Revisional surgeries after failed restrictive bariatric operations: a meta-analysis

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Introduction
Recently laparoscopic sleeve gastrectomy has gained increased popularity both as a primary operation for weight reduction and as a revisional procedure after failed restrictive bariatric surgery. On the contrary, the conversion to laparoscopic Roux-en-Y gastric bypass is a solution with some drawbacks such as long operative time and higher complication rates.
Aim
To find an evidence of BMI reduction and/or less surgical complications following revisional surgeries (laparoscopic Roux-en-Y gastric bypass, mini gastric bypass-one-anastomosis gastric bypass, and laparoscopic sleeve gastrectomy) after failed restrictive bariatric surgeries (vertical banded gastroplasty or laparoscopic adjustable gastric banding).
Patients and methods
A retrospective observational secondary study was performed on published research and meta-analysis for each eligible study according to inclusion and exclusion criteria.
Results
The 24-, 36-, and 48-month postoperative extra weight loss percentage was lower in sleeve gastrectomy than gastric bypasses, with overall significantly better decrease. Conversely, when comparing RYGB with mini gastric bypass at 12 months after conversion, there was more extra weight loss percentage for RYGB, with significant overall difference.
Conclusion
Our meta-analysis showed that both sleeve gastrectomy and gastric bypasses as revisional operations had no significant difference regarding postoperative leakage and major bleeding.

Keywords:
gastric bypass, restrictive bariatric surgeries, revisional surgeries

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Introduction

Obesity is a rising epidemic, and bariatric surgery continues to be the main therapeutic mode for a high rate of sustainable weight loss [1]. Gastric restrictive procedures, or gastroplasties, were then developed because it was considered that reduction of the size of the stomach would lead to an earlier sensation of satiety. These operations included horizontal gastroplasty, vertical banded gastroplasty (VBG), and laparoscopic adjustable gastric banding (LAGB) [2].

The main problem after VBG is that patients experience recurrence of their obesity. Overall, 55% of patients undergoing VBG have ultimately undergone revisional surgery [3] because of inadequate weight loss secondary to gastrogastric fistula or gastric motility problems from gastric outlet obstruction. Historically, the majority of patients with inadequate weight loss were converted to RYGBP [4].

There are available options to manage the complications of LAGB, including band removal without replacement and band revision, which are associated with poor outcomes [5]. Conversion to an alternative bariatric procedure is another option such as laparoscopic sleeve gastrectomy (LSG), mini gastric bypass-one anastomosis gastric bypass (MGB-OAGB), and laparoscopic Roux-en-Y gastric bypasses (LRYGB), which have been proposed as the main operations of choice [6].

Recently, LSG has gained increased popularity both as a primary operation for weight reduction [7] and as a revisional procedure after failed restrictive bariatric surgery [8]. On the contrary, the conversion to

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LRYGB is a solution with some drawbacks such as long operative time and higher complication rates [9].

Patients and methods

Study design

A retrospective observational secondary study of published research and meta-analysis was done. The protocol was approved by the faculty of Medicine-Helwan University- Research ethics review committee at 25/4/2020 with serial number 27/2020.

Search Strategy and Articles Selection (Table 2):

Literature search was performed through PubMed (Medline), Google scholar, Embase (ELSEVIER), Science Direct (ELSEVIER), and Egyptian Knowledge Bank (EKL) databases using the following terms in every possible combination of keywords:

(1) Failed adjustable gastric banding, LAGB [OR].
(2) Failed VBG [OR].
(3) Failed sleeve gastrectomy, LSG [AND].
(4) Revisional [OR] conversion [AND].
(5) RYGB [OR].
(6) (5) Sleeve gastrectomy, SG [OR].
(7) MGB-OAGB.

The PubMed search yielded 230 studies; 146 studies were relevant by abstract. However, only 29 studies were included according to inclusion criteria. Searching through Google Scholar revealed 263 studies, and 21 studies were checked by abstract; however, finally only three studies were included after removing the duplicates. Embase, Science Direct, and EKL yielded 45, 41, and 49 studies, respectively, with only two papers finally included according to inclusion criteria (one for Embase and another for EKL). The detailed search results are illustrated in Table 1.

Table 1 Search results through different databases

Literature searched	Total number of revealed studies	Number of studies (by abstract)	Number of final included/relevant studies
PubMed	230	146	29
Google Scholar	263	21	3
Embase	45	2	1
Science Direct	41	1	–
EKL	49	1	1
Total	628	171	34

Inclusion criteria

Original articles fulfilled the following criteria for inclusion:

(1) Written in the English language.
(2) Published from 2009 to 2020.
(3) Conducted on human participants.
(4) Follow-up duration of 6, 12, to 48 months.
(5) Reporting outcomes of LRYGB or LSG performed after failed restrictive bariatric surgeries on obese patients.
(6) Outcomes
    (a) Primary outcomes: decreased BMI, and extra weight loss percentage (% EWL) [(preoperative weight−current weight)/(preoperative weight−ideal weight)×100] [10].
    (b) Secondary outcomes: surgical complications, length of hospital stay, and operation time.

Exclusion criteria

The following were the exclusion criteria:

(1) Follow-up duration less than 6 months.
(2) Studies written in languages other than English.

Evaluation of articles

The articles were evaluated for the following:

(1) Relevancy.
(2) Quality of journals through the following:
    (a) Impact factor: the impact factor is calculated by dividing the number of citations in the journal citation records in year by the total number of articles published in the two previous years. An impact factor of 1.0 means that, on average, the articles published 1 or 2 years ago have been cited one time.
    (b) Scopus quartile: a quartile in Scopus is a category of scientific journals that show their credibility. The quartile reflects the demand for the journal by the scientific community. Accordingly, there are the least and most cited journals. Q_1 means highly demandable journal.
    (c) SCImago Journal Ranking (SJR): Scopus journal metrics use advanced rating systems for both authors and publications, in particular, an indicator such as SJR. SJR is a much more difficult indicator than the impact factor, which takes into account (along with citation) the degree of authority of the journals referring to a given journal, as well as the proximity of their topics.

