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ORIGINAL CONTRIBUTIONS

Three-Year Outcomes of Revisional Laparoscopic Gastric Bypass after Failed Laparoscopic Sleeve Gastrectomy: a Case-Matched Analysis

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Abstract

Background While previous studies suggest laparoscopic Roux-en-Y gastric bypass (LRYGB) as a reasonable treatment approach to address weight loss failure after laparoscopic sleeve gastrectomy (LSG), data focusing on long-term outcomes are still lacking. The purpose of this study was to evaluate weight and comorbidity outcomes comparing revisional LRYGB (rLRYGB) with primary LRYGB (pLRYGB).

Methods Retrospective single-centre case-matched analysis was conducted at a bariatric tertiary referral centre. Between January 2009 and July 2013, 239 patients were entered into a prospective database, and 32 patients undergoing rLRYGB (cases) were matched with 32 patients undergoing pLRYGB (controls) for sex, age and BMI. The end point was data at 3 years of follow-up. Thirty-one patients (12.9%) were lost to follow-up during the study period.

Results There were no significant differences in patient demographics or median BMI (kg/m^2) for pLRYGB or rLRYGB (42.8 ± 12.1 vs. 42.3 ± 11.5, respectively; p = 0.748). Coexisting comorbidities were rated similarly in both groups. At 3 years, the percentage of excess weight loss (74.4 ± 23.3 vs 52.0 ± 26, respectively; p = 0.007) was higher for pLRYGB than rLRYGB, while similar improvements of coexisting comorbidities could be observed.

Conclusion rLRYGB is a feasible and practical surgical approach that allows effective weight loss at 3 years of follow-up and alleviates refractory reflux symptoms. Although weight loss is lower compared to pLRYGB, resolution or improvement of coexisting comorbidities appears similar. Therefore, rLRYGB seems to be a reliable procedure to address failure after LSG.

Keywords Bariatric surgery · Laparoscopic Roux-en-Y gastric bypass · Failed laparoscopic sleeve · Gastrectomy · Conversion · Revisional surgery

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Introduction

Morbid obesity, defined as body mass index (BMI) ≥ 40 or BMI ≥ 35 with obesity-related comorbidities, is a chronic disease that remains a significant factor in morbidity and mortality [1]. Bariatric surgery has been proven to be a reliable and effective procedure as part of the interdisciplinary treatment concept [2]. In this context, laparoscopic sleeve gastrectomy (LSG) is considered to be a safe and established bariatric procedure in staged or standalone settings [3]. Mid-term benefits (up to 5 years) include efficient weight loss as well as improvements in comorbidities caused by restrictive and endocrine mechanisms [4]. However, in a subset of patients, inadequate weight loss, weight regain or complications such as severe gastroesophageal reflux disease (GERD) often require revisional bariatric strategies [5, 6]. Laparoscopic Roux-en-Y gastric bypass (LRYGB) has been described as reasonable treatment approach and a viable option for revisional surgery [7, 8].

Success or failure of bariatric procedures in individuals is often measured by weight loss or BMI. In this context, percent of excess weight loss (%EWL) is now recognized as one of the most reliable outcome measures that is least affected by the initial BMI [9]. A %EWL ≥50% after 12–18 months is widely accepted as an outcome measure and indicates success of the surgical procedure in addition to improvement or remission of comorbidities [10].

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The number of revisions due to insufficient weight loss, weight regain or development of certain procedure-specific complications such as GERD is continuously rising. This indicates an ongoing challenge both for the patient and the multidisciplinary bariatric team members. Debates about which procedure is most suitable are persistent [11]. In this context, data focusing on mid-term outcomes after revisional bariatric surgery, particularly after conversion from LSG to LRYGB for nonresponders, are still lacking.

