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ORIGINAL CONTRIBUTION

Mini/One Anastomosis Gastric Bypass Versus Roux-en-Y Gastric Bypass as a Second Step Procedure After Sleeve Gastrectomy—a Retrospective Cohort Study

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Abstract

Background Whether one anastomosis gastric bypass (OAGB) or Roux-en-Y gastric bypass (RYGB) is a better revisional bariatric surgery (RBS) after sleeve gastrectomy (SG) is still under debate. The aim is to compare short-term outcomes of RYGB and OAGB as a RBS after SG, pertaining to their effects on weight loss, resolution of comorbidities, and complications.

Methods We performed a single-center analysis of 55 patients ($n = 34$ OAGB, $n = 21$ RYGB). Indications for revisional surgery included weight regain/loss failure (67%) and intractable gastroesophageal reflux disease (33%). Data were collected up to 1-year follow-up (FU) and included time of revisional surgery, operation time, weight, body mass index, excess weight loss, and total weight loss (TWL), both in percent, complications and resolution of comorbidities.

Results Operation time was 79 ± 36 (OAGB-MGB) and 98 ± 24 min (RYGB) ($p = 0.03$). In the first 30 postoperative days, three patients in the RYGB group, and no patient in the OAGB group, had postoperative complications. FU was 100%. Minor complication rates at 12 months were 33.3% (RYGB) and 35.3% (OAGB). At 12 months, mean % TWL was $10.3 \pm 7.6\%$ (RYGB) and $15.8 \pm 7.8\%$ (OAGB) ($p = 0.0132$).

Conclusions OAGB after failed SG was found to be a quicker procedure with less perioperative complications. At 1-year FU, no significant differences were seen between RYGB and OAGB regarding readmission and minor complications. Still long-term FU including the risk of malnutrition is needed to have a complete evaluation of OAGB as a RBS for the future.

Keywords OAGB-MGB · RYGB · SG · Revisional surgery

Abbreviations

SG	Sleeve gastrectomy
OAGB-MGB	One anastomosis gastric bypass-mini gastric bypass
RYGB	Roux-en-Y gastric bypass
GERD	Gastroesophageal reflux disease
FU	Follow-up
BPD/DS	Biliopancreatic diversion with duodenal switch
SD	Standard deviation
BMI	Body mass index
EWL	Excess weight loss
TWL	Total weight loss
PPI	Proton pump inhibitor
GERD-HRQL	GERD–Health-Related Quality of Life Questionnaire
BPL	Biliopancreatic limb
RSI	Reflux symptom index
RBS	Revisional bariatric surgery

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Introduction

Sleeve gastrectomy (SG) is the most commonly performed bariatric procedure around the world, and studies have shown its safety and effectiveness in the short- and long term [1, 2]. However, increasing evidence has shown that SG may fail as a bariatric procedure [3, 4]. Failure of SG leading to revision

results predominantly from insufficient weight loss, weight regain, and intractable gastroesophageal reflux disease (GERD) including Barrett's esophagus [3–5]. Revisional bariatric surgery (RBS) in the form of re-sleeve or gastric bypass (Roux-en-Y gastric bypass [RYGB], one anastomosis gastric bypass-mini gastric bypass [OAGB-MGB], biliopancreatic diversion with duodenal switch [BPD/DS], and single anastomosis duodeno-ileostomy with sleeve gastrectomy [SADI-S]) are described in the current literature [6].

The ideal RBS of failed SG remains unclear. Suggestions include conversion to RYGB in the case of reflux and BPD/DS in the case of weight regain after SG [7–9]. Arman et al. reported that 25% of failed SGs (20/110 patients) involved conversion to another construction, including 10 BPD/DS, 4 RYGB, and 3 re-sleeve procedures for weight issues, increasing the percentage of excess BMI loss (%EBMIL) from 62.5 to 81.7% ($p = 0.015$) with BPD/DS as the preferred procedure for weight regain [3]. Felsenreich et al. described a conversion rate of 36% (19/56 patients) at a median of 36 months after SG. Those patients were converted to RYGB ($n = 18$) owing to significant weight regain ($n = 10$), reflux ($n = 6$), or acute revision ($n = 2$) [4].

Insufficient weight loss and weight regain remain an important long-term complication. A mean excess weight loss (EWL) of 50–60% [1, 2, 10–12] can be achieved in the long term after SG, but many have had less positive results. In addition to failed weight loss/regain, GERD is another long-term complication that occurs in about 20–30% of patients, and the long-term incidence and impact of Barrett's esophagus are still unclear [2, 5, 13, 14].

OAGB-MGB as a primary and revisional surgery is growing in adoption around the world [15, 16]. OAGB-MGB links the effect of RYGB as a low-pressure system and a less dangerous malabsorptive procedure than BPD/DS [17, 18]. Thus, it associates the positive effects of BPD/DS and RYGB with further EWL and the treatment of GERD. The current literature confirms the safety and long-term effectiveness of OAGB-MGB as a primary procedure [19] as well as a revisional surgery for failed gastric-restrictive procedures [17, 18, 20, 21].