Table 2 Study characteristics

	Study	No RYGB	No MGB	No SG	Study design	Country	Duration		Conversion	
							From	To	From	To
LAGB studies (24 studies)										
1	Bhaskar *et al*. [12]	15	–	26	Retrospective	India	2007	2010	LAGB	RYGB and SG
2	Abu-ghazla *et al* [13]	18	–	18	Retrospective	Israel	2006	2010	LAGB	RYGB and SG
3	Tran *et al*. [14]	53	–	8	Retrospective	USA	2006	2013	LAGB	RYGB and SG
4	Shimizu *et al*. [15]	9	–	2	Retrospective	USA	2004	2011	LAGB and VBG and SG	RYGB and SG
5	Moon *et al*. [16]	41	–	13	Retrospective	USA	2008	2012	LAGB	RYGB and SG
6	Khoursheed *et al*. [17]	53	–	42	Retrospective	Kuwait	2005	2012	LAGB	RYGB and SG
7	Marin-Perez *et al*. [18]	39	–	20	Prospective	USA	2005	2012	LAGB	RYGB and SG
8	Stefanidis *et al*. [19]	25	–	23	Prospective	USA	2005	2013	LAGB	RYGB and SG
9	Carr *et al*. [20]	64	–	*25*	Retrospective	UK	2006	2012	LAGB	RYGB and SG
10	Carandina *et al*. [21]	74	–	34	Retrospective	France	2007	2012	LAGB	RYGB and SG
11	Gonzalez-Heredia *et al*. [22]	12	–	26	Retrospective	USA	2008	2014	LAGB	RYGB and SG
12	Castro *et al*. [23]	71	–	17	Retrospective	Portugal	2007	2014	LAGB	RYGB and SG
13	Angrisani *et al*. [24]	24	–	27	Retrospective	Italy	2007	2011	LAGB	RYGB and SG
14	Ngiam *et al*. [25]	9	–	9	Prospective	Singapore	2003	2013	LAGB	RYGB and SG
15	Yeung *et al*. [26]	32	–	72	Retrospective	USA	2009	2014	LAGB	RYGB and SG
16	Pawan *et al*. [27]	9	26	17	Retrospective	Taiwan	2002	2011	LAGB	RYGB and SG and MGB
17	Janik *et al*. [28]	1354	–	1354	Prospective	USA	2015	2017	LAGB	RYGB and SG
18	Creange *et al*. [29]	192	–	283	Retrospective	USA	2003	2015	LAGB	RYGB and SG
19	Avsar *et al*. [30]	29	–	20	Prospective	Turkey	2012	2018	LAGB	RYGB and SG
20	Khan *et al*. [31]	113	–	28	Prospective	UK	2009	2014	LAGB	RYGB and SG
21	Rafols *et al*. [32]	905	191	123	Retrospective	Multicenter	2002	2017	LAGB	RYGB and SG and MGB
22	Almalki *et al*. [33]	35	81	–	Retrospective	Taiwan	2001	2015	LAGB and VBG	RYGB and MGB
23	Qiu *et al*. [34]	12	–	2	Retrospective	USA	2012	2015	LAGB and LSG	RYGB and SG
24	Janik *et al*. [35]	5043	–	9192	Retrospective	USA	2015	2018	LAGB	RYGB and SG
VBG studies (3 studies)										
25	Salama and Sabry *et al*. [4]	21	39	–	RCT	Egypt	2013	2015	VBG	RYGB and MGB
26	van Wezenbeek *et al*. [36]	115	–	16	Retrospective	Netherlands	2009	2015	VBG	RYGB and SG
27	Nevo *et al*. [37]	33	21	–	Retrospective	Israel	2008	2018	VBG	RYGB and MGB
LSG studies (7 studies)										
28	Alsabah *et al*. [38]	12	–	23	Retrospective	Kuwait	2009	2012	LSG	RYGB and SG
29	Yilmaz *et al*. [39]	9	–	23	Retrospective	Turkey	2009	2016	LSG	RYGB and SG
30	Qiu *et al*. [34]	4	–	1	Retrospective	USA	2012	2015	LAGB and LSG	RYGB and SG
31	Chiappetta *et al*. [40]	21	34	–	Retrospective	Germany	2014	2016	LSG	RYGB and MGB
32	Antonopulos *et al*. [41]	83	–	61	Retrospective	France	2010	2017	LSG	RYGB and SG
33	Poublon *et al*. [42]	306	185	–	Retrospective	Netherlands	2012	2017	LAGB and LSG	RYGB and MGB
34	Al-Sabah *et al*. [43]	46	–	38	Retrospective	Kuwait	2008	2019	LSG	RYGB and SG
	Sum	8881	577	11 543						

LAGB, laparoscopic adjustable gastric band; LSG, laparoscopic sleeve gastrectomy; MGB, mini gastric bypass; RCT, randomized clinical trial; RYGB, Roux-en-Y gastric bypass; SG, sleeve gasterectomy; VBG, vertical band gastroplasty.

Data extraction

For each eligible study, data were extracted by the researchers two times one week in between relative to the following:

(1) Number of patients.
(2) Mean age and/SD.
(3) Sex.
(4) Preoperative BMI.
(5) Time to revision of the primary operation.
(6) BMI after 6, 12, 24, 36, and 48 months.
(7) Perioperative parameters and outcomes:
   (a) Mean operative time.
   (b) Length of hospital stay.
   (c) Intraoperative and postoperative complications.
   (d) %EWL [(preoperative weight–current weight)/(preoperative weight–ideal weight)× 100] [10].

Current weight means the weight of patient at the time of assessment.

Statistical analysis

All data were analyzed using REVMAN software using the random effect model. In case of SD not reported in presence of range, it will be calculated by dividing range by 4 [11].

Duration

The study was performed for 1 year after approval of the research ethics committee.

Ethical consideration

The protocol was submitted for approval by the Faculty of Medicine, Helwan University, research ethics review committee.

Approval date and serial number

The protocol was approved from Faculty of Medicine, Helwan University, research ethics review committee at 25/4/2020 with serial number 27/2020.

Meta-analysis interpretation

(1) I^2 is the index to quantify the dispersion of effect sizes in a meta-analysis. I^2 values of 25, 50, and 75%, correspond to small, moderate, and large amounts of heterogeneity.

Overall effect: the *P* value from the *Z* test to examine whether the pooled estimate of effect is statistically significant.

