OBES SURG (2016) 26:517–524
DOI 10.1007/s11695-015-1782-8

ORIGINAL CONTRIBUTIONS

The Effect of Route of Anvil Insertion on Stricture Rates with Circular Stapled Gastrojejunostomy During Laparoscopic Gastric Bypass

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Published online: 4 July 2015

Abstract
Background A higher incidence of gastrojejunal (GJ) anastomotic strictures has been reported following laparoscopic gastric bypass (LRYGB) with the 21 mm compared to 25 mm circular stapler. We hypothesized that the rate of stricture formation is affected by route of anvil insertion and its position relative to the gastric pouch staple line [trans-gastric above staple line (trans-gastric) vs. trans-oral through staple line (trans-oral)] following LRYGB.
Methods Retrospective review of consecutive patients who underwent LRYGB with circular stapled GJ studied in four groups: trans-gastric-21 mm, trans-gastric-25 mm, trans-oral-21 mm, and trans-oral-25 mm. Primary outcome studied was GJ stricture; secondary outcomes were results with endoscopic therapy and weight loss at 12 months. Predictors studied were age, gender, body mass index (BMI), comorbidities, and operative technical factors including anvil size and insertion route. Regression analyses were performed to identify predictors of GJ stricture.
Results Eight hundred seventy-six patients underwent LRYGB. Seventy-six (8.7 %) developed a GJ stricture. The highest stricture rate occurred in the trans-gastric-21 mm group (17 %, $p<.01$ for all comparisons). Stricture rates were similar for trans-gastric-25 mm (8.4 %), trans-oral-21 mm (5.2 %), and trans-oral-25 mm (1.6 %) groups. Independent predictors of stricture were: trans-gastric-21 mm (OR 10.9, 95%CI 1.4–85.1; $p=.022$) and age (OR 0.97, 95%CI 0.95–0.99; $p=.002$). Endoscopic dilation relieved symptoms in all patients. There was no difference in %EWL at 12 months in patients with and without a stricture.
Conclusions We conclude that the trans-oral-21 mm anvil is associated with a low stricture rate. With the advantage of smaller abdominal wall wound, trans-oral-21 mm may be the preferred size and route of anvil insertion.

Keywords Laparoscopic gastric bypass · Gastric bypass · Gastrojejunostomy · Circular stapler · Anvil · Anastomosis · Stricture · Bariatric

Introduction

Laparoscopic Roux-en-Y gastric bypass is the most commonly performed bariatric procedure for the treatment of severe obesity worldwide [1]. It provides for effective long-term weight loss in most patients, improvement in quality of life, resolution of obesity-related comorbidities, and reduction in mortality [2, 3].

Gastrojejunal (GJ) anastomotic stricture is one of the common complications associated with LRYGB and it occurs in about 8 % of the patients [4]. Since the introduction of the laparoscopic technique in 1994 [5], a variety of surgical techniques to construct the GJ anastomosis have been developed, yielding different rates of stricture formation: from 3 to 8 % with hand-sewn, 0 to 6 % with linear stapled, and 5 to 31 % with circular stapled anastomoses [4–16]. Many series have shown that the use of a 21-mm circular stapler is associated with higher rates of stricture, and most surgeons prefer the use of 25-mm circular staplers to avoid this complication [4–11].

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However, others have demonstrated low rates of GJ stricture with the 21-mm staplers when the anvil is inserted orally [3] and delivered through the staple line [5].

We hypothesized that the rate of stricture formation with circular stapled gastrojejunostomy is independently affected by the route of anvil insertion and its position relative to the gastric pouch staple line [trans-gastric and above the staple line (trans-gastric) vs. trans-oral and through the staple line (trans-oral)] following LRYGB. Thus, the use of a trans-oral-21 mm stapler may yield a similarly low incidence of stricture as the 25-mm stapler. Our primary aim was to identify patient and technical factors independently associated with GJ stricture after LRYGB in circular stapled anastomosis. Our secondary aims were to study the technical details and outcomes after endoscopic therapy and excess weight loss (EWL) at 12 months following LRYGB.

