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REVIEW

Indications, Operative Techniques, and Outcomes for Revisional Operation Following Mini-Gastric Bypass-One Anastomosis Gastric Bypass: a Systematic Review

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Abstract

In addition to being a relatively reversible and less complex operation, mini-gastric bypass-one anastomosis gastric bypass (MGB-OAGB) has demonstrated comparable weight loss and metabolic improvement rates with Roux-en-Y gastric bypass (RYGB). However, surgical strategies for managing its failures and late complications were poorly defined. This article aims to review the indications, operative techniques, and outcomes for revisional surgery following MGB-OAGB. A systematic review was performed using the PubMed database from 1997 to 2019. Of 179 included patients, 89 underwent revision to RYGB; 52 to sleeve gastrectomy (SG); 32 reversal to original anatomy; and 6 underwent partial revision with gastro-gastrostomy alone. Most common indications were severe malnutrition, chronic bile reflux, intractable marginal ulcerations, and insufficient weight loss. Postoperative complication rates ranged from 5 to 35%.

Keywords Revision · Conversion · Mini-gastric bypass · One anastomosis gastric bypass · Omega-loop gastric bypass · Operative techniques

Introduction

Mini-gastric bypass-one anastomosis gastric bypass (MGB-OAGB) was first described by Rutledge et al. [1] in 1997. It was conceptualized based on a combination of Collis gastroplasty and an antecolic Billroth II loop gastrojejunostomy, involving a 1.5- to 2-m afferent limb length from the ligament of Treitz [2]. In contrast to Roux-en-Y gastric bypass (RYGB), MGB-OAGB afforded less demanding technical challenges due to the need for only one anastomosis, which also led to its shorter operative time [3]. The anatomy of MGB-OAGB allowed the option of conversion to RYGB or sleeve gastrectomy (SG), if a revision was required in the future [4, 5]. In addition, recent literature has demonstrated comparable excess weight loss and resolution rate for type II diabetes mellitus between MGB-OAGB and RYGB [6–8].

While MGB-OAGB has been rapidly gaining popularity among bariatric surgeons in the Asia Pacific region and Europe, it is still relatively uncommon in the USA. Approximately 4.8% of the over 685,000 bariatric procedures performed worldwide annually consisted of MGB-OAGB [6, 7]. One of the main concerns bariatric surgeons harbored towards MGB-OAGB was its poorly defined long-term outcomes. Due to a lack of an isolated biliopancreatic limb in MGB-OAGB, surgeons have theorized that patients would be more likely to experience intractable bile reflux as well as marginal ulcers. The reported revision rate ranged from 2 to 5% in patients undergoing MGB-OAGB [9–11]. In this study, we aimed to conduct a comprehensive literature review on the indications, operative techniques, and outcomes of revisional surgery following MGB-OAGB.

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Materials and Methods

Data Source and Search Strategy

We performed a comprehensive literature review with regard to the reported indications and surgical techniques of revisional surgery following MGB-OAGB. A search strategy was designed and implemented to capture all relevant studies from available literature. The PubMed database was queried from January 1997 to April 2019. The search strategy consisted of search terms developed to capture a combination of two key concepts: "mini-gastric bypass (a.k.a. one-anastomosis, single anastomosis, or omega-loop gastric bypass)" and "revision or reversal." Each title/abstract citation was reviewed by at least two reviewers (U.K. and Y.J). Full-text articles for title/abstracts were marked as relevant, and the pre-determined inclusion/exclusion criteria were applied to the resulting list of full-text articles. Studies were finalized for inclusion in the review following discussion with a third reviewer (E.D.). We used Mendeley (Elsevier; Amsterdam, Netherlands) to organize citations.

Article Eligibility and Selection Criteria

To be included in the current review, studies had to meet several inclusion criteria. Only original research reports in the English language, including both full publication and conference abstracts, were eligible for inclusion. Studies must pertain to patients that have undergone MGB-OAGB. For studies describing revisional operations, the type of revisional operation performed and their intraoperative and postoperative complications must be described. We excluded studies that did not include patients who had revisional operation following MGB-OAGB or did not describe revisional operative techniques.