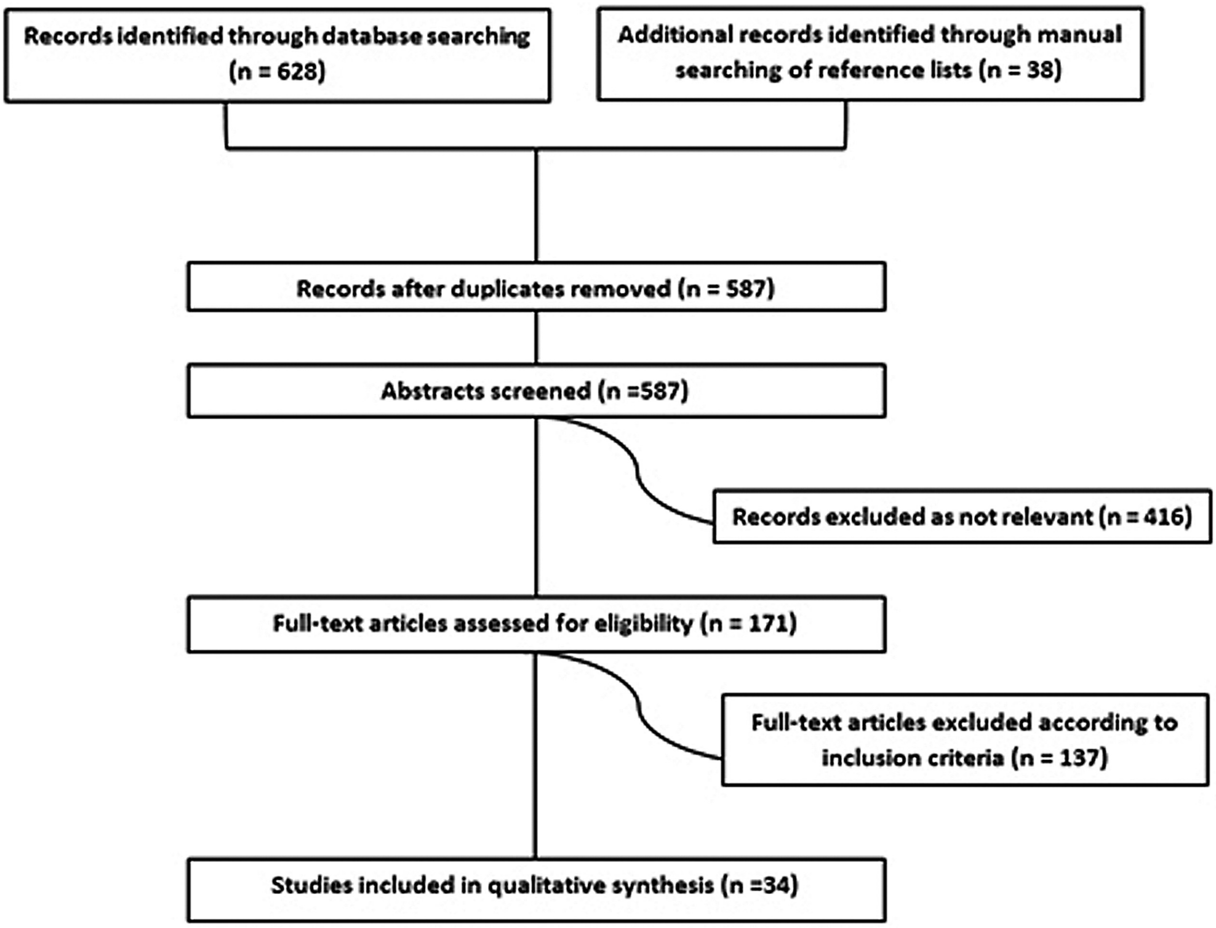
Results

As shown in Fig. 1, the search yielded 628 studies using the study keywords; however, 587 items were included after excluding duplicates. After scanning the title and/or abstract, 401 studies were eliminated or nonrelevant and 15 were eliminated because they were reviews, comments, or case reports (total equal 416 studies). After a full-length paper examination, 132 studies were eliminated, and five research studies were eliminated due to language issues (total equal 137 studies). Thus, 34 studies were finally included in the analysis.

Studies characteristics

The included studies comparing revisional bariatric procedures were 34 studies, involving 21 001 patients, where of 8881 cases underwent RYGB, 11 543 cases had LSG, and 577 cases underwent MGB. Major characteristics of included studies are shown in Table 2.

Figure 1

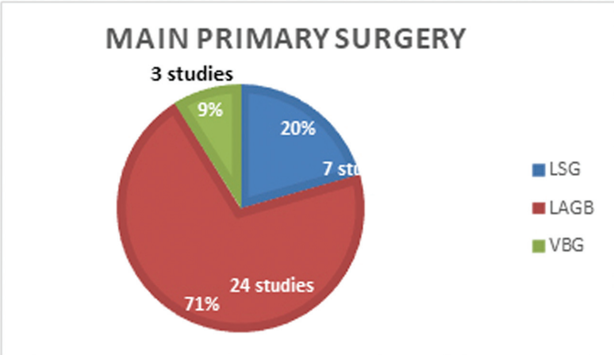


PRISMA flow diagram. LAGB, laparoscopic adjustable gastric band; LSG, laparoscopic sleeve gastrectomy; VBG, vertical band gastroplasty.

As shown in Fig. 2, the main primary bariatric procedures were represented by VBG in three studies, LAGB in 24 studies, and in seven studies, it was represented by LSG.

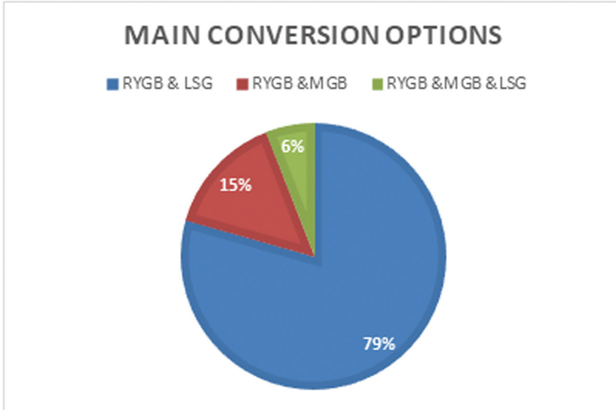
Regarding the main conversion surgical procedure (Fig. 3), comparison of RYGB with LSG was done in 27 studies, whereas comparison of RYGB with MGB was done in five studies, and RYGB was compared with MGB and LSG in just two papers.

Figure 2



Main primary operation in the included 34 studies. LSG, laparoscopic sleeve gastrectomy; MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass.

Figure 3



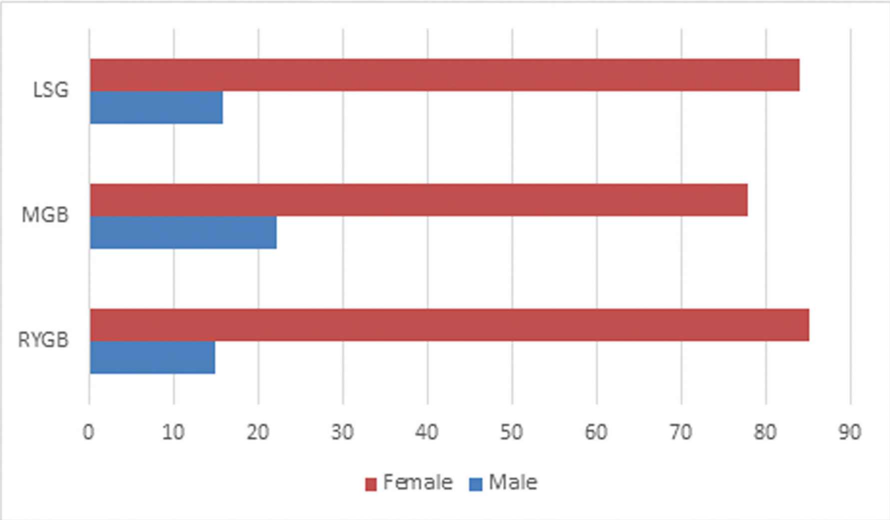
Main conversion options in the included 34 studies. LSG, laparoscopic sleeve gastrectomy; MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass.