In order to control and eliminate confounding factors (age, sex and BMI), as a cause of difference, a case-matched study design was chosen to enable suitable comparisons and conclusions being made. Based on this kind of analysis, the purpose of this study was to investigate and report midterm weight and comorbidity outcomes of patients who have been converted from LSG to LRYGB due to weight loss failure and have completed at least 3 years of follow-up.

Methods

Patients

This was a retrospective single-centre analysis conducted in a tertiary referral centre for bariatric surgery. All patients undergoing bariatric surgery between January 2009 and July 2013 were entered into a prospective database. Approval was granted by an independent ethics committee. All included operations were performed by three experienced surgeons. All indications for primary or revisional bariatric procedures were endorsed in an interdisciplinary consensus meeting (obesity board). There were no differences or changes in techniques during the study period. Planned two-stage procedures and patients requiring a switch from LSG to LRYGB due to acute, early or late, chronic leaks and strictures were excluded. We identified and reviewed 239 patients in a retrospective manner. A total of 47 revisional LRYGB (rLRYGB) and 192 primary LRYGB (pLRYGB) patients completed at least 3 years of follow-up. A total of 32 rLRYGB cases were eligible for matching, with 32 patients undergoing pLRYGB (controls) on a one-to-one basis for sex, age (±3 years) and BMI (±2 kg/m^2). Matching was impossible in seven patients because no control patient fulfilled the required matching criteria. The full matching process is depicted in Fig. 1.

Failure of weight loss was defined by a percentage of excessive weight loss (%EWL) of less than 50% after 12–18 months and was calculated by the formula:

$$\%\mathrm{EWL} = \left[(\text{Operative Weight} - \text{Follow-up Weight}) \Big/ \text{Ideal Weight}\right] \times 100.$$

Ideal body weight was set as that equivalent to a BMI of 25 kg/m^2.

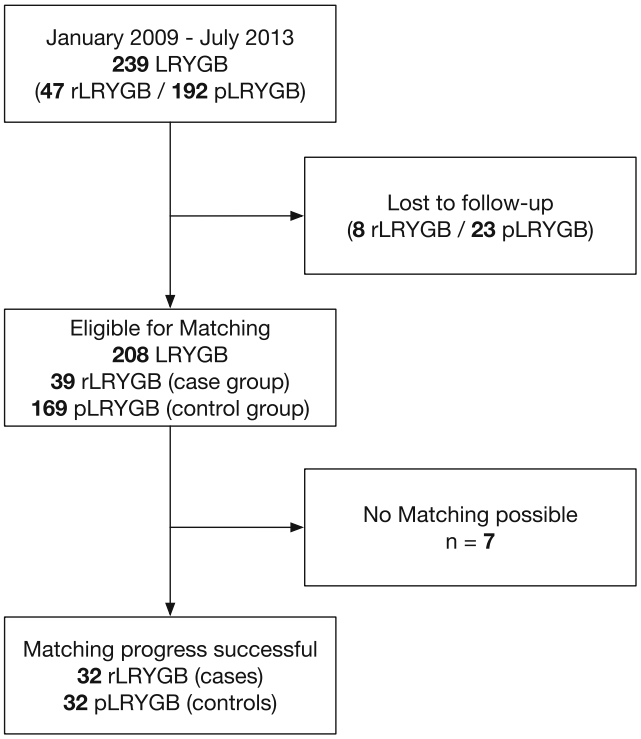

Fig. 1 Flow diagram for matching

Diabetes was defined by Glycated Haemoglobin A1c (HbA1c) ≥6.5%, fasting blood glucose ≥7 mmol/l on two different occasions or a necessity for antidiabetic medication. The definition of hypertension was blood pressure above 140 mmHg (systolic) and/or 90 mmHg (diastolic) or requirement for antihypertensive medication. Dyslipidaemia was defined as a concentration of total cholesterol >5.7 mmol/l, serum high-density lipoprotein level < 1.0 mmol/l, triglyceride level > 1.7 mmol/l or medication to lower lipid concentrations.