Data Synthesis

Two reviewers independently extracted the following data from the included studies: authors, year, sample size, revisional operative technique, indication for revision, revisional surgical approach, operative time, length of stay, follow-up duration, intraoperative, and postoperative complications. A descriptive synthesis of incidence, indications, and operative techniques was performed. In addition, specific technical pearls described in case reports were cited.

Due to the use of secondary data and lack of identifiable patient information, the current reviewer was deemed exempt from the institutional review board (IRB) review.

Results

Summary of Included Studies

A total of 140 studies were retrieved from database searches. After title and abstract screening, 28 remained for full-text evaluation, among which 17 studies were included for systematic review, encompassing a total of 179 patients. The other studies were excluded for the following reasons: duplicates (n = 43), did not pertain to revisional surgeries following MGB-OAGB (n = 65), represented reviews of previously published data (n = 4). The study selection process was summarized in a PRISMA flowchart (see Fig. 1) [12].

All included studies were either case reports or case series, with sample sizes ranging between 1 and 42 patients. Sixteen studies (94.1%) were from teaching hospital and one from non-teaching hospital (5.9%). The majority of studies were from hospitals in Europe (11/17, 64.7%), followed by Asia (3/17, 17.6%), Middle East (2/17, 11.8%), and North America (1/17, 5.9%). The characteristics of the included studies were summarized in Table 1.

Of the 179 patients, 89 patients underwent revisional surgery to Roux-en-Y gastric bypass (RYGB); 52 to sleeve gastrectomy (SG); 32 reversal to original anatomy; and 6 underwent partial revision with gastro-gastrostomy alone. Reported revisional surgical approaches were mostly laparoscopic (176 out of 179 included patients, 98.3%), with only one robotic procedure, one open operation, and one endoscopic approach being reported. Severe malnutrition (26%) and chronic bile reflux (25%) were the most common indications for revision, followed by intractable marginal ulcerations (7%) and insufficient weight loss (7%). Indications for revisional operations following MGB-OAGB are tabulated in Table 2.

Operative Techniques for Revisional Operations Following MGB-OAGB

Revision to RYGB

Revision to RYGB was the most commonly performed revisional operation following failure or complication after MGB-OAGB due to its ability to maintain weight loss and ameliorate bile reflux and marginal ulceration by diverting the biliopancreatic contents away from the gastrojejunostomy (GJ) anastomosis. The most common indication, reported in 11 studies, was bile reflux, accounting for 43.4% of included cases, followed by intractable marginal ulcerations (13.2%).

According to Lee et al. [11], the surgery involved two primary steps. First, the afferent limb of the MGB-OAGB was divided proximal to the gastrojejunostomy (GJ) anastomosis. Second, the afferent limb was then moved downstream along the efferent limb, now becoming the Roux limb, for a predetermined length, before being re-connected with a