Table 3 Different age groups of the included studies

		RYGB age		MGB age		SG age	
No	Study	Mean	SD	Mean	SD	Mean	SD
LAGB (17 studies)							
1	Bhaskar *et al*. [12]	38	8.5			32	13
2	Abu-ghazla *et al*. [13]	43.7	13.2			38.6	11.3
5	Moon *et al*. [16]	43.7	9.8			40.8	13
6	Khoursheed *et al*. [17]	39	8.3			35.6	10.4
7	Marin-Perez *et al*. [18]	49	14			44	17
8	Stefanidis *et al*. [19]	47.8				42	
9	Carr *et al*. [20]	47.7	10.01			49.8	10.65
10	Carandina *et al*. [21]	42.1	9.8			42.4	12.1
11	Gonzalez-Heredia *et al*. [22]	33.9	7.9			38.6	14.7
12	Castro *et al*. [23]	44.9	9.8			48.4	12.1
13	Angrisani *et al*. [24]	34.9	9.4			37.5	10.8
15	Yeung *et al*. [26]	50.7	–			44.9	–
16	Pawan *et al*. [27]	40.6	11.5	35.9	8.8	42.8	7.9
17	Janik *et al*. [35]	44.5	9.3			44.6	9.4
18	Creange *et al*. [29]	44.8	12.2			43.2	11.7
21	Rafols *et al*. [32]	37.2	10.1	40.6	11.2	41	11.4
24	Janik *et al*. [35]	48.65	10.78			48.27	10.84
	VBG (2 studies)						
26	van Wezenbeek *et al*. [36]	43	8.9			41.6	11.4
27	Nevo *et al*. [37]	50	8.4	43.2	12.1		
	LSG (5 studies)						
29	Yilmaz *et al*. [39]	37.3	9.1			36.1	12.2
31	Chiappetta *et al*. [40]	46.5	11.1	46.1	10.8		
32	Antonopulos *et al*. [41]	47	10			48	10.25
33	Poublon *et al*. [42]	48	9.6	46	9		
34	Al-Sabah *et al*. [43]	37	10.7			37.1	8.9
	Mean	43.33	4.92	42.36	3.82	41.77	4.59

LAGB, laparoscopic adjustable gastric band; LSG, laparoscopic sleeve gastrectomy; MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy; VBG, vertical band gastroplasty.

Figure 4



Sex distribution in the included studies.

Table 4 Different sex groups of the included studies

		RYGB		SG		MGB	
No	Study	Male	Female	Male	Female	Male	Female
LAGB (18 studies)							
1	Bhaskar *et al*. [12]	2	13	4	22	–	–
2	Abu-ghazla *et al*. [13]	8	10	4	14	–	–
5	Moon *et al*. [16]	5	49	4	37	–	–
6	Khoursheed *et al*. [17]	7	46	6	36	–	–
7	Marin-Perez *et al*. [18]	6	33	5	15	–	–
9	Carr *et al*. [20]	13	51	8	17	–	–
10	Carandina *et al*. [21]	5	69	3	31	–	–
12	Castro *et al*. [23]	7	64	5	12		
13	Angrisani *et al*. [24]	4	21	4	22	–	–
15	Yeung *et al*. [26]	19	13	15	57	–	–
16	Pawan *et al*. [27]	2	7	7	10	10	16
17	Janik *et al*. [35]	52	1302	52	1302	–	–
18	Creange *et al*. [29]	23	169	79	204	–	–
19	Avsar *et al*. [30]	40	96	39	97	–	–
21	Rafols *et al*. [32]	156	741	29	94	20	171
22	Almalki *et al*. [33]	12	23	0	0	21	60
24	Janik *et al*. [35]	730	4313	1566	7626		
VBG (3 studies)							
25	Salama and Sabry [4]	6	24			6	24
26	van Wezenbeek *et al*. [36]	9	96	3	13		
27	Nevo *et al*. [37]	9	24			5	16
LSG (5 studies)							
29	Yilmaz *et al*. [39]	3	6	8	15		
31	Chiappetta *et al*. [40]	2	19			11	23
32	Antonopulos *et al*. [41]	14	69	13	48		
33	Poublon *et al*. [42]	48	258	0	0	46	139
34	Al-Sabah *et al*. [43]	8	38	7	31		
	Sum	1190	7554	1861	9703	119	449

LAGB, laparoscopic adjustable gastric band; LSG, laparoscopic sleeve gastrectomy; MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy; VBG, vertical band gastroplasty.

The overall mean±SD age in the included studies (Table 3) was 43.33±4.92 years for patients who had RYGB, 42.36±3.82 years for MGB patients, and 41.77 ±4.59 years for LSG patients, with no significant difference (*P*>0.05) between the mean ages in each group (Table 3).

The average number of female patients (Fig. 4) was 7554 (85.06%) in RYGB patients, 9703 (84.06%) in LSG patients, and 449 (77.82%) in MGB patients, with no significant difference (*P*>0.05) between mean sex percentages in each group (Tables 4 and 5,).

In RYGB patients, the mean pre-revisional BMI (Table 6) was 41.59±7.11 kg/m^2, 42±3.55 kg/m^2 for LSG patients, and 38.58±11.48 kg/m^2 for MGB group, with a significant difference (Table 6) in the RYGB group (*P*<0.05) and no significant difference in other groups (*P*>0.05).

The average duration between the primary and conversion operations (Table 10) was 54.68±18.81 and 52.09±18.04 months for bypasses and LSG patients, respectively. There was no significant difference (Table 10) between the different conversion groups (*P*>0.05) (Tables 7–12).

Table 5 Univariate analysis of age

	F	Significance (*P* value)*
Age of RYGB group	0.411	0.668
Age of MGB group	5.586	0.152
Age of LSG group	0.140	0.870

LSG, laparoscopic sleeve gastrectomy; MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass. *One-way analysis of variance; significant if *P* value less than 0.05.

Table 6 Different preconversion BMI groups of the included studies

		Preconversion BMI in RYGB group		Preconversion BMI in SG group		Preconversion BMI in MGB group	
No	Study	Mean	SD	Mean	SD	Mean	SD
LAGB (22 studies)							
1	Bhaskar *et al*. [12]	38	4.65	36	5		
2	Abu-ghazla *et al.* [13]	41.6	5.3	40	9.6		
5	Moon *et al*. [16]	41.8	6.2	39	6.6		
6	Khoursheed *et al*. [17]	43.2		38.5			
7	Marin-Perez *et al*. [18]	42	6	39	6		
8	Stefanidis *et al*. [19]	40		39.7			
9	Carr *et al*. [20]	49.5	6.62	52.7	12.11		
10	Carandina *et al*. [21]	45.6	6.2	48.2	6.5		
11	Gonzalez-Heredia *et al*. [22]	44.6	13.6	48.6	12.8		
12	Castro *et al*. [23]	45.1	6.3	42.2	6.58		
13	Angrisani *et al*. [24]	43.2	4.8	39.7	8.4		
14	Ngiam *et al*. [25]	34.9	14.6	35.2	19		
15	Yeung *et al*. [26]	41.41		39.63			
16	Pawan *et al*. [27]	36.9	6.8	33.8	7.3	39.3	8.9
17	Janik *et al*. [28]	40.6	5.2	40.6	5.2		
18	Creange *et al*. [29]	44	7.2	43	7.6		
19	Avsar *et al*. [30]	45.1	8.6	41.4	5.8		
20	Khan *et al*. [31]	47.3	0.8	46.8	2.2		
21	Rafols *et al*. [32]	40.3	6.9	41.4	8.8	39.8	6.9
22	Almalki *et al*. [33]	37.1	8.4			37.8	9.6
23	Qiu *et al*. [34]	42.5		52			
24	Janik *et al*. [35]	43.35	6.81	42.03	6.85		
VBG (2 studies)							
25	Salama and Sabry [4]	26.5	39.79			26.5	39.79
27	Nevo *et al*. [37]	41.4	7.8			39.7	5.9
LSG (6 studies)							
28	Alsabah *et al*. [38]	48.3		42			
30	Qiu *et al*. [34]	42.3		46			
31	Chiappetta *et al*. [40]	36.6	6.9			45.7	8
32	Antonopulos *et al*. [41]	41.7	10.22	40.5	6.08		
33	Poublon *et al*. [42]	40.2	4			40.9	4.5
34	Al-Sabah *et al*. [43]	42.67	6.85	42	6		
	Mean	41.59	7.11	42	3.55	38.58	11.48

LAGB, laparoscopic adjustable gastric band; LSG, laparoscopic sleeve gastrectomy; MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy; VBG, vertical band gastroplasty.