Whether re-sleeve, RYGB, OAGB-MGB, or BPD/DS is the best RBS after failed SG is unclear. The current literature shows varying results and no comparisons between revisional RYGB and revisional OAGB-MGB after failed SG have been performed. Thus, the aim of the present study is to analyze the short-term results of RYGB and OAGB-MGB as revisional surgery after failed SG from a single center.

Methods

Data was collected prospectively. From October 2014 to December 2016, 55 patients underwent revisional or second step procedures after failed SG with conversion to RYGB ($n = 21$) and OAGB-MGB ($n = 34$) at a center of excellence for obesity and metabolic surgery. Primary SGs were performed in our hospital ($n = 33$) and in other hospitals around Europe and Middle East ($n = 22$). Our technique of SG has been described before [22]. Data collected included the following: gender, age, body mass index (BMI), EWL, total weight loss (TWL), time, and indication for revisional surgery, operation time, and peri- and postoperative morbidity. Patients underwent follow-up (FU) at 1, 3, and 6 months and 1 year after surgery up to December 2017. Patients filled out the StuDoQ|Metabolische & Bariatrische Erkrankungen-Questionnaire, which is the official questionnaire of the national German register for obesity and metabolic surgery, at 3 and 12 months after surgery. The eligibility criteria were failed SG with indication for revisional surgery owing to weight regain/insufficient weight loss or intractable GERD. Continuous variables were presented as mean ± standard deviation (SD). Categorical variables were summarized with the use of frequencies and analyzed with the χ^2 test. Continuous variables, when normally distributed, were reported as mean, SD, and range. Intergroup differences were tested by a two-sample t test for normally distributed data. A p value < 0.05 was considered significant. Statistical analysis was performed using SPSS 25.0 for Windows (SPSS Inc., Chicago, IL, USA). Informed consent was obtained from all participants. All procedures involving human participants were performed 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. This work has been reported in line with the STROCSS (Strengthening the Reporting of Cohort Studies in Surgery) criteria [23]. Ethical approval was obtained from the local ethics committee (Landesärztekammer Hessen, Germany, reference number FF 3/2018), and all participants provided written informed consent for data sharing. The National Clinical Trials number is NCT03526783.

Surgical Indications

Revisional surgery to RYGB or OAGB-MGB was performed because of insufficient weight loss, weight regain, or intractable GERD. In the preoperative setting, all patients underwent upper endoscopy and most underwent computed-tomography-volumetry. The GERD–Health-Related Quality of Life (GERD-HRQL) Questionnaire was completed prior to surgery and the reflux symptom index (RSI) was completed prior to and 1-year post-surgery. The GERD-HRQL includes 10 questions with scores between 0 and 5 and a total score ranging from 0 to 50 [24], with a higher score indicating a worse quality of life. The RSI includes nine questions with scores between 0

and 5 and a total score ranging from 0 to 45 [25]. RSI of greater than or equal to 13 is indicative of significant reflux disease.

Indication for conversion in the case of intractable GERD included esophagitis ≥ grade B according to the Los Angeles Classification and a GERD-HRQL score ≥ 12 in proton pump inhibitor (PPI) treatment [24].

Indications for conversion in the case of insufficient weight loss or weight regain included significant weight regain (> 15%), based upon whether they had gained > 15% of their 1-year postoperative weight, insufficient weight loss with an EWL < 50% [26], and recurrence of diabetes mellitus type 2 ($n = 2$).

Resolution of comorbidities was defined as provided by the ASMBS outcome reporting standards [27].

In our department, the indication for OAGB-MGB is given in a failed SG when weight issues are the main patient problem, while the indication for RYGB is given in a failed SG when GERD is the main patient problem.

In the case of important GERD (RSI > 20, GERD D) [25] and weight regain, the indication for long biliopancreatic limb (BPL) RYGB (alimentary limb 70 cm, BPL 200 cm) was given ($n = 2$).

Figure 1 shows our current treatment algorithm in failed SG.