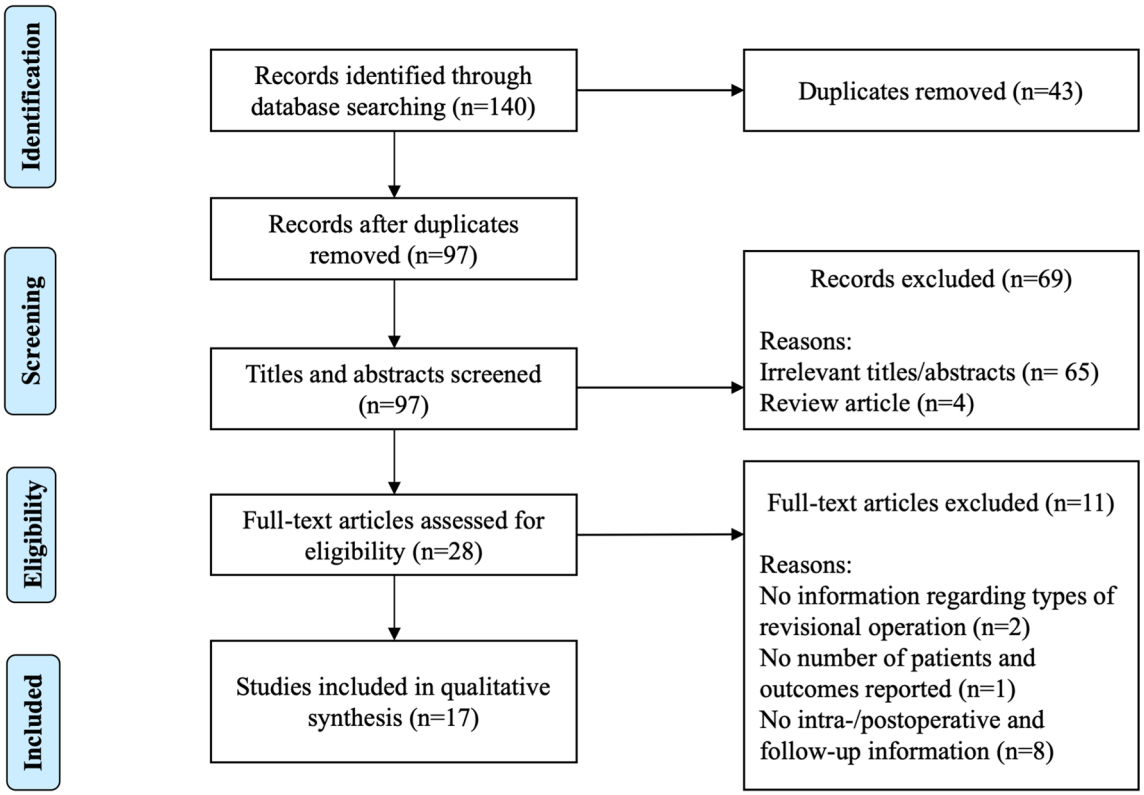

Fig. 1 PRISMA flowchart. PRISMA flowchart demonstrating the study selection process

jejunojejunostomy (JJ) anastomosis (Fig. 2e). The Roux limb length for patients with insufficient weight loss was 150 cm and for patients with bile reflux was 50 cm. The mean body mass index (BMI) decrease was 3 kg/m^2 in those with insufficient weight loss, at 24-month follow-up. In their study, conversion to RYGB was found to have less estimated blood loss, shorter length of hospital stays; and shorter operative time compared with revision to SG.

Bolckmans et al. [10] described three different techniques of conversion to RYGB in their retrospective study of 27 patients. The first technique, like in the Lee study [11], involved a conversion to RYGB by dividing the biliopancreatic limb proximal to the GJ anastomosis (Fig. 2e). The second technique involved division of the GJ anastomosis separating the jejunum form the gastric pouch using a linear endostapler. The gastric pouch was then shortened with the intention of decreasing pouch volume and potentially decreasing acid producing gastric mucosa (Fig. 2f). The third technique involved removal of the entire GJ anastomosis by transection of the jejunal loop and the distal pouch, followed by recreation of the GJ anastomosis (Fig. 2g). According to Bolckman et al., complication rates were higher in the emergency conversion group compared with the elective conversion group (50% (4/8) versus 5% (1/20), $p < 0.01$). At the mean follow-up interval of 64.5 ± 30.1 months, the majority of patients with bile reflux, afferent loop syndrome, and marginal ulcers reported improvement in symptoms.

Poghosyan et al. [13] reported a total of 17 patients undergoing revision to RYGB. They described their technique of resecting the distal portion of the gastric pouch as well as the GJ anastomosis with linear staplers, similar to the third technique described in the study by Bolckmans et al. [10]. However, they used a circular stapler to create the new GJ anastomosis. The roux limb was 150 cm in length. Following the revisional operations, patients experienced improvement in hypoalbuminemia and anemia as well as gradually improved their underweight BMI.

Chevallier et al. [14] reported 9 cases of revision to RYGB in their case series of 1000 patients undergoing MGB-OAGB. The authors described resection of the GJ anastomosis with shortening of the gastric pouch with a biliopancreatic limb length of 1.5 m (Fig. 2g). Patients were able to maintain their weight loss and experienced improvement in bile reflux symptoms. Apers et al. [15] also reported 14 patients who required revision to RYGB in their retrospective study of 287 patients who underwent MGB-OAGB. Several case reports and case series again corroborated the technical feasibility of revision to RYGB with no intraoperative or postoperative complications [16–22] (Table 1).