Table 7 Different time (months) to conversion groups of the included studies

		RYGB		SG	
No	Study	Mean	SD	Mean	SD
LAGB (7 studies)					
1	Bhaskar *et al*. [12]	34	20	36	20
5	Moon *et al*. [16]	30.6	13.1	39.5	13.7
7	Marin-Perez *et al*. [18]	50	35	31	23
10	Carandina *et al*. [21]	82.5	40.5	76.2	61.5
11	Gonzalez-Heredia *et al*. [22]	73.32	27.9	59.7	27.9
13	Angrisani *et al*. [24]	82.5	36.8	75.7	42.3
15	Yeung *et al*. [26]	63.6		72	
VBG (one study)					
26	van Wezenbeek *et al*. [36]	47.8	34.8	30.7	26.5
LSG (2 studies)					
31	Chiappetta *et al*. [40]	33.3	22.8		
34	Al-Sabah *et al*. [43]	49.2	22.8	48	19.2
	Mean	54.68	18.81	52.09	18.04

LAGB, laparoscopic adjustable gastric band; LSG, laparoscopic sleeve gastrectomy; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy; VBG, vertical band gastroplasty.

Table 8 Univariate analysis of total percentage of females/ male

	F	Significance (*P* value)*
RYGB group	0.398	0.676
LSG group	0.165	0.849
MGB group	0.559	0.611

LSG, laparoscopic sleeve gastrectomy; MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass. *One-way analysis of variance; significant if *P* value less than 0.05.

Table 9 Univariate analysis of preconversion BMI

	F	Significance (*P* value)*
Preconversion BMI for RYGB group	3.837	0.034
Preconversion BMI for SG group	0.080	0.780
Preconversion BMI for MGB group	2.084	0.240

SG, sleeve gastrectomy; MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass. *One-way analysis of variance; significant if *P* value less than 0.05.

Indication for conversion

About the indication for revisional procedure (Table 11), there were three main indications for conversion: inadequate weight loss (mean incidence=45.8%), weight regain (mean incidence=42.10%), and gastroesophageal reflux disease (GERD) (mean incidence=11%).

Quality assessment for the included studies

The assessment for studies' quality (Fig. 5) was done according to the impact factor, scientific journal ranking, and Scopus quartile. The majority of the studies (31 studies, 91.18%) were of high quality (Q1, impact factor>1, and SJR>1).

Table 10 Univariate analysis of time for conversion (months)

	F	Significance (*P* value)*
Time to conversion for RYGB	0.673	0.540
Time to conversion for SG	0.720	0.525

RYGB, Roux-en-Y gastric bypass; SG, sleeve gasterectomy. *One-way analysis of variance; significant if *P* value less than 0.05.

Meta-analysis

BMI decreased after conversions

(1) Comparison between gastric bypass (RYGB and MGB) and SG (Fig. 6).

(a) 3–6 months (short term) after conversion:

In seven studies, comparing the short-term BMI results between gastric bypass and SG revealed no significant difference, with significantly high heterogeneity percent (I^2=94%, P<0.00001) and overall effect of 0.67 (Table 13).

(1) 12 months after conversion:

In 13 studies comparing the 12 months postconversion BMI results between gastric bypass and SG there was no significant difference, with significantly high heterogeneity percent (I^2=84%, P<0.00001) and overall effect of 0.25.

(1) Long term postconversion BMI decrease:

(1) 24 months after conversion:

In three studies comparing the 24-month postconversion BMI results between gastric bypass and SG, there was no significant difference, with significantly high heterogeneity percent (I^2=97%, P<0.00001) and overall effect of 1.21.

Table 11 Indications for conversions

No	Study	Total number of patients	Indications for conversion				
			Inadequate weight loss	Weight regain	GERD	Others	
1	Bhaskar *et al*. [12]	41	73.17%		4.88%	21.95%	
2	Abu-ghazla *et al.* [13]	36	22.2%	40%		Symptomatic intolerance	37.8%
3	Tran *et al*. [14]	61	17%		5%	Dysphagia	55%
						Others	28%
4	Shimizu *et al*. [15]	11					
5	Moon *et al*. [16]	54					
6	Khoursheed *et al*.[17]	95	94.74%			5.26%	
7	Marin-Perez *et al*. [18]	59	74.58%		3.39%	22.3%	
8	Stefanidis *et al*. [19]	48					
9	Carr *et al*. [20]	89	51.7%			Band slippage	6.7%
						Band complications	41.6%
10	Carandina *et al*. [21]	108	72.2%			7.4%	20.4%
11	Gonzalez-Heredia *et al*. [22]	38	23.8%			Band slippage	59.5%
						Band complications	16.7%
12	Castro *et al*. [23]	88	73.2%			Band slippage	34%
13	Angrisani *et al*.[24]	51	64.7%	7.84%		Band complications	27.46%
14	Ngiam *et al*. [25]	18					
15	Yeung *et al*. [26]	104	71.15%			Band problems	28.85%
16	Pawan *et al*. [27]	52	77.4%	7.5%		Achalasia like symptoms	11.3%
17	Janik *et al*., *2017* [28]	2708					
18	Creange *et al*. [29]	475					
19	Avsar *et al*. [30]	49	23%		2.7%	Band slippage	18.9%
						Band complications	55.4%
20	Khan *et al*. [31]	141					
21	Rafols *et al*. [32]	1219					
22	Almalki *et al*.[33]	116	31%	50.9%	18.5%	Achalasia	13.9%
23	Qiu *et al*. [34]	14					
24	Janik *et al*. [35]	14235					
25	Salama and Sabry [4]	60		70%			30%
26	van Wezenbeek *et al*. [36]	131	RY	19.08%	32.06%	3.05%	
			SG	3.05%	3.05%	0	
27	Nevo *et al*. [37]	54	RY	81.9%		Dysphagia and vomiting	RY 18.1%
			MGB	95.3%			MGB 4.7%
28	Alsabah *et al*. [38]	35					
29	Yilmaz *et al*. [39]	32	25%	56.2%	18.8%		
30	Qiu *et al*. [34]	5					
31	Chiappetta *et al*. [40]	55					
32	Antonopulos *et al*. [41]	144					
33	Poublon *et al*. [42]	491	RY	18.13%	29.08%		
			MGB	11.61%	21.38%		
34	Al-Sabah *et al*. [43]	84	10.6%	74.1%	12.9%		

GERD, gastroesophageal reflux disease; MGB, mini gastric bypass. On calculation of the percentages, it may be not equal to 100% because of the presence of common indications between the patients.

(1) 36 months after conversion:

In three studies comparing the 36-month postconversion BMI results between gastric bypass and SG, there was no significant difference, with significantly high heterogeneity percent (I^2=72%, P=0.03) and overall effect of 0.61.

(1) 48 months after conversion:

In three studies comparing the 48-month postconversion BMI results between gastric bypass and SG, there was no significant difference, with significantly high heterogeneity percent (I^2=87%, P=0.0005) and overall effect of 0.64.