Surgery was performed by four bariatric surgeons with more than 10 years of experience in this field.

horizontal (45-mm linear stapler) staple lines. In the case of a dilated sleeve, re-sleeve was performed using a gastric tube (24 Ch). In a case of a giant hiatal hernia (> 5 cm), we performed a dissection of the angle of His and the hiatus and posterior closure of the crura using a gastric tube (42 Ch). Then, the ligament of Treitz was located and identified. Starting at the ligament of Treitz, a 50-cm length (200-cm length in the case of a long-BPL-RYGB) of the small intestine was measured in 5-cm increments and divided with a 60-mm linear stapler. The detached afferent limb of the jejunum was brought up and sutured to the gastric pouch. A termino-lateral gastroenterostomy was created with a 45-mm linear stapler after a small incision was made with an ultrasound dissector at the anterior wall of the stomach and jejunum. A gastric tube (24 Ch) was guided to the jejunum and a double hand-sewn suture on the front wall (Vicryl 0) was performed and tested for leaks with methylene blue. A 150-cm alimentary limb (70-cm length in the case of a long-BPL-RYGB) was measured in 5-cm increments to perform latero-lateral enteroenterostomy. The jejunal limbs were incised with an ultrasound dissector and an anastomosis was created with two 45-mm linear staplers. The resulting defect was closed with a running suture (Vicryl 0). Brolin stitch was performed and mesenterial defects were closed. A drainage was placed in the left upper abdomen. Patients received PPI treatment for 6 weeks after surgery.

Laparoscopic Roux-en-Y Gastric Bypass

RYGB was performed starting with lysis of the typical adhesions after SG. The lesser curvature was skeletonized at the level of the second to the third vascular arcade, opening the omental bursa. A gastric pouch was created with one or two

Laparoscopic One Anastomosis Gastric Bypass-Mini Gastric Bypass

OAGB-MGB was performed starting with lysis of the typical adhesions after SG. The lesser curvature was skeletonized in the avascular zone of the angulus opening the omental bursa. A long gastric pouch was started beginning below the crow's

Fig. 1 Current intern treatment algorithm in failed sleeve gastrectomy. SG, sleeve gastrectomy; OAGB-MGB, one/mini anastomosis gastric bypass; RYGB, Roux-en-Y gastric bypass; GERD, gastroesophageal reflux disease; BMI, body mass index
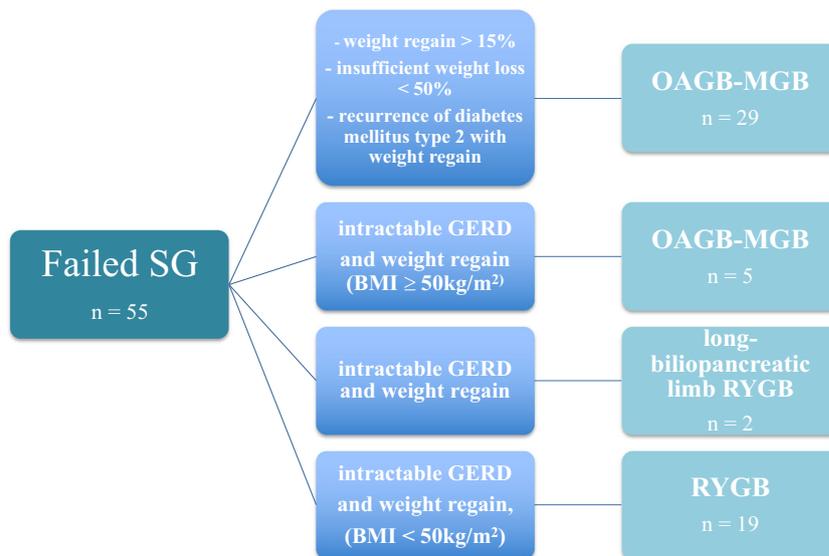
foot with a horizontal 60-mm linear stapler. In the case of a dilated sleeve, re-sleeve was performed using a gastric tube (42 Ch). In a case of a giant hiatal hernia (> 5 cm), we performed dissection of the angle of His and the hiatus and posterior closure of the crura using a gastric tube (42 Ch). Then, the ligament of Treitz was located and identified. Starting at the ligament of Treitz, a 200-cm length of the small intestine was measured in 5-cm increments and then brought up and sutured to the gastric stump. A termino-lateral gastroenterostomy was created with a 45-mm linear stapler after a small incision was made with an ultrasound dissector at the anterior wall of the stomach and jejunum. A gastric tube (24 Ch) was guided to the jejunum and a double hand-sewn suture on the front wall (Vicryl 0) was performed and tested for leaks with methylene blue. A drainage tube was placed in the left upper abdomen. Patients received PPI treatment for 6 months after surgery.

Results

A total of 55 patients were included. Conversion to RYGB was performed in 21 patients (2 males, 19 females) and conversion to OAGB-MGB in 34 (11 males, 23 females). Indications for revisional surgery included weight regain/insufficient weight loss ($n = 37$, 67%) and intractable GERD ($n = 18$, 33%; 13/18 patients underwent RYGB and 5/18 underwent OAGB-MGB, while in these 5 patients BMI was ≥ 50 kg/m^2). Due to a giant hiatal hernia, additional hiatoplasty was performed in eight patients during RYGB and in four during OAGB-MGB. Patient data are listed in Table 1.

Mean preoperative sleeve volume was measured by computed-tomography-volumetry in 52 patients with a mean volume of 182.12 ± 59.15 ml (80–370). In three patients, computed-tomography-volumetry was missing.

