion, ability to work, dissatisfaction at work, dissatisfaction with daily life, MCS) compared to the patients with a long Roux limb (≥35 cm), and the Cohen's *d* value exceeded 0.2, pointing to a small but clinically meaningful difference. In addition, the patients with an average length of the Roux limb (30 cm) had superior scores for 10 main outcome measures (esophageal reflux, abdominal pain, diarrhea, constipation, total symptom scale, quality of ingestion, ability to work, dissatisfaction at work, dissatisfaction with daily life, MCS) compared to the patients with a long Roux limb (≥35 cm). Therefore, the average length of the Roux limb (30 cm) also had a small but meaningful clinical impact on all of these outcome measures (Cohen's $d > 0.2$). However, we detected no notable differences between a short length of the Roux limb (≤25 cm) and the average length of the Roux limb (30 cm). Fukuhara et al.

Table 5 Patient scores for the 19 main outcome measure per the length of the Roux limb

Main outcome measure	Patient scores				Bonferroni/Dunn multiple comparisons		
	≤25 cm (short) ($n = 87$)	30 cm (average) ($n = 187$)	≥35 cm (long) ($n = 181$)	*P* value**		*P* value	Cohen's *d*
Esophageal reflux subscale	1.4 ± 0.5	1.4 ± 0.6	1.6 ± 0.8	0.0094	≤25 vs. ≥30 cm	–	–
					≤25 vs. ≥35 cm	0.0086	0.32
					30 vs. ≥35 cm	0.0123	0.25
Abdominal pain subscale	1.5 ± 0.9	1.6 ± 0.6	1.8 ± 0.9	0.0220	≤25 vs. ≥30 cm	–	–
					≤ 25 vs. ≥35 cm	0.0123	0.25
					30 vs. ≥35 cm	0.0287	0.26
Meal-related distress subscale	2.0 ± 1.0	2.1 ± 0.8	2.1 ± 0.9	≥ 0.1	–	–	–
Indigestion subscale	1.9 ± 0.7	2.0 ± 0.8	2.2 ± 0.9	0.0115	≤25 vs. ≥30 cm	–	–
					≤ 25 vs. ≥35 cm	0.0043	0.37
					30 vs. ≥35 cm	–	–
Diarrhea subscale	2.1 ± 1.3	1.9 ± 1.0	2.2 ± 1.2	0.0389	≤25 vs. ≥30 cm	–	–
					≤ 25 vs. ≥35 cm	–	–
					30 vs. ≥35 cm	0.0138	0.27
Constipation subscale	2.0 ± 1.0	2.0 ± 0.9	2.3 ± 1.1	0.0161	≤25 vs. ≥30 cm	–	–
					≤25 vs. ≥35 cm	–	–
					30 vs. ≥35 cm	0.0077	0.28
Dumping subscale	1.9 ± 1.1	1.9 ± 0.9	2.1 ±1.1	≥ 0.1	–	–	–
Total symptom scale	1.9 ± 0.7	1.8 ± 0.6	2.0 ± 0.7	0.00375	≤25 vs. ≥30 cm	–	–
					≤25 vs. ≥35 cm	–	–
					30 vs. ≥35 cm	0.0141	0.28
Change in body weight (%)[a]	−8.8 ± 7.1	−9.1 ± 6.6	−8.7 ± 6.2	≥ 0.1	–	–	–
Amount of food ingested per meal[a]	7.4 ± 2.1	7.3 ± 1.8	7.1 ± 2.1	≥ 0.1	–	–	–
Necessity for additional meals	1.9 ± 0.8	1.8 ± 0.8	1.9 ± 0.9	≥ 0.1	–	–	–
Quality of ingestion subscale[a]	3.8 ± 1.0	3.8 ± 0.9	3.6 ± 0.9	0.031	≤25 vs. ≥30 cm	–	–
					≤25 vs. ≥35 cm	–	–
					30 vs. ≥35 cm	0.0135	0.27
Ability to work	1.7 ± 0.8	1.7 ± 0.8	2.0 ± 1.0	0.0029	≤25 vs. ≥30 cm	–	–
					≤25 vs. ≥35 cm	0.0028	0.39
					30 vs. ≥35 cm	0.0065	0.28
Dissatisfaction with symptoms	1.7 ± 0.9	1.8 ± 0.9	1.9 ± 1.0	≥ 0.1	–	–	–
Dissatisfaction at meals	2.1 ± 1.2	2.1 ± 1.1	2.3 ± 1.1	0.0982	–	–	–
Dissatisfaction at work	1.6 ± 1.0	1.6 ± 0.9	1.9 ± 1.1	0.004	≤25 vs. ≥30 cm	–	–
					≤25 vs. ≥35 cm	0.0120	0.31
					30 vs. ≥35 cm	0.0026	0.32
Dissatisfaction for daily life	1.8 ± 0.8	1.8 ± 0.8	2.0 ± 0.9	0.0237	≤25 vs. ≥30 cm	–	–
					≤25 vs. ≥35 cm	0.0294	0.28
					30 vs. ≥35 cm	0.0168	0.25
Physical component summary[a]	51.6 ± 4.4	50.9 ± 5.2	50.3 ± 6.5	≥ 0.1	–	–	–
Mental component summary[a]	51.2 ± 5.3	50.3 ± 5.8	48.9 ± 5.5	0.0027	≤25 vs. ≥30 cm	–	–
					≤25 vs. ≥35 cm	0.0012	0.44
					30 vs. ≥35 cm	0.0162	0.25