Table 12 Quality assessment for the included 34 studies

No	Study	Journal	Impact factor	Scientific journal ranking (SJR)	Scopus quartile (Q)
LAGB Studies (24 studies)					
1	Bhaskar *et al.* [12]	Asian Journal of Endoscopy Surgery	0.7	0.367	3
2	Abu-ghazla *et al.* [13]	Surgery for Obesity and Related Diseases	3.812	1.73	1
3	Tran *et al.* [14]	Surgical Endoscopy	3.149	1.457	1
4	Shimizu *et al.* [15]	Obesity Surgery	3.42	1.439	1
5	Moon *et al.* [16]	Surgery for Obesity and Related Diseases	3.812	1.73	1
6	Khoursheed *et al.* [17]	Surgical Endoscopy	3.149	1.457	1
7	Marin-Perez *et al.* [18]	Surgery for Obesity and Related Diseases	3.812	1.73	1
8	Stefanidis *et al.* [19]	Surgical Endoscopy	3.149	1.457	1
9	Carr *et al.* [20]	Surgery for Obesity and Related Diseases	3.812	1.73	1
10	Carandina *et al.* [21]	Surgery for Obesity and Related Diseases	3.812	1.73	1
11	Gonzalez-Heredia *et al.* [22]	Surgical Endoscopy	3.149	1.457	1
12	Castro *et al.* [23]	Acta Medica Portuguesa	0.628	0.191	3
13	Angrisani *et al.* [24]	Obesity Surgery	3.42	1.439	1
14	Ngiam *et al.* [25]	Obesity Surgery	3.42	1.439	1
15	Yeung *et al.* [26]	Surgical Endoscopy	3.149	1.457	1
16	Pawan *et al.* [27]	Obesity Surgery	3.42	1.439	1
17	Janik *et al.* [28]	Annals Of Surgery	10.13	4.15	1
18	Creange *et al.* [29]	Surgery for Obesity and Related Diseases	3.812	1.73	1
19	Avsar *et al.* [30]	Obesity Surgery	3.42	1.439	1
20	Khan *et al.* [31]	Surgery for Obesity and Related Diseases	3.812	1.73	1
21	Rafols *et al.* [32]	Surgery for Obesity and Related Diseases	3.812	1.73	1
22	Almalki *et al.* [33]	Obesity Surgery	3.42	1.439	1
23	Qiu *et al.* [34]	Obesity Surgery	3.42	1.439	1
24	Janik *et al.* [35]	Obesity Surgery	3.42	1.439	1
VBG Studies (3 studies)					
25	Salama and Sabry [4]	Minimally Invasive Surgery	2.1	0.55	2
26	van Wezenbeek *et al.* [36]	World Journal of Gastrointestinal Surgery	2.582	1.168	1
27	Nevo *et al.* [37]	Obesity Surgery	3.42	1.439	1
LSG studies (7 studies)					
28	Alsabah *et al.* [38]	Obesity Surgery	3.42	1.439	1
29	Yilmaz *et al.* [39]	Obesity Surgery	3.42	1.439	1
30	Qiu *et al.* [34]	Obesity Surgery	3.42	1.439	1
31	Chiappetta *et al.* [40]	Obesity Surgery	3.42	1.439	1
32	Antonopulos *et al.* [41]	Obesity Surgery	3.42	1.439	1
33	Poublon *et al.* [42]	Obesity Surgery	3.42	1.439	1
34	Al-Sabah *et al.* [43]	Surgery for Obesity and Related Diseases	3.812	1.73	1

LAGB, laparoscopic adjustable gastric band; LSG, laparoscopic sleeve gastrectomy; VBG, vertical band gastroplasty.

(1) Overall analysis:

The overall analysis for postoperative BMI between gastric bypass and SG showed that there was no significant difference, with significantly high heterogeneity percent (I^2=94%, P<0.00001) and overall effect of 1.25.

Table 14

Comparison between gastric bypasses (RYGB and mini gastric bypass)

(1) 3–6 months (Short term) after conversion:

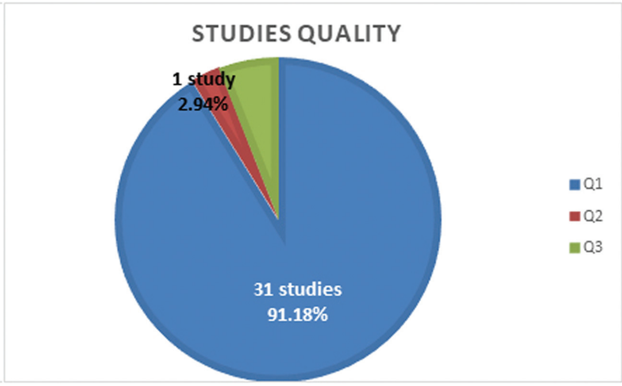
In two studies comparing the short-term BMI results between RYGB and MGB, there was no significant difference, with significantly high heterogeneity percent (I^2=83%, P=0.02), and overall effect of 1.08 (Fig. 7).

(1) 12 months after conversion:

In five studies comparing the 12-month postconversion BMI results between RYGB and MGB, there was no significant difference, with significantly moderate heterogeneity percent (I^2=57%, P=0.05) and overall effect of 2.16.

(1) Long term postconversion BMI decrease
   (a) 24 months after conversion:

Figure 5



Quality assessment of the included studies.

In two studies comparing the 24-month postconversion BMI results between RYGB and MGB, there was a significant difference favoring MGB, with nonsignificant no heterogeneity percent (I^2=0%, P=0.51) and overall effect of 3.65.

(1) 36 months postconversion:

In two studies comparing the 36-month postconversion BMI results between RYGB and MGB, there was a nonsignificant difference, with significantly high heterogeneity percent (I^2=90%, P=0.002) and overall effect of 0.29.

(1) Overall analysis:

The overall analysis for postoperative BMI between RYGB and MGB showed that there was no significant difference, with significantly high heterogeneity percent (I^2=89%, P<0.00001) and overall effect of 0.4.

Percentage of extra weight loss after conversions

(1) Comparison between gastric bypasses (RYGB and MGB) and SG (Fig. 8).
   (a) 3–6 months (Short term) after conversion:

In eight studies comparing the short-term % EWL results between gastric bypass and SG, there was no significant difference, with significantly high heterogeneity percent (I^2=90%, P<0.00001) and overall effect of 0.54.

(1) 12 months after conversion:

In 15 studies comparing the 12-month postconversion % EWL results between gastric bypass and SG, there was no significant difference, with significantly high heterogeneity percent (I^2=87%, P<0.00001) and overall effect of 0.10.

(1) Long-term postconversion BMI decrease
   (1) 24 months after conversion:

In seven studies comparing the 24-month postconversion % EWL results between gastric bypass and SG, there was a significant difference favoring SG, with significantly moderate heterogeneity percent (I^2=70%, P=0.003) and overall effect of 3.59.

(1) 36 months after conversion:

In four studies comparing the 36-month postconversion % EWL results between gastric bypass and SG, there was a significant difference favoring SG, with nonsignificant moderate heterogeneity percent (I^2=44%, P=0.15) and overall effect of 3.43.