Materials and Methods

Study Design and Participants

We conducted a retrospective review of a prospectively maintained database and electronic medical records data (Epic, Verona, WI) of consecutive patients who underwent primary LRYGB with circular stapled GJ between March 2003 and August 2014 at the University of Wisconsin Hospital and Clinics for the treatment of severe obesity. Patients were considered candidates for RYGB if they met NIH consensus criteria for bariatric surgery [17]. LRYGB had been performed at our institution since March of 2002. To decrease the effect of the learning curve on the results, we elected to exclude all the cases performed during the first year of the Bariatric Program experience. Patients were categorized into four groups according to the surgical technique used to construct the gastrojejunal (GJ) anastomosis, specifically studying the route of anvil insertion and its position relative to the gastric pouch staple line: trans-gastric and above the staple line (trans-gastric) vs. trans-oral and through the staple line (trans-oral) (Fig. 1) and stapler size used (21 vs. 25 mm). The four groups were:

- *Trans-gastric-21 mm*: trans-gastric anvil, introduced above the gastric pouch staple line and 21 mm stapler size
- *Trans-gastric-25 mm*: trans-gastric anvil, introduced above the gastric pouch staple line and 25 mm stapler size
- *Trans-oral-21 mm*: trans-oral anvil, introduced through the gastric pouch staple line and 21 mm stapler size
- *Trans-oral-25 mm*: trans-oral anvil, introduced through the gastric pouch staple line and 25 mm stapler size

Stapler height was 3.5 mm in all cases. This study was approved by the University of Wisconsin Institutional Review Board number M-2009-1067.

Baseline demographic data were recorded including age (year), gender, body mass index (BMI), weight (kg), and presence of obesity-related comorbidities including hypertension (HTN), type 2 diabetes (T2DM), obstructive sleep apnea (OSA), and degenerative joint disease (DJD). Obesity-related comorbidities were identified by reviewing all available notes from the bariatric surgeon, referring physician notes, and the preoperative anesthesiology evaluation.

Our primary outcome was the occurrence of GJ stricture. Secondary outcomes included time interval between LRYGB and endoscopy, stricture size, number of endoscopic dilations required, percentage of excess weight lost (%EWL), and percentage of total body weight lost (%TWL) achieved at 12 months following LRYGB. %EWL was calculated as: (Preoperative weight minus Follow-up weight)/(Preoperative weight minus ideal body weight)×100. Ideal body weight was calculated as the equivalent to a BMI of 25 kg/m^2. %TWL was calculated as: (Preoperative weight minus Follow-up weight) / (Preoperative weight)×100. Data were reported as mean±standard error of the mean (SEM) unless otherwise indicated.

Surgical Techniques

All cases were done laparoscopically. A Roux limb of 100 or 150 cm was measured, and a stapled side-to-side jejunojejunostomy was created. The mesenteric defect at the jejunojejunostomy was routinely closed. The GJ anastomosis was constructed using either 25 or 21 mm circular stapler with two different anvil placement methods (trans-oral or trans-gastric). The four different techniques were used at the discretion of the attending surgeon. The trans-gastric-21 mm technique was used from March to December of 2003 and was abandoned due to a perceived higher incidence of anastomotic stricture. All other three techniques were used contemporaneously (Table 1). The trans-oral-21 mm group is a group of consecutive patients done by one of the surgeons (GMC). A lesser curvature based 5 cm gastric pouch was created either before or after anvil's placement according to the anvil route used.

1. *Trans-oral anvil placement (trans-oral)*

In this technique, an anvil (OrVil™) is passed trans-orally through a small gastrotomy in the already created stapled gastric pouch (Fig. 1). The OrVil™ device is a pre-packaged commercially available device which combines the anvil head, secured in the tilted position, mounted on a 90-cm-long polyvinyl chloride (PVC) delivery tube, and secured to the tube with a suture. The PVC delivery tube is inserted through the patient's mouth, delivered through a small gastrotomy in the horizontal gastric pouch staple line, and pulled from the left lower quadrant port site to assist bringing