The average GERD-HRQL score was 12.9 ± 9.12 (range 0–35) in the RYGB group and 4.59 ± 5.02 (range 0–17) in the OAGB-MGB group. The average RSI score was 9.95 ± 8.6 (range 0–32) in the RYGB group and 4.97 ± 5.71 (range 0–19) in the OAGB-MGB group. At 1-year FU, the average RSI score was 2.9 ± 9.69 (range 0–45) in the RYGB group ($p = 0.0169$) and 4.21 ± 5.8 (range 0–32) in the OAGB-MGB group ($p = 0.5879$).

FU at 1 year (December 2017) was 100% (55/55 patients).

RYGB Group

In the RYGB group ($n = 21$) prior to SG, mean BMI was 49.8 ± 9.3 kg/m^2 (range 36.3–68.6). Three patients (14.2%) had a BMI > 60 kg/m^2 before SG. Conversion was performed 33.3 ± 22.8 months (range 2–84) after SG with a mean EWL of $54 \pm 28\%$ (range 11–124) after SG.

The mean operation time of conversion of SG in RYGB was 98.2 ± 24.3 min (range 39–150). All conversions were performed laparoscopically. No intraoperative complications were seen. Blood loss was < 10 ml in all patients. Length of hospital stay was 5 days in all patients, following our intern protocol. Within the first 30 postoperative days, three patients (three women) developed postoperative complications. An anastomotic ulcer was diagnosed via upper endoscopy at postoperative day 27 and was treated conservatively by intravenous PPI therapy and per oral aluminum complex (Sucralfate 1-1-1-1) (Clavien–Dindo Classification Grade II). One patient developed a postoperative ileus due to stenosis of the enteroenterostomy site and reoperation was performed on the third postoperative day by revision of the entero-entero anastomosis (Clavien–Dindo Classification Grade IIIb). Elevated inflammation signs, elevated lipase, and signs of mild postoperative pancreatitis on the computed tomography scan of the abdomen were treated conservatively in the third patient (Clavien–Dindo Classification Grade II).

Table 1 Patient's data prior to revisional surgery ($n = 55$)

	$n = 55$	RYGB ($n = 21$)	OAGB-MGB ($n = 34$)	p value
Age (years)	46.5 ± 11.1 (22–68)	46.14 ± 10.8 (22–61)	46.76 ± 11.48 (25–68)	$p = 0.84$
BMI before SG (kg/m^2)	53.4 ± 9.5 (36.3–72.6)	49.8 ± 9.3 (36.3–68.6)	56.5 ± 8.8 (38.4–72.6)	$p = 0.0097$
BMI at conversion (kg/m^2)	42.2 ± 8.7 (22.3–62.7)	36.6 ± 6.9 (22.2–51.9)	45.7 ± 8 (30.1–62.9)	$p = 0.0001$
BMI drop at 12 months (kg/m^2)		3.6 ± 3.3 (−3.3–9.3)	9.7 ± 5.8 (1.9–23.3)	$p = 0.0001$
Time after SG (months)	36.5 ± 22.3 (2–91)	35.59 ± 24.73 (2–84)	38.53 ± 22.02 (3–91)	$p = 0.6481$
EWL after SG (%)	42 ± 23 (0–124)	54 ± 28 (11–124)	35 ± 15 (0–76)	$p = 0.0018$
Nadir EWL after SG (%)	48 ± 23 (24–144)	61 ± 9 (24–144)	41 ± 15 (26–106)	$p = 0.0001$
Weight regain after nadir weight after SG (kg)	4.91 ± 4.09 (0–19)	4.2 ± 6.9 (0–9)	5.2 ± 4.7 (0.4–19)	$p = 0.5251$
TWL after SG (%)	21.5 ± 10.4 (0–47.2)	25.7 ± 12.8 (4.9–47.2)	18.9 ± 7.8 (0–35.5)	$p = 0.0175$

BMI body mass index, *SG* sleeve gastrectomy, *EWL* excess weight loss, *TWL* total weight loss

The progression of weight, BMI, EWL, and TWL are listed in Table 2.

OAGB-MGB Group

In the MGB group prior to SG ($n = 34$), mean BMI was 56.5 ± 8.8 kg/m^2 (range 38.4–72.6). Nine patients (26.5%) had a BMI > 60 kg/m^2 before SG. Conversion was performed 38.5 ± 22 months (range 3–91) after SG with a mean EWL of $35\% \pm 15$ (range 0–76).

The mean operation time of conversion of SG in OAGB-MGB was 78.7 ± 35.7 min (range 25–183). All conversions were performed laparoscopically. No intraoperative complications were seen. Blood loss was < 10 ml in all patients. Length of stay was 5 days in all patients, following our intern protocol. During the first 30 postoperative days, no patient had a surgical complication. The progression of weight, BMI, EWL, and TWL are listed in Table 3.