Revision to the Original Anatomy

The second most commonly described option for revisional operation following MGB-OAGB was reversal to original

Table 1 Revisional operations following mini-gastric bypass-one anastomosis gastric bypass

Authors	Year	*N*	Revision to	Primary indication	Approach	Removal of GJ with a portion of the jejunal loop	OR time (min)	LOS (days)	Intra-op complications	Major postop complications	F/U (months)	F/U outcomes
Dang et al. [17]	2009	1	RYGB	Severe malnutrition	Laparoscopic	No	n/a	4	No	No	6	Nutrition improved; serum albumin normalized
Lee et al. [11]	2011	23	11 RYGB; 10 SG; 2 original anatomy	Inadequate weight loss, malnutrition	Laparoscopic	No	RYGB 119 ± 44; SG 156 ± 42	RYGB 4.6 ± 1.6; SG 10.6 ± 9.4	No	No	24	BMI decreased 3 points in RYGB group; malnutrition improved in SG
Kassir et al. [20]	2015	1	RYGB	Afferent Loop Syndrome	Laparoscopic	No	120	n/a	No	No	3	Symptom resolved
Chevallier et al. [14]	2015	9	RYGB	7 biliary reflux; 2 Marginal ulcer	Laparoscopic	Resected, side-to-side JJ anastomosis	n/a	n/a	No	No	n/a	Bile reflux improved
Facchiano et al. [19]	2016	1	RYGB	Chronic bile reflux	Laparoscopic	No	50	4	No	No	3	Bile reflux improved
Chen et al. [4]	2016	42	SG	Severe malnutrition, anemia	Laparoscopic	No	173.6 ± 40.3	6.3 ± 5.5	No	Yes, 3 GG leaks; 1 internal bleeding	12 to 36	Malnutrition and anemia improved
Parmar et al. [22]	2016	1	RYGB	Perforated marginal ulcer	Open	n/a	n/a	n/a	No	No	n/a	Doing well
Reche et al. [25]	2016	1	Original anatomy	Severe malnutrition	Robotic	Resected, side-to-side JJ anastomosis	232	8	No	No	1	Nutrition improved
Genser et al. [23]	2017	26	Original anatomy	Severe malnutrition	Laparoscopic	First group: 14 cases did not resect GJ site; second group: 12 cases, resected GJ site, end-to-end JJ anastomosis	109.9 ± 25.2	8 ± 4.9	No	Yes, overall GG leak was 7.7%; overall GG stenosis was 3.8%. First group (7/14): 2 GG leaks; 1 GG stenosis; 1 leak at previous GJ site; 3 jejunal stenosis at previous GJ site. Second group (1/12): hematoma on the gastric wall	8 ± 9.7	BMI increased 3 points; serum albumin normalized
Amor et al. [16]	2017	1	RYGB	Chronic bile reflux	Laparoscopic	Resected, side-to-side JJ anastomosis	n/a	n/a	No	No	n/a	n/a
Poghosyan et al. [13]	2017	17	RYGB	Malnutrition, bile reflux	Laparoscopic	Resected, entero-enteric anastomosis	n/a	16 ± 17	No	Yes, 6 (35.2%) < 90 days: 3 bleeding at JJ, 1 GJ leak, 1 iatrogenic esophageal perforation, and 1 deep abscess.	23 ± 18	BMI increased 3 points in malnourished patients; digestive symptoms improved

Table 1 (continued)

Authors	Year	*N*	Revision to	Primary indication	Approach	Removal of GJ with a portion of the jejunal loop	OR time (min)	LOS (days)	Intra-op complications	Major postop complications	F/U (months)	F/U outcomes
Nimeri et al. [21]	2017	1	RYGB	Bile reflux	Laparoscopic	Resected, side-to-side JJ anastomosis	n/a	n/a	No	No	12	Bile reflux resolved
Apers et al. [15]	2018	15	1 to original anatomy; 14 to RYGB	1 (to normal anatomy) severe hypoglycemia; 6 bile reflux; 8 other (5 postprandial pain; 1 insufficient weight loss)	Laparoscopic	n/a	n/a	n/a	No	n/a	n/a	n/a
Bolckmans et al. [10]	2018	28	RYGB	Leaks, bile reflux, afferent loop syndrome	Laparoscopic	3 approaches: division of the afferent limb proximal to GJ in 18 cases; separation of GJ anastomosis in 4; resection of anastomosis in 6	n/a	4.7 ± 1.9; (33.4 ± 24.3 in 5 patients with postop complications)	No	5/28 (17.9%) grade III or more: 5% (1/20), abscess in elective setting; 50.0%(4/8), all persisting leaks in urgent setting	64.5 ± 30.1 months in 26 patients (92.9%)	Symptoms improved in bile reflux and afferent loop syndrome
Eilenberg et al. [18]	2018	4	RYGB	Ascites, elevated liver enzymes, hepato--splenomegaly	Laparoscopic	n/a	n/a	n/a	No	No	n/a	Symptoms stabilized; imaging and laboratory parameters improved
Khalaj et al. [24]	2019	7	2 reversal to original anatomy; 5 partial reversal with GG	Severe malnutrition	Laparoscopic	n/a	n/a	n/a	No	Yes, 1 expired due to severe liver failure after underwent GG	2	Weight regained in 5 patients with GG
Chang et al. [26]	2019	1	Partial reversal	Severe malnutrition	Endoscopic (lumen--apposing metal stent was inserted to create GG anastomosis.)	No	60	n/a	No	No	3	Increased in serum albumin; weight regained