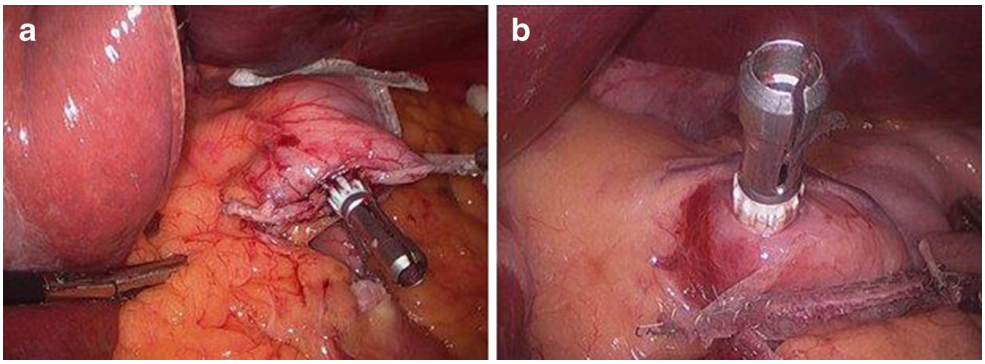

Fig. 1 **a** Anvil placement through the staple line with trans-oral technique (trans-oral). **b** Anvil placement above the staple line with trans-gastric technique (trans-gastric)

the anvil shaft into the gastric pouch. A critical step of the procedure is passing the tilted anvil head attached to the delivery tube through the posterior pharynx into the esophagus. We recommend that the anesthesiologist and an assistant are present for this portion of the procedure. The anvil head should be generously lubricated, and its convex side directed and maintained towards the hard and soft palate. Once the anvil enters the posterior pharynx, elevating the mandible, similar to a jaw thrust maneuver, and briefly deflating the balloon of the endotracheal tube facilitates the anvil passage into the gastric pouch. Once the anvil shaft has been exteriorized through the staple line of the pouch, the suture that holds it to the delivery tube is cut and the tube is disconnected from the anvil while holding the anvil in place. The same oral anvil placement technique was used for the 21-mm circular stapler (trans-oral-21 mm) and the 25-mm circular stapler (trans-oral-25 mm).

2. *Trans-gastric anvil placement (trans-gastric)*

The anvil of the EEA circular stapler is passed through a trocar site in the abdominal wall and introduced into the stomach lumen by a gastrotomy, then the shaft of the anvil is exteriorized in the anterior gastric wall about 5 cm from the gastroesophageal junction. The gastrotomy is then closed using Endo-GIA stapler, and the gastric pouch is then constructed around the anvil using multiple firings of a linear Endo-GIA stapler (Fig. 1). The same technique was used with either a 21-mm (trans-gastric-21 mm) or 25-mm (trans-gastric-25 mm) circular stapler.

After anvil placement, the alimentary limb is brought in an antecolic antegastric fashion. A left lateral port site is enlarged, and through this, the EEA is introduced to create a circular stapled GJ. This is accomplished by inserting the EEA through the cut end of the alimentary limb into the lumen and connecting it with the anvil already placed in the gastric pouch. After completing the anastomosis and removing the EEA stapler through the abdominal wall, the residual defect in the alimentary limb is closed with a linear staple load.

Symptoms, Diagnosis, and Management of GJ Strictures

GJ stricture was suspected in patients with dysphagia, postprandial vomiting, or epigastric abdominal pain. The diagnosis was confirmed by endoscopic inspection and if a standard videoptic endoscope (10-mm diameter) could not pass through the gastrojejunostomy. The endoscopic procedures were performed by a gastroenterologist or one of the attending surgeons in an outpatient endoscopy suite using a combination of narcotic analgesic and sedative hypnotics for conscious

Table 1 Baseline clinical characteristics of the study population and 4 GJ groups