RYGB Group Vs OAGB-MGB Group

Both groups were similar in age ($p = 0.84$) at conversion and time of conversion ($p = 0.6481$) after SG.

The OAGB-MGB group had a higher BMI prior to conversion (45.7 kg/m^2 in the OAGB-MGB group vs 36.6 kg/m^2 in the RYGB group) ($p = 0.0001$). At 12 months, mean additional %TWL post-revision was $10.3 \pm 7.6\%$ in the RYGB group and $15.8 \pm 7.8\%$ in the OAGB-MGB group ($p = 0.0132$, Fig. 2). Figure 3 shows the trend of EWL over time.

Comparing conversion of failed SG to RYGB or OAGB-MGB showed a significantly favorable operation time. OAGB-MGB was performed in 79 ± 36 min (range 25–183) vs RYGB in 98 ± 24 min (range 39–150) ($p = 0.03$).

At preoperative assessment, 18 (32.7%) patients were being treated for one or more comorbidities: 12 (21.8%) for type 2 diabetes mellitus (eight by insulin), 21 (38.2%) had oral treatment for dyslipidemia, 7 (12.7%) were on continuous positive airway pressure, and 12 (21.8%) were under medical treatment for hypertension. In addition, 18 patients (32.7%) took PPIs for GERD.

FU was protocolled up to 1 year after surgery. Table 4 shows the different symptoms and complications as asked in the official questionnaire of the national German register for obesity and metabolic surgery (StuDoQ|Metabolische & Bariatrische Erkrankungen-Questionnaire) at 12 months. Readmission due to gastrointestinal problems was 7/21 (33.3%) in the RYGB and 12/34 (35.3%) in the OAGB-MGB group during the first postoperative year. Diagnostics included upper endoscopy and a glucose tolerance test. Upper abdominal pain was mostly related to anastomotic ulcers, bile reflux, and dumping syndrome. Lower abdominal pain was mostly related to flatulence, diarrhea, and obstipation. All complications seen up to 1 year were Clavien–Dindo I and II complications, and pharmacological treatment (Clavien–Dindo II) was given in GERD (PPI per os), bile reflux (Colestyramine per os), dumping (dietary changes, acarbose), and anastomotic ulcers (high dosage of intravenous PPI for 1 week). All symptoms resolved with this treatment. No revisional surgery was performed during the first year of FU and mortality was 0%. No significant differences were seen between the bypass groups. One-year FU showed more upper gastrointestinal symptoms in the RYGB and more lower gastrointestinal symptoms in the OAGB-MGB group, but without any statistical significance between groups.

Table 5 shows the metabolic changes. Twelve patients had type 2 diabetes mellitus, two of whom reported a recurrence of type 2 diabetes mellitus after SG. In these two patients, OAGB-MGB was performed. Percentages of comorbidities resolved were type 2 diabetes mellitus, 100%, hypertension, 66.7%, dyslipidemia, 61.5%, and obstructive sleep apnea, 80%. One-year FU showed greater metabolic improvement after OAGB-MGB.

Discussion

In parallel to the worldwide increasing numbers of SG, revisional bariatric surgery after SG is increasing due to insufficient weight loss, weight regain, and intractable GERD.

Table 2 RYGB group ($n = 21$)

	Prior to SG	Prior to RYGB	3 months FU ($n = 21$)	12 months FU ($n = 21$)
Weight in kg	137.9 ± 28.5 (85–189)	101.6 ± 23.5 (52.5–160)	94.6 ± 21.6 (54–152)	87.1 ± 18.2 (52–129)
BMI in kg/m^2	49.8 ± 9.3 (36.3–68.6)	36.6 ± 6.9 (22.2–51.9)	34.1 ± 6.2 (23.1–48.7)	33.5 ± 5.6 (22.2–44.8)
EWL in % since SG	–	54 ± 28 (11–124)	65 ± 23 (23–117)	76 ± 23 (35–125)
EWL in % since RYGB	–	–	11 ± 12 (−7–41)	22 ± 18 (1–67)
TWL in % since SG	–	25.7 ± 12.8 (4.9–47.2)	30.8 ± 10.9 (10.8–50.6)	36 ± 10.8 (16–54.4)
TWL in % since RYGB		–	5.1 ± 5.2 (−2.1–20)	10.3 ± 7.6 (24–33.1)

SG sleeve gastrectomy, *RYGB* Roux-en-Y gastric bypass, *FU* follow-up, *EWL* excess weight loss, *TWL* total weight loss, *BMI* body mass index

Table 3 OAGB-MGB group ($n = 34$)