Treatment with nightly continuous positive airway pressure (CPAP) or an apnoea–hypopnoea index >5 events/hour indicated obstructive sleep apnoea syndrome. In patients with GERD symptoms, additional endoscopy was performed to screen for mucosal damage.

LSG Surgical Technique

LSG was performed laparoscopically using a five-trocar technique. The greater gastric curvature was dissected 5 cm orally from the pylorus while preserving the antrum. Short gastric vessels were sealed and cut all the way up to the gastroesophageal junction using the Thunderbeat™ device (Olympus Corp). A 32-Fr stomach tube was placed transorally close to the lesser curvature. The stomach was then transected bordering the stomach tube using one 45-mm (black) and four to five

60-mm (violet) linear cartridge laparoscopic staplers (EndoGIA™, Auto- Suture, Covidien).

LRYGB Surgical Technique

Conversion from LSG to LRYGB as well as pLRYGB was performed laparoscopically based on the method described by Lönroth [12]. Briefly, the standardized five-trocar technique was used. The stomach was initially divided close to the lesser curvature using the Ultracision™ device (Ethicon Endosurgery Inc.) after dissection of adhesions. A narrow proximal gastric pouch was then shaped by horizontal stapling (violet cartridge, EndoGIA™, Auto-Suture, Covidien) approximately 3 cm caudal to the gastroesophageal junction. No resection of the gastric remnant occurred. The jejunum was localized directly at the ligament of Treitz and brought up in an antemesocolic alignment. Terminolateral gastrojejunal anastomosis was conducted by using a 30-mm linear stapler (violet cartridge, EndoGIA™, Auto-Suture, Covidien), resulting in a biliopancreatic limb of approximately 50 cm. The length of the alimentary limb was set to 150 cm in all patients, and the jejunojejunostomy was conducted using a linear stapler (beige cartridge, EndoGIA™, Auto-Suture, Covidien).

Postoperative Care, Follow-Up and Outcomes

Postoperative care was standardized in both groups. Patients were permitted to ingest 500–1000 ml of water on the day of surgery. Blood tests to screen for inflammatory markers (CRP and leucocytes) were performed. There was no routine imaging for tracking leakage. A pureed diet was started on day 2. Postoperative follow-up was scheduled in the outpatient clinic in a combined surgical and endocrine setting after 4 weeks, 3 months, 6 months, 12 months, 1 year, 18 months, 2 years, 3 years, 4 years and 5 years. The end point was data at the 3-year follow-up.

Normalization of baseline characteristics without any medication or requirement of CPAP defined remission of hypertension, dyslipidaemia, GERD or sleep apnoea syndrome respectively.

(HbA1c) <6.5% without medication defined remission of diabetes mellitus.

Weight loss (kg) was calculated by the formula: [Operative Weight – Follow-up Weight].

Percentage of weight loss was calculated by the formula: [Weight loss/Operative Weight] × 100.

Percentage of excess weight loss was calculated by the formula as already mentioned above: [(Operative Weight − Follow-up Weight)/Ideal Weight] × 100.

Statistics

The analyses were based on a case-matched study. Statistics were presented as the mean (SD) or numbers (%). Paired Student's *t* test or Wilcoxon signed-rank test was used to compare means of quantitative variables as appropriate. Categorical data were compared using chi-square tests or Fisher's exact tests as appropriate. Significance tests were two-sided, and $p < 0.05$ was considered to be statistically significant. All statistical analyses, as well as initial matching of cases and controls, were performed using SPSS version 22.0 (SPSS, Chicago, IL, USA).

Results

Baseline Characteristics

Between January 2009 and July 2013, a total of 239 patients received LRYGB in our tertiary referral centre for bariatric surgery. A total of 192 patients (80.3%) underwent pLRYGB, and 47 patients (19.7%) underwent rLRYGB due to weight loss failure after LSG. Thirty-one patients (12.9%) were lost to follow-up during the study. Within the period reviewed, a total of 217 LSG were performed. At 3 years of follow-up, 208 patients were eligible for matching, including 39 rLRYGB (18.7%) and 169 pLRYGB (81.3%). Figure 1 presents the flow of participants through the matching process.