GJ groups	All patients	TRANS-GASTRIC-21 mm	TRANS-GASTRIC-25 mm	TRANS-ORAL-21 mm	TRANS-ORAL-25 mm	*P* value
N	876	100	655	53	62	
Age (years)	46.9±0.4	44.1±1.1	47.3±0.5	46.6±1.6	47.1±1.5	.093
Time of utilization of GJ technique (range)		3/2003-12/2003	1/2004-8/2014	11/2011-8/2014	11/2009-6/2014	
Gender (% Female)	80 %	83 %	80 %	90 %	65 %	.005
BMI (kg/m2)	48.5±0.3	50.1±0.7	48.9±0.3	44.5±0.9	46.2±0.8	<.001
Type 2 dabetes (%)	35 %	26 %	35 %	43 %	35 %	.155
Hypertension (%)	55 %	58 %	58 %	35 %	43 %	.001
Sleep apnea (%)	39 %	32 %	42 %	35 %	16 %	<.001
Degenerative joint disease (%)	19 %	53 %	15 %	22 %	6 %	<.001

sedation. The patient was placed in the left lateral decubitus position. Once a stricture was confirmed, sequential balloon dilation was performed up to a maximum of 20 mm. Dilation was routinely performed using a controlled radial expansion (CRE) Wire guided Esophageal/Pyloric 180-cm dilator (Boston Scientific, Natick, MA) with three dilation diameters each balloon passage. Dilations began with a 6–7–8 mm balloon, followed in sequence by an 8–9–10 mm, 10–11–12 mm, 12–13.5–15 mm, 15–16.5–18 mm, and an 18–19–20 mm balloon. The initial triple dilation balloon used depended upon the estimated diameter of the stoma. Pressures of inflation were monitored using the Alliance II integrated inflation system (Boston Scientific, Natick, MA). Inflation pressures were adjusted according to the manufacturer's pre-stated recommendations. After dilation, the endoscope was passed through the stoma to confirm enlargement of the stoma, ensure adequate hemostasis, and check for ulceration distal to the anastomosis. Patients were routinely treated with proton pump inhibitors. Patients were followed for clinical response and underwent repeat endoscopy if symptoms did not improve.

Statistical Analyses

Univariate analysis was performed to study differences between the patients who developed a GJ stricture and those who did not. Patient characteristics, operative and perioperative data, and the unadjusted association between each variable and the outcome were studied using Student's *T* tests and chi-square tests. One-way ANOVA or chi-square test was used to compare the continuous and categorical variables between the four groups. Multivariate logistic regression with a backward selection procedure was performed to assess the joint effect of all potentially predictive variables and to define those that were independently associated with the presence of stricture following LRYGB. Variables included were age, BMI, gender, T2DM, HTN, OSA, DJD, and surgical technique for GJ (group). Variables were analyzed in the multivariate model to obtain the predictive effect of each, adjusted for the presence of the other significant variables (adjusted odds ratio). Statistical significance was considered to be $P \leq .05$. SPSS, version 22 (SPSS Inc., Chicago, IL) was used for all statistical analyses.

Results

Eight hundred seventy-six patients underwent LRYGB during the study period. Table 1 shows the number of patients in each of the four types of circular GJ studied and the time period of utilization of each technique. There were differences in patients' characteristics at baseline in between groups: trans-oral-25 mm group had a greater proportion of male subjects than all other groups, BMI was greater for trans-gastric-21 mm and trans-gastric-25 mm groups, and prevalence of hypertension, sleep apnea, and degenerative joint diseases was different between the four groups (Table 1).

Seventy-six patients (8.7 %) developed a GJ stricture (Table 2). The highest stricture rate was for the trans-gastric-21 mm group (17 %, $p<0.03$ for all comparisons). Stricture rates were lower for trans-gastric-25 mm (8.4 %), trans-oral-21 mm (5.2 %), and trans-oral-25 mm (1.6 %) groups. In univariate analyses, patients that developed a stricture were younger (42.8±1.1 vs. 47.3±0.4, $p<.001$). There were no other differences in patient's clinical characteristics between patients with and without stricture.

Diagnosis of GJ stricture was made on average at 2±1.0 (range 0.7–5.2)months after surgery. Mean stricture diameter was 8±0.4 mm. Endoscopic dilation relieved symptoms in all patients who were found to have a stricture on endoscopy; an average of 2±1 endoscopic dilations was required per patient, and 50 % of patients required only 1 dilation.