Total *N* = 179 (89 to RYGB; 52 to SG; 32 to original anatomy; 6 GG)

N number of patients, *OR time* operative time, *LOS* length of hospital stay, *F/U* follow-up, *RYGB* Roux-en-Y gastric bypass, *SG* sleeve gastrectomy, *GJ* gastrojejunostomy, *JJ* jejunojejunostomy, *GG* gastrogastroctomy, *n/a* no data available

Table 2 Indication for revision following mini-gastric bypass-one anastomosis gastric bypass

Indication for revision after MGB	Number of patients (%)
Severe malnutrition	46 (26%)
Chronic bile reflux	45 (25%)
Intractable marginal ulceration	13 (7%)
Insufficient weight loss	12 (7%)
Anemia	11 (6%)
Intolerance/postprandial pain	11 (6%)
Early postoperative complications (anastomotic leaks or bleeding)	8 (4%)
Afferent loop syndrome	7 (4%)
Gastrojejunal anastomotic stenosis	5 (3%)
Liver-related morbidity (ascites, elevated liver enzymes)	4 (2%)
Hypoglycemia	3 (2%)
Perforated marginal ulcers	2 (1%)
Others (diarrhea, gastrojejunal fistula, gastric remnant perforation, internal herniation)	12 (7%)

anatomy, being reported in 5 of the 17 included studies. The most common indication (54.8%) was severe malnutrition, followed by bile reflux (29.0%). Reversal to original anatomy following MGB-OAGB was considered a technically more challenging option, involving two primary steps: (1) re-establishment of continuity between gastric pouch and remnant stomach via gastro-gastrostomy (GG) and (2) reversal of prior established GJ.

Genser et al. [23] had reported the largest case series (n = 26) of this surgical technique. To restore the original gastric anatomy, a linear endostapler was used to create GG anastomosis. For the first 14 patients, they divided the prior GJ anastomosis separating the jejunum from the pouch without resection (Fig. 2a). However, this resulted in a 50% morbidity rate with 21% of these patients experiencing jejunal stenosis at the previous GJ anastomosis. Subsequently, they elected to resect the GJ anastomosis site and create an end-to-end jejunojejunostomy in their next 12 patients (Fig. 2b) and were able to reduce the stenosis rate to 8.3%. Patients reported a 3-point increase in mean BMI as well as improved serum albumin from 2.5 ± 0.4 g/dL to normal level at a mean follow-up period of 8 ± 9.7 months.

Revision to original anatomy has also been reported by Reche et al., Apers et al., and Khalaj et al. [15, 24, 25] (Table 1). Of note, Reche et al. [25] reported utilizing the robotic platform for this procedure. The authors theorized that the advantages of the robotic platform, including three-dimensional visualization, greater degrees of freedom of the instruments, and stability of the camera, may allow surgeons additional benefits in overcoming the technical challenges afforded by this revisional surgery. However, they reported an operative time of 232 min, significantly longer than reports of laparoscopic procedures by all other included reports.

Revision to Sleeve Gastrectomy

Conversion to SG was most frequently performed for those who experienced severe protein-calorie malnutrition but wished to maintain weight loss following revisional procedure. In addition, this revision could be performed as the first part of a staged procedure if a future duodenal switch was planned. Conversion to SG was described in 2 of the 17 included studies. The most common indications for revision to SG included severe malnutrition (28.6%) and anemia (26.2%).