Both groups had similar clinical characteristics at baseline, with mean patient age of 42 years and the majority of patients were female. The BMI (kg/m^2) and weight (kg) before LRYGB were similar in both groups. For patients with failed LSG, the mean time between LSG and rLRYGB was 595 ± 369.9 days. A comparison of perioperative comorbidities demonstrated very similar distributions for hypertension, diabetes mellitus, dyslipidaemia and OSAS. GERD was the only parameter that demonstrated a significant difference between cases and controls (respectively $n = 21$; 65.6% vs $n = 9$; 25.0%; $p = 0.001$).

All operations were performed laparoscopically with no resulting incidents or mortality. No postoperative leakages were identified (Table 1).

Three-Year Outcomes

Weight loss in kilogrammes (34.1 ± 15.6 vs. 22.3 ± 20.6; $p = 0.002$), percentage of weight loss (28.32 ± 10.8 vs. 17.4 ± 15.9; $p = 0.001$) as well as percentage of excess weight loss (74.7 ± 23.3 vs. 52.0 ± 40.3; $p = 0.008$) demonstrated significant advantages for the control group (pLRYGB). Additionally, the total number of patients with a %EWL ≥ 50% ($n = 27$; 84.4% vs. $n = 16$; 50%) indicated a better success rate for the primary group. Comorbidities including hypertension, diabetes, dyslipidaemia and OSAS did

Table 1 Demographics, baseline characteristics of patients' health status and comorbidities prior to primary (pLRYGB) or revisional (rLRYGB) gastric bypass procedure

Characteristics	Primary laparoscopic bypass (pLRYGB) (n = 32)	Revisional laparoscopic gastric bypass (rLRYGB) (n = 32)	P value*
Age (years)	42.8 ± 12.1 (16–63)	42.3 ± 11.5 (18–62)	0.748
Sex ratio (M/F)	10:22	10:22	0.606
BMI at time of LSG (kg/m^2)	NA	49.4 ± 5.3 (48–62)	
BMI at time of LRYGB (kg/m^2)	41.1 ± 5.1 (27.2–49.2)	40.9 ± 5.6 (28.8–48.0)	0.449
Weight at time of LRYGB (kg)	117.1 ± 19.5 (84.2–151.0)	118.3 ± 22.5 (81.1–166.0)	0.510
Interval from LSG to LRYGB (days)	NA	595 ± 369.9 (271–1542)	
%EWL < 50%	NA	32 (100%)	
Hypertension	21 (65.6%)	22 (68.8%)	0.790
Diabetes mellitus	11 (34.4%)	12 (37.5%)	0.794
Dyslipidaemia	15 (46.9%)	14 (43.8%)	0.802
Obstructive sleep apnoea syndrome	13 (40.6%)	15 (46.9%)	0.614
Gastroesophageal reflux disease	8 (25.0%)	21 (65.6%)	0.001

Values are means ± SD (range) or numbers (%), as appropriate

BMI body mass index, *NA* not applicable

**p* values are for the comparison between groups. Calculations performed with paired 2-sided Student's *t* test or chi-square tests or Fisher's exact tests as appropriate

not reveal significant improvements after the revisional procedure. However, there was a significant remission of GERD in the case group (initial: n = 21 (65.5%) at 3-year follow-up n = 3 (14.3%); p = 0.001) (Table 2).

Progression of body weight status in accordance with the time point when the first bariatric procedure was performed presented advantages for the pLRYGB group. The percentage of excess weight loss was superior in the case group (74.7 ± 23.3 vs. 66 ± 23.7 for control group; p = 0.011). The number of patients with excess weight loss ≥50% was not significantly higher for either group (24 (75%) vs. 27 (84.4%); p = 0.351) (Table 3).