In multivariate analyses, the independent predictors of stricture identified were: trans-gastric-21 mm technique (OR 10.9, 95 % CI 1.4–85.1; $p=.022$) and age (OR 0.97, 95 % CI 0.95–0.99; $p=.002$).

Follow-up information at 12 months was available for 85.4 % of patients who had at least 1 year from LRYGB (708 of 829 patients). %EWL and %TWL at 12 months were 61.5±0.6 and 33.5±0.3, respectively. %EWL was similar in between groups, but %TWL was higher in the 21-mm trans-gastric group compared to the others (Table 3). There was no difference in %EWL or %TWL in patients with and without a stricture (Table 4).

Discussion

In our series, the use of 21-mm circular anvil delivered trans-orally and through the gastric pouch staple line for circular stapled GJ during LRYGB yielded a low rate of stricture, similar to the rate with the 25-mm anvil delivered either using a trans-oral or trans-gastric, through or above the gastric pouch staple line approach. The 21-mm circular anvil delivered using the trans-gastric approach and above the gastric pouch staple line was associated with a significantly higher stricture rate. This suggests that the location of the anvil delivery relative to the gastric pouch staple line has an independent impact in GJ stricture rates.

The reported rates of stricture in the literature vary widely, and many factors are thought to contribute to this variation, including the very definition of stricture, the technique used to construct the GJ anastomosis (hand-sewn vs linear vs. circular stapled anastomosis), the diameter of circular stapler (21 vs. 25 mm), the route used for the alimentary limb (antecolic vs. retrocolic), type of suture (absorbable vs. non-absorbable), and surgeon's experience. One important technical aspect

Table 2 Stricture rates for the study population and 4 GJ groups

GJ groups	All patients	TRANS-GASTRIC-21 mm	TRANS-GASTRIC-25 mm	TRANS-ORAL-21 mm	TRANS-ORAL-25 mm	*P* value
N	876	100	655	53	62	
Stricture N (%)	76 (8.7 %)	17 (17 %)	55 (8.4 %)	3 (5.2 %)	1 (1.6 %)	.003
P value vs. TRANS-ORAL-25 mm		.002	.050	.349	–	
P value vs. TRANS-ORAL-21 mm		.045	.614	–	–	
P value vs. TRANS-GASTRIC-25 mm		.008	–	–	–	
Length of stay (days)	2.3±0.2	2.4±0.2	2.3±0.2	2.5±0.1	2.0±0.2	.943

when using the circular stapled technique was reported in 2010 [3] when Suter et al. demonstrated a significant reduction of GJ anastomotic stricture with 21 mm circular stapler when passing the anvil trans-orally and through the staple line rather than through the posterior wall of the gastric pouch (0.8 vs. 5.9 %, $p<0.0001$). Table 5 shows the rates of GJ stricture reported in selected series with different GJ anastomosis techniques.

Circular stapled GJ technique is preferred by many surgeons given its reproducibility and ease of use, with the 25-mm stapler diameter being most commonly used. This is due to the higher incidence of stricture reported in the literature with the use of 21 mm compared to 25 mm circular stapler. Reported stricture rates are higher in many series comparing 21 to 25 mm staplers ranging from 6 to 27 % after 21 mm vs. 3 to 9 % for 25 mm [3–5, 7, 9, 15, 16]. However, almost uniformly, the higher stricture rate in these cases series is associated with the trans-gastric above the staple line introduction of the 21 mm anvil and that the finding of a higher rate of stricture formation reported with the 21 mm stapler in most series [9, 15, 16] could be primarily due to the position of the anvil relative to the gastric pouch staple line and not necessarily related to the diameter of the stapler. Other complications have been reported with each anvil introduction technique, specifically pharyngeal and esophageal injuries with the trans-oral route [18]. We did not have any pharyngeal or esophageal injury in our series. In addition, our group's rate of superficial site infections (SSI) using the circular stapled anastomosis was studied in a separate publication [19], and SSI rates were found to be similar when comparing the trans-oral versus the trans-gastric insertion routes.