Lee et al. [11] reported their experience of this procedure in ten patients with severe malnourishment following MGB-OAGB. The operation entailed horizontally dividing the GJ anastomosis on the antimesenteric side of the jejunum using an endostapler without compromising the jejunal loop, and then creating a GG anastomosis between the proximal gastric pouch and the antrum of the gastric remnant with a hand-sewn technique, followed by creating a new sleeve using linear endostaplers (Fig. 2c). The patients experienced improvement in nutritional status, including increases in serum albumin from 3.4 ± 0.3 to 4.0 ± 0.4 g/dL and calcium level from 8.4 ± 1.2 to 8.8 ± 2.1 mg/dL, without increases in body weight. Mean BMI before revision was 25.1 ± 4.8 and after revision was 24.4 ± 3.5 kg/m^2 at 2-year follow-up.

Chen et al. [4]. reported their case series of 42 patients who underwent revisional surgery following MGB-OAGB with a similar technique (Fig. 2c). Following conversion to SG, patients were found to have an increase in mean hemoglobin level from 10.7 ± 1.9 to 12.9 ± 1.4 g/dl at 3-year follow-up. Additional metabolic improvement was seen in secondary hyperparathyroidism and calcium absorption. Interestingly, the cholesterol levels were also found to be increased following revision as well as mean BMI from 25.3 ± 5.6 to 27.1 ± 6.8 kg/m^2 at 3-year follow-up.

Gastro-gastrostomy Alone

Khalaj et al. [24] reported 5 cases that underwent laparoscopic partial reversal with gastro-gastrostomy alone due to protein-calorie malnutrition in their prospective case series of patients who underwent MGB-OAGB. A GG anastomosis was created between the gastric pouch and the remnant stomach. Four patients reported weight regain after revision with improvement in hypoalbuminemia and anemia at 2-month follow-up. However, no data regarding late complications including marginal ulceration was reported during their study period.

Chang et al. [26] had demonstrated the feasibility of endoscopic partial reversal of MGB-OAGB by creating a GG anastomosis with the insertion of a lumen-apposing metal stent. This endoscopic technique was performed in a patient who experienced severe malnutrition requiring enteral feeding through a gastrostomy tube. The procedure was performed under visual guidance of endoscopic ultrasound. The endoscope was inserted transorally into the gastric pouch. Simultaneously, a pediatric endoscope was inserted through the feeding gastrostomy to the remnant stomach for verification of the GG site. At 2-month post-procedure, the patient endorsed 4-kg weight regain and contrast studies showed free contrast passage through the stent at 3-month follow-up. However, due to a short follow-up interval, no late complication was reported in their study.

Overall Morbidity and Mortality

No intraoperative complication was reported in any of the included studies. Of the 179 patients, 21 patients (11.7%) experienced major postoperative complications. The overall morbidity rate of revision to RYGB was 13.5% (12/89), while revision to SG was 7.8% (4/52), and revision to original anatomy was 15.6% (5/32). No mortality attributable to the revisional surgery was reported; however, there was one patient with underlying liver disease who expired after partial revision with creation of GG anastomosis due to profound liver failure. The intraoperative and postoperative complications are tabulated in Table 1.

Discussion

Our comprehensive review of 17 studies and 179 patients who underwent revisional surgery after MGB-OAGB showed that the most commonly employed surgical technique was revision to RYGB, followed by revision to SG, original anatomy, and gastro-gastrostomy alone. The most common indications for revision following MGB-OAGB were intractable malnutrition and bile reflux. The choice of revisional surgery type appeared to depend on both indication and institutional preference. The overall morbidity rate was 11.7% and no mortality was reported.

Revisional surgery after MGB-OAGB, just like revisional surgery after other bariatric procedures, was technically feasible but associated with considerable morbidities. Revision of MGB-OAGB has the technical advantage of involving only one anastomosis instead of two, which makes revisional operations less complex. The complication rates reported in this review were within range of those reported for revisional surgeries following other bariatric procedures, which could be as high as 32% [27]. Although the overall morbidity rates of conversion following MGB-OAGB were lower in this review than historical literature on gastric bypass [27, 28], we were unable to draw a conclusion that revision of MGB-OAGB was safer than revision of RYGB due to the low quality of evidence available at this moment.