** <0.05 according to ANOVA

*** $P < 0.0167$ according to Bonferroni/Dunn multiple comparisons

[a] The higher the score or value, the better the condition; otherwise (without letter a), the higher the score, the poorer the condition

Table 6 Patient scores for the 19 main outcome measure according to the ante- or retrocolic reconstruction route

Main outcome measures	Route of the Roux limb			
	Antecolic ($n = 292$)	Retrocolic ($n = 175$)	*P* value (*t* test)	Cohen's *d*
Esophageal reflux subscale	1.5 ± 0.7	1.6 ± 0.6	>0.1	–
Abdominal pain subscale	1.6 ± 0.7	1.6 ± 0.6	>0.1	–
Meal-related distress subscale	2.1 ± 0.8	2.0 ± 0.9	>0.1	–
Indigestion subscale	2.1 ± 0.8	2.0 ± 0.9	>0.1	–
Diarrhea subscale	2.1 ± 1.2	2.0 ± 1.1	>0.1	–
Constipation subscale	2.0 ± 0.9	2.2 ± 1.1	0.068	0.17
Dumping subscale	2.0 ± 1.0	2.1 ± 1.0	>0.1	–
Total symptom scale	1.9 ± 0.7	1.9 ± 0.7	>0.1	–
Change in body weight (%)[a]	−9.0 ± 6.2	−8.8 ± 7.1	>0.1	–
Amount of food ingested per meal[a]	7.2 ± 2.0	7.2 ± 1.8	>0.1	–
Need for additional meals	1.9 ± 0.8	1.9 ± 0.8	>0.1	–
Quality of ingestion subscale[a]	3.7 ± 1.0	3.8 ± 0.8	>0.1	–
Ability to work	1.8 ± 0.9	1.9 ± 0.9	>0.1	–
Dissatisfaction with symptoms	1.7 ± 0.9	1.9 ± 1.0	0.028	0.21
Dissatisfaction at meals	2.2 ± 1.1	2.2 ± 1.1	>0.1	–
Dissatisfaction at work	1.7 ± 1.0	1.7 ± 1.0	>0.1	–
Dissatisfaction for daily life subscale	1.9 ± 0.8	1.9 ± 0.9	>0.1	–
Physical component summary[a]	50.8 ± 5.9	50.8 ± 5.2	>0.1	–
Mental component summary[a]	50.1 ± 5.9	49.7 ± 5.1	>0.1	–

[a] The higher the score or value, the better the condition; otherwise (items without letter a), the higher the score, the poorer the condition

Table 7 Patient scores for the 19 main outcome measure according to the gastrointestinal anastomotic construction method

Main outcome measures	Construction method			
	CS ($n = 69$)	LS ($n = 267$)	HS ($n = 105$)	*P* value (ANOVA)
Esophageal reflux subscale	1.3 ± 0.5	1.5 ± 0.7	1.4 ± 0.5	0.0298
Abdominal pain subscale	1.5 ± 0.6	1.7 ± 0.8	1.7 ± 0.8	≥0.1
Meal-related distress subscale	2.0 ± 0.7	2.1 ± 0.9	2.1 ± 0.9	≥0.1
Indigestion subscale	1.9 ± 0.7	2.1 ± 0.8	2.1 ± 0.9	≥0.1
Diarrhea subscale	1.9 ± 1.0	2.1 ± 1.1	2.2 ± 1.2	≥0.1
Constipation subscale	2.1 ± 0.9	2.1 ± 1.0	2.1 ± 1.1	≥0.1
Dumping subscale	1.8 ± 0.9	2.0 ± 1.0	2.0 ± 1.0	≥0.1
Total symptom scale	1.8 ± 0.5	2.0 ± 0.7	1.9 ± 0.7	≥0.1
Change in body weight (%)[a]	−8.9 ± 6.6	−8.5 ± 6.3	−9.9 ± 6.4	≥0.1
Amount of food ingested per meal[a]	7.4 ± 1.7	7.1 ± 1.8	7.3 ± 1.8	≥0.1
Necessity for additional meals	1.9 ± 0.9	1.9 ± 0.8	1.9 ± 0.8	≥0.1
Quality of ingestion subscale[a]	3.9 ± 0.8	3.7 ± 0.9	3.8 ± 1.0	≥0.1
Ability for working	1.7 ± 0.8	1.9 ± 0.9	1.7 ± 0.8	≥0.1
Dissatisfaction with symptoms	1.6 ± 0.8	1.8 ± 0.9	1.9 ± 0.9	≥0.1
Dissatisfaction at meals	2.2 ± 1.0	2.2 ± 1.1	2.2 ± 1.2	≥0.1
Dissatisfaction at work	1.6 ± 0.9	1.8 ± 1.0	1.7 ± 1.1	≥0.1
Dissatisfaction subscale	1.8 ± 0.8	1.9 ± 0.9	1.9 ± 0.9	≥0.1
Physical component summary[a]	51.0 ± 5.1	50.5 ± 6.1	51.2 ± 5.0	≥0.1
Mental component summary[a]	50.7 ± 5.0	49.5 ± 6.0	50.2 ± 5.1	≥0.1