(1) 48 months after conversion:

In two studies comparing the 48-month postconversion % EWL results between gastric bypass and SG, there was a significant difference favoring SG, with nonsignificant low heterogeneity percent (I^2=17%, P=0.27) and overall effect of 6.33.

(1) Overall analysis:

The overall analysis for postoperative % EWL between gastric bypass and SG showed that there was a significant difference favoring SG, with significantly high heterogeneity percent (I^2=86%, P<0.00001) and overall effect of 2.79.

(1) Comparison between gastric bypasses (RYGB and MGB) (Fig. 9).
   (a) 12 months after conversion:

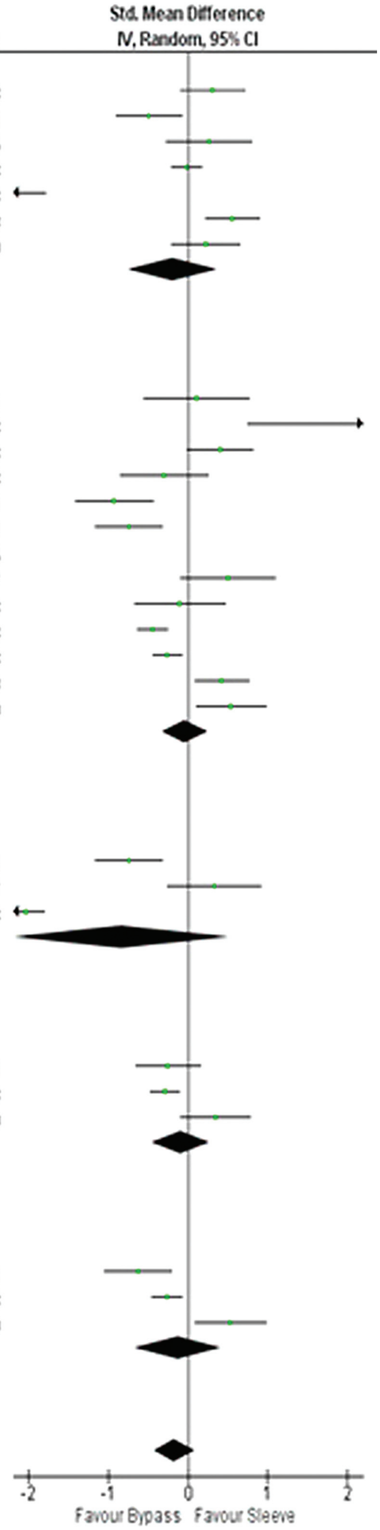
In five studies comparing the 12-month postconversion % EWL results between RYGB and MGB, there was a significant difference favoring RYGB, with significantly high heterogeneity percent (I^2=89%, P<0.00001) and overall effect of 3.27.

(1) 24 months after conversion:

In two studies comparing the 24-month postconversion % EWL results between RYGB and MGB, there was no significant difference, with significantly high heterogeneity percent (I^2=89%, P=0.003) and overall effect of 0.48.

Figure 6

Study or Subgroup	Bypass Mean	Bypass SD	Bypass Total	Sleeve Mean	Sleeve SD	Sleeve Total	Weight	Std. Mean Difference IV, Random, 95% CI	Year
1.1.1 BMI (3-6) months									
Khourshed et al, 2013	33.8	5.7	53	31.6	8.4	42	3.7%	0.31 [-0.10, 0.72]	2013
Caradina et al, 2014	36.4	5.5	74	39.5	7.8	34	3.7%	-0.49 [-0.90, -0.08]	2014
Castro et al, 2015	34.8	6.7	71	33.1	4.7	17	3.5%	0.26 [-0.27, 0.80]	2015
Creange et al, 2018	36.47	6.37	192	36.57	6.83	283	4.0%	-0.02 [-0.20, 0.17]	2018
Khan et al, 2018	35.57	0.52	113	37.16	1.17	28	3.5%	-2.27 [-2.77, -1.78]	2018
Antonopulos et al, 2019	35.2	7.05	83	32.1	2.23	61	3.8%	0.56 [0.22, 0.89]	2019
Al Sabah et al, 2020	35.7	5.2	46	34.5	5.4	38	3.6%	0.22 [-0.21, 0.66]	2020
Subtotal (95% CI)			**632**			**503**	**25.8%**	**-0.19 [-0.75, 0.37]**	
Heterogeneity: Tau^2 = 0.53; Chi^2 = 100.77, df = 6 (P < 0.00001); I^2 = 94%									
Test for overall effect: Z = 0.67 (P = 0.50)									
1.1.2 BMI 12 Months									
Abu-ghazla et al, 2011	31.8	5.1	18	31	8.9	18	3.2%	0.11 [-0.55, 0.76]	2011
Shimizu et al, 2013	67.5	16.9	9	16.8	2.1	2	1.1%	2.91 [0.75, 5.06]	2013
Khourshed et al, 2013	34.7	5.5	53	32.3	6.4	42	3.7%	0.40 [-0.01, 0.81]	2013
Marin-perez et al, 2013	31	7	39	33	6	20	3.4%	-0.30 [-0.84, 0.25]	2013
Carr et al, 2014	39.4	5.17	64	44.3	5.46	25	3.6%	-0.92 [-1.41, -0.44]	2014
Caradina et al, 2014	31.4	4.8	74	35.1	5.4	34	3.7%	-0.74 [-1.15, -0.32]	2014
Castro et al, 2015	35.1	3.4	71	33.4	0	17		Not estimable	2015
Pawan et al, 2017	29.15	5.75	35	26.3	5.3	17	3.4%	0.50 [-0.09, 1.09]	2017
Avsar et al, 2018	31.6	7.8	29	32.3	5.4	20	3.4%	-0.10 [-0.67, 0.47]	2018
Raflos et al, 2018	31.05	5.7	1096	33.6	6.5	123	4.0%	-0.44 [-0.63, -0.25]	2018
Creange et al, 2018	33.71	5.69	192	35.42	7.28	283	4.0%	-0.26 [-0.44, -0.07]	2018
Antonopulos et al, 2019	32.5	6.63	83	30.2	3.05	61	3.8%	0.42 [0.09, 0.76]	2019
Alsabah et al, 2020	34.5	5.5	46	31.7	4.7	38	3.6%	0.54 [0.10, 0.98]	2020
Subtotal (95% CI)			**1809**			**700**	**40.7%**	**-0.04 [-0.32, 0.25]**	
Heterogeneity: Tau^2 = 0.19; Chi^2 = 68.65, df = 11 (P < 0.00001); I^2 = 84%									
Test for overall effect: Z = 0.25 (P = 0.80)									
1.1.3 BMI 24 Months									
Caradina et al, 2014	31.4	4.8	74	35.1	5.4	34	3.7%	-0.74 [-1.15, -0.32]	2014
Pawan et al, 2017	28.55	6.2	35	26.6	4.8	17	3.4%	0.33 [-0.25, 0.91]	2017
Creange et al, 2018	22.93	5.5	192	38.34	8.74	283	3.9%	-2.02 [-2.25, -1.80]	2018
Subtotal (95% CI)			**301**			**334**	**11.0%**	**-0.83 [-2.18, 0.52]**	
Heterogeneity: Tau^2 = 1.37; Chi^2 = 71.68, df = 2 (P < 0.00001); I^2 = 97%									
Test for overall effect: Z = 1.21 (P = 0.23)									
1.1.4 BMI 36 Months									
Caradina et al, 2014	32.1	5.3	74	33.4	5.1	34	3.7%	-0.25 [-0.65, 0.16]	2014
Creange et al, 2018	34.26	6.61	192	36.46	8.34	283	4.0%	-0.29 [-0.47, -0.10]	2018
Alsabah et al, 2020	33.5	5.3	46	31.6	5.5	38	3.6%	0.35 [-0.08, 0.78]	2020
Subtotal (95% CI)			**312**			**355**	**11.3%**	**-0.09 [-0.46, 0.27]**	
Heterogeneity: Tau^2 = 0.07; Chi^2 = 7.06, df = 2 (P = 0.03); I^2 = 72%									
Test for overall effect: Z = 0.51 (P = 0.61)									
1.1.5 BMI 48 Months									
Caradina et al, 2014	33	5.5	74	36.7	6.7	34	3.7%	-0.62 [-1.04, -0.21]	2014
Creange et al, 2018	34.83	5.66	192	36.77	8.48	283	4.0%	-0.26 [-0.44, -0.08]	2018
Al Sabah et al, 2020	33.4	5.3	46	31	3.2	38	3.6%	0.53 [0.09, 0.97]	2020
Subtotal (95% CI)			**312**			**355**	**11.3%**	**-0.13 [-0.67, 0.41]**	
Heterogeneity: Tau^2 = 0.19; Chi^2 = 15.11, df = 2 (P = 0.0005); I^2 = 87%									
Test for overall effect: Z = 0.47 (P = 0.64)									
Total (95% CI)			**3366**			**2247**	**100.0%**	**-0.17 [-0.42, 0.09]**	
Heterogeneity: Tau^2 = 0.43; Chi^2 = 449.85, df = 27 (P < 0.00001); I^2 = 94%									
Test for overall effect: Z = 1.25 (P = 0.21)									
Test for subgroup differences: Chi^2 = 1.43, df = 4 (P = 0.84), I^2 = 0%									