The choice of revisional surgery following MGB-OAGB largely depended on the indication for revision. Revision to RYGB may be necessary in patients with severe bile reflux who had failed medical management or those with intractable marginal ulceration, as the majority of patients reported improved in symptoms. Although revision to RYGB following MGB-OAGB was technically simpler compared with revision to SG or normal anatomy, this operation should be avoided in those with severe malnutrition due to the risk of further malabsorption posed by the remaining bypassed biliopancreatic limb. Moreover, prior to revision, it is important to know the measurement of all three limbs before deciding whether the GJ anastomosis needs to be relocated, versus simply creating the enteroenterostomy to form the "Y" of the Roux-en-Y. A simple addition of an enteroenterostomy may cause or exacerbate malnutrition if the limb lengths are unknown. Instead, reversal to original anatomy has been shown to be beneficial in terms of weight regain [29]. However, reversal to original anatomy following MGB-OAGB can be technically challenging and was associated with an increased risk of GG anastomotic leak and stenosis. Similar to revision to SG, the potential of leakage at the GG anastomosis and a long staple line also posed concerns for postoperative complications.

One area of specific concern following MGB-OAGB revision was the potential for jejunal stenosis at the previous GJ site. Genser et al. [23] reported increased risk of jejunal stenosis following horizontal division of the GJ anastomosis without resection of the jejunal loop. They found that this could be ameliorated with resection of the jejunal section at risk and performing a primary anastomosis of the two resected ends. However, Lee et al. [11] and Chen et al. [4] both reported safe completion of this technique without compromising the lumen of the jejunum during follow-up. Although there had been no studies reporting resection of GJ anastomosis along with a portion of the jejunal loop during revision to SG (Fig. 2d), this technique may potentially reduce the risk of