CS circular stapler, *LS* linear stapler, *HS* hand-sewn

[a] The higher the score or value, the better the condition; otherwise (items without letter a), the higher the score, the poorer the condition

[3] noted that the use of a 30-cm jejunal pedicle (Roux limb) effectively prevents reflux of the duodenal contents/bile into the residual stomach, regardless of the size of the residual stomach. As reported previously, the implantation of ectopic jejunal pacemakers may explain the inferior outcome scores in patients with a long Roux limb, although

Table 8 Effect of the anastomotic construction method (circular stapler vs. linear stapler) on the esophageal reflux subscale scores

	Construction method			
	CS ($n = 69$)	LS ($n = 267$)	*P* value*	Cohen's *d*
Esophageal reflux subscale	1.3 ± 0.5	1.5 ± 0.7	0.0148	0.35

CS circular stapler, *LS* linear stapler

* $P < 0.0167$, according to Bonferroni/Dunn multiple comparisons

the mechanisms of jejunal pacing are not fully understood [18, 19]. A shorter length of the Roux limb has been shown to be preferable to a longer length based on the results of the PGSAS-45, although the precise mechanisms underlying this observation cannot be identified within the scope of this study.

Imamura et al. [20] reported that the application of the retro-colic route for duodenojejunostomy after pancreaticoduodenectomy is favorable for preventing delayed gastric emptying. In contrast, Masui et al. [21] reported no differences in the incidence of delayed gastric emptying between patients treated with different reconstruction routes. Both groups of authors concluded that the jejunum used for reconstruction should be placed vertically downward to enhance food passage through the gastrointestinal anastomosis during the early postoperative period. In our patients, the antecolic route yielded significantly lower (i.e., better) dissatisfaction with symptom scores and showed a small effect. Hence, we believe the antecolic reconstruction route to be favorable, although a somewhat longer duration of follow-up is required.

Roux-en Y reconstruction is commonly performed for the treatment of morbid obesity. Leyba et al. [22] reported, in a randomized controlled trial involving patients with morbid obesity, that the incidence of anastomotic stricture after linear stapler anastomosis for gastrojejunostomy was significantly lower than that observed after circular stapler anastomosis. No previously reported studies have compared the methods of gastrojejunostomy for Roux-en Y reconstruction after distal gastrectomy for gastric cancer. Given the retrospective nature of the current study and accrual of an uneven number of cases for each type of anastomosis arising from a multitude of factors, further studies are needed to confirm whether CS is really a favorable method for completing gastrojejunostomy.

Differences in the method of reconstruction may presumably be responsible for at least some of the symptoms noted in postgastrectomy patients. However, symptoms occurring after gastrectomy are essentially multifactorial and may also be influenced by several other factors, such as age, the extent of lymphadenectomy, institution where the surgery was performed, time after surgery, size of the residual stomach, length of the Roux limb and reconstruction route. Since this was a multi-institutional cross-sectional study with a large amount of data collected in various numerical forms for the assessment, a multivariate analysis to adjust for confounders was not performed at this time. This limitation should be mentioned as a weakness of this study, in addition to the retrospective nature of the study design and lack of a solid protocol enabling the accrual of an adequate number of patients for each of the relevant categories, including the size of the remnant stomach and length of the Roux limb.

According to the current data obtained with the PGSAS-45, a novel questionnaire developed by the Japan Postgastrectomy Syndrome Working Party, we conclude that patients undergoing DGRY benefit from the creation of a residual stomach that is not extraordinarily large as well as a shorter ($\leq$30 cm) Roux limb. We also conclude that the use of the antecolic reconstruction route positively affects the patient's well-being after surgery.

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