	Prior to SG	Prior to OAGB-MGB	3 months FU ($n = 34$)	12 months FU ($n = 34$)
Weight in kg	164.4 ± 33 (110–233)	133.2 ± 28.6 (80–214.7)	119 ± 24.3 (74.5–183)	106.3 ± 21.2 (72.5–158)
BMI in kg/m^2	56.5 ± 8.8 (38.4–72.6)	45.7 ± 8 (30.1–62.9)	40.9 ± 6.8 (28.9–53.5)	36.6 ± 6.3 (25.7–47.8)
EWL in % since SG	–	35 ± 15 (0–76)	50 ± 16 (7–82)	64 ± 16 (42–97)
EWL in % since OAGB-MGB	–	–	15 ± 10 (3–45)	29 ± 13 (9–69)
TWL in % since SG	–	18.9 ± 7.8 (0–35.5)	27.2 ± 8.7 (3.5–45.4)	34.7 ± 9.3 (19.1–60.5)
TWL in % since OAGB-MGB	–	–	8.3 ± 5.6 (1.6–27.7)	15.8 ± 7.8 (4–43.1)

SG sleeve gastrectomy, *OAGB-MGB* mini/one anastomosis gastric bypass, *FU* follow-up, *EWL* excess weight loss, *TWL* total weight loss, *BMI* body mass index

Whether re-sleeve, RYGB, OAGB-MGB, or BPD/DS is the best RBS remains under debate.

OAGB-MGB is gaining popularity as a primary surgical treatment for morbid obesity because of its reduced operation time, shorter learning curve, better weight loss, and fewer major complications compared with RYGB [19, 28]. The advantages of OAGB-MGB include the technical simplicity to handle revisional surgery, the low-pressure system of OAGB-MGB, the additional weight loss, and the metabolic answer of this procedure that adds fatty food intolerance/fat malabsorption [21, 28, 29]. While SG induces a significant elevation in intragastric pressures and gastroesophageal pressure gradient, OAGB-MGB statistically diminishes both parameters [30]. Furthermore, OAGB-MGB is believed to cause marked fatty food and sweets intolerance and is more malabsorptive than the standard RYGB owing to its longer BPL [29], without reaching the malabsorptive dangers of BPD/DS with its disadvantageous side effects [31, 32], thereby resulting in additional weight loss. These advantages of primary surgery could be transferred to revisional surgery after failed SG.

The heterogeneity of the current studies with different revisional procedures and examined parameters makes it difficult to compare revisional surgeries after failed SG. In 2014, Cheung et al. pe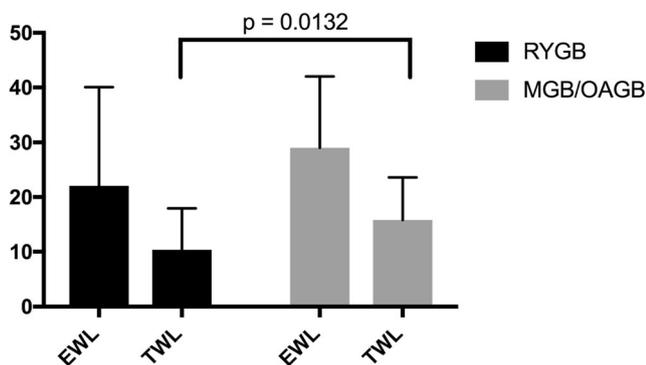rformed a systematic review of 11 primary studies (218 patients) on revisional bariatric surgery following failed primary SG and found only limited evidence for selecting the appropriate revisional operation. Both RYGB and re-sleeve achieved effective weight loss following failed SG. They concluded that the less technically challenging nature of re-sleeve may be more widely applicable and that further research is required to elicit the sustainability of long-term weight loss benefits [33]. The negative effects of re-sleeve in the form of the risk of leakage, the high-pressure system, and the absence of an additional malabsorptive effect must be kept in mind when choosing this type of revisional surgery.

Summarizing the current literature, revisional OAGB-MGB for a failed restrictive procedure was found to be safe and effective for 5 years. However, quality of life and upper gastrointestinal function seem to be lower compared with primary OAGB-MGB [34]. Furthermore, RYGB was found to be a feasible, effective, and a well-tolerated alternative in selected patients with failed SG with improved secondary weight loss and GERD. Quezeda et al. reported that over
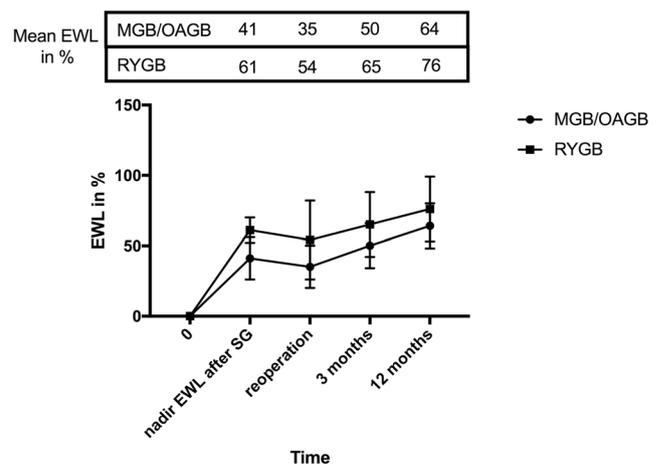