The progress of %EWL in patients for pLRYGB and rLRYGB through the study period is depicted in Fig. 2.

Discussion

Morbid obesity is a chronic disease for which we currently have no cure. However, bariatric surgery is an effective

Table 2 Characteristics of body weight status and improvements of coexisting comorbidities 3 years after primary (pLRYGB) or revisional (rLRYGB) gastric bypass procedure

Characteristics	Primary laparoscopic bypass (pLRYGB) (n = 32)	Revisional laparoscopic gastric bypass (rLRYGB) (n = 32)	P value*
Weight (kg)	83.1 ± 14.6 (62.2–110.0)	96.1 ± 19.7 (58.9–133.6)	0.003
BMI (kg/m^2)	29.0 ± 3.8 (23.0–39.4)	33.4 ± 5.9 (23.5–43.6)	0.002
Weight loss (kg)	34.1 ± 15.6 (9.4–65.8)	22.3 ± 20.6 (−22.3–72.9)	0.002
% Weight loss (%)	28.3 ± 10.8 (9.8–50.6)	17.4 ± 15.9 (−27.5–43.9)	0.001
% Excess weight loss (%)	74.7 ± 23.3 (23.0–131.7)	52.0 ± 40.3 (−10.0–163.6)	0.008
Patients with excess weight loss ≥50%	27 (84.4%)	16 (50%)	0.007
Hypertension	17 (80.9%)	16 (72.7%)	0.802
Diabetes mellitus	9 (81.8%)	9 (75.0%)	1.000
Dyslipidaemia	13 (86.6%)	10 (71.4%)	0.603
Obstructive sleep apnoea syndrome	9 (69.2%)	13 (86.6%)	0.430
Gastroesophageal reflux disease	7 (87.5%)	9 (42.9%)	0.774

Values are means ± SD (range) or numbers (%), as appropriate

BMI body mass index

**p* values are for the comparison between groups. Calculations performed with Wilcoxon signed-rank tests, Chi-square tests or Fisher's exact tests as appropriate

Table 3 Body weight status in patients 3 years after primary (pLRYGB) or revisional (rLRYGB) gastric bypass procedure according to weight at time of the first bariatric procedure

Characteristics	Primary laparoscopic bypass (pLRYGB) (n = 32)	Revisional laparoscopic gastric bypass (rLRYGB) (n = 32)	P value*
% Excess weight loss (%)	74.7 ± 23.3 (23.0–131.7)	66 ± 23.7 (19.7–112.6)	0.011
Patients with excess weight loss ≥50%	27 (84.4%)	24 (75%)	0.351

Values are means ± SD (range) or numbers (%), as appropriate

*p values are for the comparison between groups. Calculations performed with Wilcoxon signed-rank tests, chi-square tests or Fisher's exact tests as appropriate

procedure to achieve weight loss and to improve obesity-related comorbidities for a large number of patients [13]. Nevertheless, weight loss and outcomes can vary greatly among patients. Although an increasing focus on comprehensive lifestyle programmes and medical management after bariatric surgery is established, several patients only accomplish minor weight loss, demonstrate significant weight regain or do not benefit from remission of comorbidities [14]. Approximately 15–30% of patients fail to lose excess weight after bariatric interventions. [15]. Gadiot et al. determined a 15.2% failure rate after LSG in their analysis, mainly due to insufficient weight loss and reflux [16], which is consistent with our findings.

LSG was described as the first step of a two-stage procedure which included a duodenal switch or an RYGB. This is becoming one of the most frequent bariatric procedures worldwide [17]. Insufficient weight loss, weight regain or the development of certain procedure-specific complications such as GERD is still rising, however, which indicates a substantial and challenging issue for both the patient and the multidisciplinary team as the number of bariatric interventions increases [11].