The only independent technical factor associated with stricture formation in our series was the use of 21 mm stapler with the trans-gastric and above the gastric pouch staple line anvil insertion method. We suggest that this technique leaves a relatively ischemic area in the gastric pouch in between the cut end of the gastric pouch and the GJ anastomosis when the anvil is delivered above the gastric pouch staple line. This

Table 3 Percentage of excess weight loss (%EWL) and percentage of total body weight loss (%TWL) for the study population and 4 GJ groups

GJ groups	All patients	TRANS-GASTRIC-21 mm	TRANS-GASTRIC-25 mm	TRANS-ORAL-21 mm	TRANS-ORAL-25 mm
N	829	100	626	36	62
N (%) of follow-up	708 (85.4 %)	85 (85 %)	541 (86.4 %)	30 (83.3 %)	52 (83.9 %)
1 year %EWL	61.5±0.6	65.1±1.7	61.5±0.7	56.3±3.5	58.6±2.5
P value vs. TRANS-ORAL-25 mm		.119	.633	.938	–
P value vs. TRANS-ORAL-21 mm		.066	.363	–	–
P value vs. TRANS-GASTRIC-25 mm		.243	–	–	–
1 year %TWL	33.5±0.3	36.6±0.9	33.6±0.4	28.9±1.7	29.9±1.4
P value vs. TRANS-ORAL-25 mm		<.001	.026	.948	–
P value vs. TRANS-ORAL-21 mm		<.001	.024	–	–
P value vs. TRANS-GASTRIC-25 mm		.015	–	–	–

Data presented in this table is for patients who reached 1 year of follow-up at the end of the study

Table 4 Baseline clinical characteristics, operative and perioperative factors, percentage of excess weight loss (%EWL), and percentage of total body weight loss (%TWL) at 1 year after LRYGB for patients with and without stricture

	Stricture	No stricture	*p* value
N (%)	76 (8.7 %)	839 (91.3 %)	
Age (years)	42.8±1.1	47.3±0.4	<.001
Gender (% Female)	80 %	80 %	.956
BMI (kg/m^2)	50.2±0.9	48.4±0.3	.071
Weight (kg)	141.5±25	136.6±25	.140
Type 2 diabetes (%)	25 %	36 %	.077
Hypertension (%)	53 %	55 %	.718
Sleep apnea (%)	46 %	38 %	.178
Degenerative joint disease (%)	17 %	20 %	.761
Length of stay (days)	2.5±0.3	2.3±0.2	.549
N (%) of follow-up at 1 year	62/70 (89 %)	646/760 (85 %)	
%EWL at 1 year	62.4±2.2	61.4±0.7	.640
%TWL at 1 year	35.0±1.2	33.3±0.4	.192

relatively ischemic area is avoided when the anvil is delivered through the staple line. This finding is consistent with another series by Suter et al. which reported low rates of stricture despite the use of 21 mm EEA. The authors used similar technique to deliver the anvil trans-orally and through the staple line [3]. They demonstrated a significant reduction of GJ anastomotic stricture with 21 mm circular stapler when passing the anvil trans-orally and through the staple line rather than through the posterior wall of the gastric pouch (0.8 vs 5.9, $p<0.0001$) [3]. Others have obtained a low rate of stricture using a 21-mm inserted trans-orally, but passing the anvil into the posterior wall of the gastric pouch but noting if specifically incorporating the gastric pouch staple line. Rondan et al. reported 4.7 % stricture rate in 338 cases of LRYGB which were performed using 21 mm circular staplers [5]. The authors, however, attributed this low rate partly to the tension-reducing effect of the retrogastric, retrocolic approach they used for the alimentary limb and the anterior stitches at the GJ anastomosis [5]. On the contrary, all cases in our series were performed with an antegastric antecolic fashion and we obtained a similar stricture rate using the 21-mm than Rondan et al. and Suter et al.; both of which employed retrocolic passage of the alimentary limb. Given the smaller abdominal wall wound with less pain associated with the 21-mm stapler and the low stricture rate demonstrated in our experience with the trans-oral technique, we recommend the use of a 21-mm stapler with the anvil introduced trans-orally and through the staple line.