Fig. 2 Excess weight loss (EWL) % and total weight loss (TWL)% 12 months after RYGB and OAGB-MGB. A statistic significant difference was seen regarding weight loss. OAGB-MGB, one/mini anastomosis gastric bypass; RYGB, Roux-en-Y gastric bypass

Fig. 3 Trend of excess weight loss. EWL in percent in the OAGB-MGB and RYGB group with the sleeve procedure, the nadir weight reached after SG, EWL at the time of reoperation, and the progression of EWL after the second step operation at 3 and 12 months. Means are expressed in the upper box. SG, sleeve gastrectomy; OAGB-MGB, one/mini anastomosis gastric bypass; RYGB, Roux-en-Y gastric bypass; EWL, excess weight loss

Table 4 Comparison of 1-year FU complications (Clavien–Dindo Classification I–II)

	RYGB ($n = 21$)	OAGB-MGB ($n = 34$)
Upper GI symptoms		
- Nausea	- 5/21 (23.8%)	- 4/34 (11.8%)
- Vomiting	−4/21 (19%)	- 2/34 (5.9%)
- Upper abdominal pain	- 3/21 (14.3%)	- 4/34 (11.8%)
- Lower abdominal pain	- 2/21 (9.5%)	- 4/34 (11.8%)
Anastomotic ulcer	- 2/21 (9.5%)	- 6/34 (17.6%)
Symptomatic bile reflux		- 2/34 (5.9%)
Lower GI symptoms		
- Foul smelling bowels	- 2/21 (9.5%)	- 12/34 (35.3%)
- Flatulence	- 3/21 (14.3%)	- 12/34 (35.3%)
- Diarrhea	- 3/21 (14.3%)	- 12/34 (35.3%)
- Obstipation	- 1/21 (4.8%)	- 1/34 (2.9%)
Dermatologic symptoms		
- Dystrophic nails	- 1/21 (4.8%)	- 3/34 (8.8%)
- Dermatitis	- 0/21 (0%)	- 3/34 (8.8%)
- Glossitis	- 0/21 (0%)	- 0/34 (0%)
Neurologic symptoms		
- Muscle pain	- 0/21 (0%)	- 3/34 (8.8%)
- Ataxia	- 0/21 (0%)	- 0/34 (0%)
- Paresthesia	- 2/21 (9.5%)	- 5/34 (14.7%)
Hair loss	4/21 (19%)	7/34 (20.6%)
Fatigue	5/21 (23.8%)	5/34 (14.7%)
Dumping syndrome	4/21 (19%)	1/34 (2.9%)
GERD	1/21 (4.8%)	4/34 (11.8%)
Readmission	7/21 (33.3%)	12/34 (35.3%)

RYGB Roux-en-Y gastric bypass, *OAGB-MGB* one/mini anastomosis gastric bypass, *GERD* gastroesophageal reflux disease

90% of GERD patients had resolved or improved symptoms [35], but Poghosyan et al. underlined the high-cost morbidity (11.7%) of revisional RYGB [36]. At least, BPD/DS yielded greater weight loss compared with RYGB, and Carmeli et al. concluded that the mechanism of failure should guide the selection of the RBS [37]. However, BPD/DS involves an important risk of complications such as severe protein calorie malnutrition and micro-nutrient and vitamin deficiencies [12].

A novel study with a concomitant literature review by Parmar et al. demonstrated that the conversion of SG to RYGB is effective for GERD symptoms, but not for further

Table 5 Resolution of comorbidities at 1-year FU

	RYGB ($n = 21$)	OAGB-MGB ($n = 34$)
Resolution of comorbidities		
- Diabetes mellitus	- 3/5 (60%)	- 7/7 (100%)
- Hypertension	- 0/3 (0%)	- 6/9 (66.7%)
- Dyslipidemia	- 2/8 (25%)	- 8/13 (61.5%)
- Sleep apnea	- 0/2 (0%)	- 4/5 (80%)

RYGB Roux-en-Y gastric bypass, *OAGB-MGB* one/mini anastomosis gastric bypass

weight loss. The authors reported that 100% of the patients had an improvement in symptoms, and 80% of the patients were able to stop their antacid medications. Due to modest weight loss, the study group concluded that future studies are necessary to identify the best revisional procedure for insufficient weight loss or weight regain after SG [38].