The reasons for failure are usually multifactorial, including procedural/technical failure (dilatation of the sleeve), incomplete resection of the gastric fundus), biological factors or poor adherence to lifestyle modification programmes [18]. Furthermore, data suggest that LSG is associated with reduced weight loss in patients with BMI > 40 kg/m^2 [19]. According to a recently published study focusing on long-term follow-up after LSG, a high incidence of weight regain (59%) and switch to LRYGB (36%) was observed [20]. Regardless, data regarding revisional surgery, particularly after LRYGB focusing on mid-term and long-term outcomes after failed primary LSG, are still scarce [21].

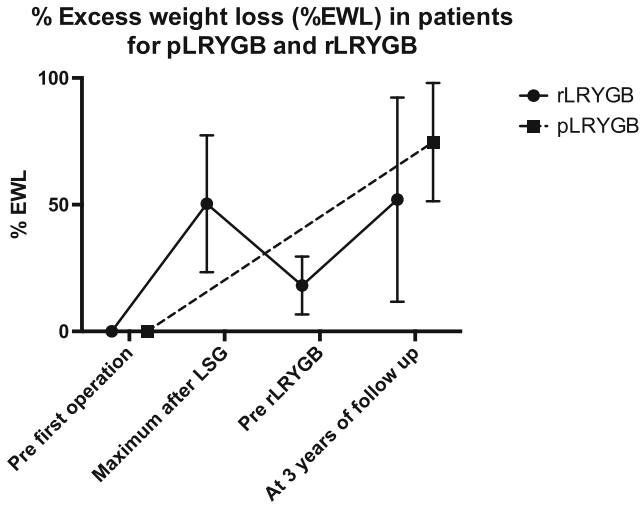

Fig. 2 % Excess weight loss (%EWL) in pLRYGB and rLRYGB patients

To the best of our knowledge, there are no large studies reporting mid-term data on body weight status and comorbidity outcomes for LRYGB after failed LSG. Langer et al. reported the conversion of 8 patients from LSG to LRYGB with a mean weight reduction of 15.2 ± 8.0 kg at a mean follow-up duration of 33 months [22]. Gautier et al. reported on 18 patients who were converted to RYGB for different indications and illustrated effective weight loss results [23]. In summary, only a few studies documented outcome data for more than 2 years. These studies had smaller sample sizes (6–29 patients) or heterogeneous indications (e.g., insufficient weight loss, GERD, weight regain, dysphagia/stenosis) [8, 23, 24]. Hence, the purpose of this study was to investigate and report the weight and comorbidity outcomes of patients who were switched from LSG to LRYGB due to weight loss failure and who completed at least 3 years of follow-up.

Currently, there is no consensus for the ideal procedure after failed LSG. Therefore, the decision of subsequent intervention is mainly based on individual preference and expertise of the bariatric centre [24]. Currently, numerous options including revisional sleeve gastrectomy (ReSG), biliopancreatic diversion and duodenal switch, banded procedures, omega loop gastric bypass and conversion to classic LRYGB exist. Weiner et al. demonstrated that a BPD/DS, as secondary surgery, is more effective than LRYGB. However, a higher complication rate and the risk of several and serious nutritional derangements are also reported with BPD/DS [25, 26]. In some publications, ReSG is demonstrated as an option to counter insufficient weight loss or weight regain [27]. The development of GERD, however, remains a potential downside. Furthermore, in a certain number of cases, combinations of weight loss failure and refractory reflux are present [16].

In this context, LRYGB has been described as a reasonable and accepted treatment approach to address all circumstances. It was therefore preferred in our centre [7, 8].