The finding of a protective effect of older age against stricture formation in our study is similar to a previous study by Blackstone et al. who found that younger age and

Table 5 Published series comparing the incidence of gastrojejunostomy strictures with different stapling techniques for laparoscopic gastric bypass

Author	Year	Roux limb	Number			GJ stricture					
			Hand-sewn	Linear	Circular	Hand-sewn *n* (%)	Linear staple *n* (%)	Circular 21 mm n (%)	Anvil Route /position[a]	Circular 25 mm n (%)	Anvil Route/Position
Ruiz-de-Adana et al. [14]	2008	Retrocolic	242	–	–	11 (4.4 %)	–	–	–	–	–
Ukleja et al. [13]	2008	Retrocolic	–	1012	–	–	61 (6 %)	–	–	–	–
Nguyen et al. [7]	2003	Retrocolic	–	–	185	–	–	19 (26.8 %)	Trans-oral/NA	10 (8.8 %)	Trans-gastric/NA
Gonzalez et al. [4]	2003	Retrocolic	87	8	13	3 (3 %)	0 (0 %)	4 (31 %)	Trans-oral/NA	–	–
Takata et al. [15]	2007	Retrocolic (20 %), Antecolic (80 %)	–	195	167	–	8 (4.1 %)	2 (23.1 %)	Trans-gastric/above	4 (2.6 %)	Trans-gastric/above
Gould et al. [9]	2006	Antecolic	–	–	226	–	–	23 (15.9 %)	Trans-gastric/above	5 (6.2 %)	Trans-gastric/above
Fisher et al. [16]	2007	NA	–	–	200	–	–	17 (17 %)	Trans-gastric/above	7 (7 %)	Trans-gastric/above
Rondan et al. [5]	2012	Retrocolic	–	–	338	–	–	16 (4.7 %)	Trans-oral/posterior	–	–
Suter et al. [3]	2010	Retrocolic (98 %)	–	–	1128	–	–	29 (5.9 %)	5 (0.8 %) Trans-oral posterior trans-oral/through	–	–

[a] Anvil position is relative to the gastric pouch staple line; either through the staple line, above the staple line or posterior to the staple line

gastroesophageal reflux disease were both independent predictors of GJ stricture [11]. The odds of developing a GJ stricture decreased with increasing patient's age. Previous studies, however, did not find an association in between patient's characteristics and the occurrence of GJ stricture [8, 15].

The association of stomal size with weight loss after RYGB is not clear. Previous studies comparing the 21 mm with 25 mm circular staplers demonstrated no difference in weight loss outcome with either technique [7, 16, 20]. On the other hand, others have found that anastomosis size correlates with postoperative weight loss. Owens et al. found that weight loss was compromised with the linear stapled anastomosis, which the authors estimated to be slightly larger than that of a 25-mm circular stapled ones compared to the 21-mm circular stapled anastomosis [21]. Weight loss outcome was not influenced, in our series, by having a GJ stricture, and subsequent dilations as patients with and without stricture had similar %EWL at 1 year of follow-up. However, %TWL was higher in the 21-mm trans-gastric group compared to the others; this may be an effect of the smaller gastrojejunostomy and/or that patients in that group had higher baseline BMI.

Limitations of our study include its retrospective nature, differences in baseline patients' clinical characteristics, and a possible effect of other unmeasured changes in surgical technique over the years. However, and importantly, the multivariate analysis methods do partly accounted for the imbalances in baseline patient's clinical characteristics and outcomes. There was also a possible effect of learning curve associated with the trans-gastric-21 mm group given that it represented the initial portion experience of the institution with LRYGB. However, by excluding the first year of our experience during which the trans-gastric-21 mm technique was utilized, this effect might have been minimized. Importantly, all other three techniques were later used contemporaneously and the trans-oral-21 mm group represents a consecutive group of patients done by one of the surgeons (GMC).

We conclude that the trans-oral-21 mm anvil is associated with a low stricture rate, similar to the rate obtained with trans-oral and trans-gastric 25 mm. With the advantage of smaller abdominal wall wound, trans-oral-21 mm may be the preferred size and route of anvil insertion.

Conflict of Interest The authors have no conflicts of interest.

Ethical Statement All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent For this type of study formal consent is not required.

Sources of Support None

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