The different small bowel lengths of proximal and distal gastric bypass, their impact on weight loss and metabolic syndrome, and the risk of malnutrition are important points of discussion in the current literature. Mahawar et al. analyzed the different small bowel limb lengths of proximal and distal gastric bypass in a systematic review. They found out that biliopancreatic limb-based distal bypass has a good weight loss, but with a high risk of significant protein malnutrition, whereas alimentary limb-based distal bypass has a much lower risk of protein malnutrition of 1–4%, but the weight loss outcomes are not much different with standard RYGB [39]. The authors concluded that proximal RYGB achieves optimum results in patients with a BMI ≤ 50 kg/m^2 and a combined limb length (alimentary + biliopancreatic) between 100 and 200 cm, and that bypassing more than 200 cm small bowel does not improve weight loss significantly. A recent systematic review by Zorrilla-Nunez et al. analyzed 13 articles regarding the biliopancreatic limb length and concluded that the release of enterohormones in response to a food load in the distal small bowel seems to play an important role in the remission of comorbidities and that the length of biliopancreatic limb might affect this process [40]. In our study both groups had a combined limb length of 200 cm; thus, the longer biliopancreatic limb of OAGB-MGB might be the reason for better weight loss ($p = 0.0132$) and the better impact on comorbidities. Further studies have to point out the impact of the different limb lengths on weight loss and resolution of comorbidities after weight regain or weight loss failure in s.a. SG.

Whether preoperative sleeve volume is important to evaluate preoperatively remains a point of discussion. In our study, computed-tomography-volumetry showed a mean sleeve volume of 182.12 ± 59.15 ml (80–370), indicating in quite all patients the presence of an important sleeve dilatation, 36.5 ± 22.3 months after primary SG. These numbers conformed with the current literature, but should be interpreted with caution, while dilatation is not necessarily linked to an increase of daily caloric intake and insufficient weight loss [41].

GERD is important to evaluate in this study, since two patients after SG were converted to gastric bypass (RYGB $n = 1$, OAGB-MGB = 1) after 2 and 3 months due to important reflux symptoms and a RSI score of 19 and 32. Indeed, these patients had a prompt resolution of GERD symptoms. At the 1-year FU, 4.8% of the

RYGB and 11.8% of the OAGB-MGB patients had still reflux symptoms, but a statistical significant reduction of GERD symptoms was seen after RYGB. Conversion of SG reduced RSI score significantly after RYGB ($p = 0.0169$). Additional hiatoplasty due to a giant hiatal hernia was performed in eight patients during RYGB and in four patients during OAGB-MGB. If additional hiatoplasy affects GERD symptoms [42] or if the low-pressure system of gastric bypass is the right treatment in these patients is not yet discussed in the literature. If OAGB-MGB is a good treatment for GERD remains unclear, since RSI was not statistically different before and after OAGB-MGB.

In our study, weight loss was better ($p = 0.0132$), operation time was faster ($p = 0.03$), and perioperative complications were lower in the OAGB-MGB compared with the RYGB group.

After the 1-year FU, no statistical significance was seen in regard to postoperative complications, since readmission was similar in both groups (33 vs 35%).

Since revisional procedures are associated with higher rates of readmission and overall morbidity [43], it is important to choose a safe and straightforward technical surgical procedure for revisional surgery to maintain the best effects on further weight loss and existing GERD.

The addition of further weight loss, a shorter operation time, and less perioperative complications in our study underlines the positive effects of OAGB-MGB as a RBS after failed SG compared with RYGB.

Some limitations of the present study must be mentioned. First, the study had a FU of only 1 year. Long-term FU is needed to point out the positive and negative effects of OAGB-MGB in the long term. Since OAGB-MGB is a malabsorptive procedure, long-term FU is needed to understand the risk of protein malnutrition, bone demineralization, and vitamin deficits and only long-term data can give us a balance between both positive and negative effects of OAGB-MGB for the future.

Second, a selection bias could attenuate the study results. In our department, the indication for OAGB-MGB is given in failed SG due to weight issues, and that for RYGB is given in failed SG due to GERD. Thus, the OAGB-MGB group had a higher BMI at conversion (45.7 kg/m^2 in the OAGB-MGB group vs 36.6 kg/m^2 in the RYGB group, $p = 0.0001$) and comparison of weight loss should be interpreted with caution.

Third, three patients (14.2%) of the RYGB group and nine patients (26.5%) of the OAGB-MGB group had a BMI > 60 kg/m^2 before SG. In these patients, as often discussed in the current literature, SG remains a first step procedure [44]. In our study cohort, we did not differentiate between RBS and planned second step procedures, since in the clinical setting and next to our intern protocol no differentiation between RBS and second stage is necessary, while current patient status helps us to choose the further procedure (Fig. 1).

Conclusion

At 1-year FU, no significant differences were seen between RYGB and OAGB-MGB regarding readmission and minor complications. OAGB-MGB after failed SG was found to be a quicker procedure with less perioperative complications, but since it is a malabsorptive procedure long-term FU including the risk of malnutrition is needed to have a complete evaluation of OAGB-MGB as a revisional surgery for the future.

Compliance with Ethical Standards

Conflict of Interest All authors declare that they have no conflicts of interest.

Informed Consent Informed consent was obtained from all the individual participants included in the study.

Ethical Approval All procedures performed in this study 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.

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