Our results correspond to recent outcomes reported in the literature. Nguyen et al. outlined %EWL of 68% after 3 years for pLRYGB and described the procedure to be a safe and effective approach for the treatment of morbid obesity [28]. One of the main findings of our analysis was the significantly greater weight change at 3 years after pLRYGB compared to rLRYGB. Similar to our study, Mahawar et al. confirmed in their review that most studies comparing primary vs. revisional Roux-en-Y gastric bypass reported inferior weight loss with revisional RYGB [5]. However, most studies had a follow-up of 1 and 2 years based on a small sample size of patients with failed LSG. Thereaux et al. depicted similar results when focusing on failed adjustable gastric banding after 5 years of follow-up [21]. Accountable influences for these findings are difficult to define. Furthermore, weight loss is more complicated to understand because of different starting points. We do not consider technical conditions to have a tangible impact because feasibility studies did not reveal any significant limitations for shaping a small gastric pouch or the accomplishment of anatomical gastrointestinal rearrangements after previous LSG [23]. Studies have confirmed the safety of revisional bariatric surgery according to our study, which showed similar complication rates between primary and revisional bariatric surgery. However, complex revisional bariatric surgery should be approached with significant caution, even in experienced hands [29]. Impairments in eating behaviours or diminished compliance to dietary advice, psychological factors, although challenging to estimate, could have a possible effect. Metabolic and physiological adjustments (bile flow changes, enteric hormonal modulation and modulation of gut flora) after a previous bariatric procedure could cause relevant adaptation mechanisms and therefore lead to poorer results [30].

Another important finding was the significant reduction of GERD symptoms after rLRYGB, which is consistent with the literature [7, 8] and confirms the potential of rLRYGB for afflicted patients after LSG.

In contrast to other studies, we consider more than the pre-revisional bariatric surgery weight as a reference point. We also assessed weight change using the body weight at the time of the first bariatric procedure. Comparatively, pLRYGB provided greater %EWL than rLRYGB, including failed LSG. When evaluating these findings, differences in overall follow-up need to be considered when interpreting the results to clearly address all questions. We excluded all planned two-staged procedures because we apply the concept of sleeve gastrectomy (1st stage) followed by an LRYGBP (2nd stage) only in super-obese patients to reduce perioperative risks. This is a general and accepted concept that has been described previously [31]. Hence, an appropriate matching process—especially regarding initial BMI—was therefore not applicable.

The strengths of our study include (i) the case-matched study design, (ii) the homogeneity within the groups and (iii) the possibility to report 3-year body weight and comorbidity outcomes of rLRYGB after failed LSG including a primary LRYGB group.

The present study is limited by common biases that are associated with the retrospective character of the analysis. Precision and completeness of data acquisition are very difficult to control. We further revealed a loss-to-follow-up rate of 12.9%. The matching process failed to pair seven patients, which could be a possible consequence of the limitation mentioned above. Furthermore, the sample size for the revision group remained small. To encounter this condition, we used a carefully matched control group.

Currently, procedures tailored to the individual needs of our patients are the current advancement of choice. In conclusion, revisional bariatric surgery does not achieve results as primary surgery. However, rLRYGB is a feasible and appropriate surgical procedure to achieve effective weight loss after failed LSG at 3 years of follow-up. It also helps to alleviate patients from refractory reflux. Nevertheless, mid-term weight loss is lower in direct comparison to the pLRYGB group, while improvement or resolution of coexisting comorbidities demonstrates similar progress. In this context, rLRYGB seems to be a suitable procedure to address failure after LSG within interdisciplinary treatment concepts. Further, long-term studies are needed to verify these results.

Conclusion

Our results demonstrate that rLRYGB is a feasible and practical approach that allows effective weight loss at 3 years of follow-up after failed LSG and alleviates patients from refractory reflux symptoms. Although mid-term weight loss is lower in direct comparison to the pLRYGB group, improvement and resolution of coexisting comorbidities appear similar. Furthermore, rLRYGB seems to be a reliable procedure to address failure after LSG within the concept of interdisciplinary treatment.

Compliance with Ethical Standards

Conflict of Interest All authors declare no commercial associations that might represent conflicts of interest with this article.

Human and Animal Rights and Informed Consent All procedures performed 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.

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