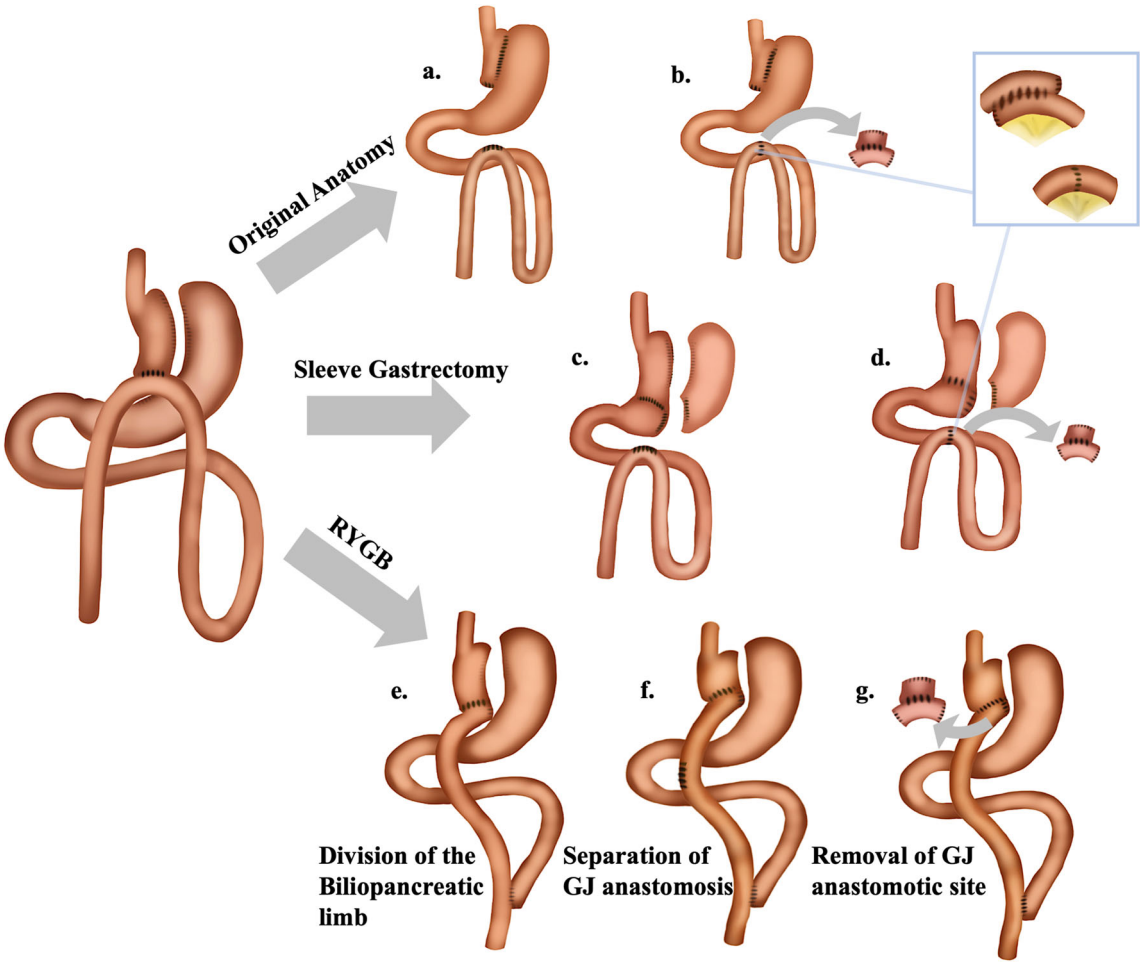

Fig. 2 Revisional operative techniques following mini-gastric bypass-one anastomosis gastric bypass. Illustration demonstrates three main revisional operations following mini-gastric bypass-one anastomosis gastric bypass (MGB-OAGB). In revision to original anatomy (**a**, **b**), gastro-gastrostomy (GG) anastomosis is created between the gastric pouch and the remnant stomach. In the first technique (**a**), the gastrojejunostomy (GJ) anastomosis is separated, and the jejunal loop is maintained. In the second technique (**b**), the GJ anastomotic site is completely resected, and an end-to-end jejunojejunostomy (JJ) anastomosis is created. In conversion to sleeve gastrectomy (**c**, **d**), GG anastomosis between the proximal gastric pouch and the antrum of the gastric remnant is created, followed by removal of the fundus and body. The GJ anastomosis can be separated (**c**) or completely resected (**d**). In conversion to Roux-en-Y gastric bypass (RYGB) without removal of the GJ anastomosis (**e**), the biliopancreatic limb is divided proximal to the GJ anastomosis, followed by creating a side-to-side enteroenteral anastomosis between the transected biliopancreatic limb and common limb. In the second technique (**f**), a distal portion of the gastric pouch is resected while separating the GJ anastomosis and the jejunal loop is maintained. In the third technique (**g**), the GJ anastomotic site is completely resected with the transection of the jejunal loop, followed by recreating GJ anastomosis

jejunal stenosis in a similar fashion as in revision to original anatomy with either end-to-end or side-to-side JJ anastomosis.

In view of the technical difficulty and the high complication rates associated with emergent operation, partial reversal with gastro-gastrostomy has been reported as an alternative option for malnourished patients who were not eligible or did not desire a complex revisional operation. With advances in endoscopic devices, endoscopic bariatric procedures have been shown as a less invasive alternative to surgery [30]. However, data regarding the long-term efficacy and safety profile of these investigational procedures is still pending.

Limitations

One of the primary limitations of the current review was the paucity of high-quality evidence regarding the subject matter in the literature. The majority of evidence consisted of single-institute case series and case reports. Due to the complexity of revisional surgeries, significant heterogeneity in patient characteristics and surgical indications existed within the included cohort. Several studies that reported only the number of patients that underwent revision after MGB-OAGB had been excluded from this review due to incomplete details regarding the surgical techniques and outcomes. Moreover, there was a lack of consistency in measurement of outcomes and

effectiveness following revisions as well as the definition of complications and follow-up duration among included studies.

Conclusions

The most common indications for revision following MGB-OAGB include intractable malnutrition, bile reflux, and marginal ulceration. Revision to RYGB was the most common operative technique performed, while other surgeons have reported success with revision to original anatomy as well as sleeve gastrectomy. Revisional surgery following MGB-OAGB appears to carry an acceptable risk profile with an overall complication rate ranging between 5 and 35%. However, due to a scarcity of high-quality evidence and the outcomes reported, it is still questionable whether the complication rates of revisional operations following MGB-OAGB are comparable with other revisional bariatric procedures. Further longitudinal prospective studies are encouraged.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

This article does not contain any studies with human participants or animals performed by any of the authors.

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