Subgroup meta-analysis for postoperative BMI between gastric bypass and sleeve gastrectomy.

(1) Overall analysis:

The overall analysis for postoperative BMI between RYGB and MGB showed that there was a significant difference favoring RYGB, with significantly high heterogeneity percent (I^2=89%, P<0.00001) and overall effect of 3.28.

Table 13 Postoperative BMI changes

Short-term BMI results (3–6 months after conversion)							
		BMI 6 months RYGB		BMI 6 months SG		BMI 6 months MGB	
No	Study	Mean	SD	Mean	SD	Mean	SD
6	Khoursheed *et al*. [17]	33.8	5.7	31.6	8.4		
10	Carandina *et al*. [21]	36.4	5.5	39.5	7.8		
12	Castro *et al*. [23]	34.8	6.7	33.1	4.7		
18	Creange *et al*. [29]	36.47	6.37	36.57	6.83		
20	Khan *et al*. [31]	35.57	0.52	37.16	1.17		
25	Salama and Sabry [4]	29.89	5.69			30.15	5.36
31	Chiappetta *et al*. [40]	34.1	6.2			40.9	6.8
32	Antonopulos *et al*. [41]	35.2	7.05	32.1	2.23		
34	Al-Sabah *et al*. [43]	35.7	5.2	34.5	5.7		
Long term BMI results (12 months postconversion)							
		BMI 12 months RYGB		BMI 12 months SG		BMI 12 months MGB	
No	Study	Mean	SD	Mean	SD	Mean	SD
2	Abu-ghazla *et al.* [13]	31.8	5.1	31	8.9		
4	Shimizu *et al*. [15]	67.5	16.9	16.8	2.1		
6	Khoursheed *et al*. [17]	34.7	5.5	32.3	6.4		
7	Marin-Perez *et al*. [18]	31	7	33	6		
9	Carr *et al*. [20]	39.4	5.17	44.3	5.46		
10	Carandina *et al*. [21]	31.4	4.8	35.1	5.4		
12	Castro *et al*. [23]	*35.1*	*3.4*	*33.4*	*0*		
16	Pawan *et al*. [27]	30.9	6.3	26.3	5.3	27.4	5.2
18	Creange *et al*. [29]	33.71	5.69	35.42	7.28		
19	Avsar *et al*. [30]	31.6	7.8	32.3	5.4		
21	Rafols *et al*. [32]	31.8	6	33.6	6.5	30.3	5.4
22	Almalki *et al*. [33]	30.3	6.8			27.2	6.2
31	Chiappetta *et al*. [40]	33.5	5.6			36.6	6.3
32	Antonopulos *et al*. [41]	32.5	6.63	30.2	3.05		
33	Poublon *et al*. [42]	31.6	3.5			30.7	3.5
34	Al-Sabah *et al*. [43]	34.5	5.5	31.7	4.7		
Long-term BMI results							
		BMI 24 months RYGB		BMI 24 months SG		BMI 24 months MGB	
No	Study	Mean	SD	Mean	SD	Mean	SD
10	Carandina *et al*. [21]	31.4	4.8	35.1	5.4		
16	Pawan *et al*. [27]	30.3	7	26.6	4.8	26.8	5.4
18	Creange *et al*. [29]	22.93	5.5	38.34	8.74		
33	Poublon *et al*. [42]	32.6	5.9			30.8	5.2
		BMI 36 months RYGB		BMI 36 months SG		BMI 36 months MGB	
No	Study	Mean	SD	Mean	SD	Mean	SD
10	Carandina *et al*. [21]	32.1	5.3	33.4	5.1		
18	Creange *et al*. [29]	34.26	6.61	36.46	8.34		
27	Nevo *et al*. [37]	33.9	7.9			30.7	9.4
33	Poublon *et al*. [42]	31.1	5.1			34.5	7.1
34	Al-Sabah *et al*. [43]	33.5	5.3	31.6	5.5		
		BMI 48 months RYGB		BMI 48 months SG		BMI 48 months MGB	
No	Study	Mean	SD	Mean	SD	Mean	SD
10	Carandina *et al*. [21]	33	5.5	36.7	6.7		
18	Creange *et al*. [29]	34.83	5.66	36.77	8.48		
34	Al-Sabah *et al*. [43]	33.7	5.3	31	3.2		

DF, difference; LAGB, laparoscopic adjustable gastric band; MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy; VBG, vertical band gastroplasty.

Table 14 Postoperative extra weight loss percentage changes

No	Study	% EWL 6 months RYGB		% EWL 6 months SG		% EWL 6 months MGB	
Short-term % EWL results (3–6 months after conversion)							
No	Study	Mean	SD	Mean	SD	Mean	SD
6	Khoursheed *et al*. [17]	42	13.1	45.6	14.5		
10	Carandina *et al*. [21]	45.2	14.2	37.4	13.8		
11	Gonzalez-Heredia *et al*. [22]	36.2	19.4	53.04	17.3		
12	Castro *et al*. [23]	51	26.2	50.4	21.9		
18	Creange *et al*. [29]	17.8	7.5	14.5	7		
19	Avsar *et al*. [30]	53.6	22.3	51.3	23.6		
20	Khan *et al*. [31]	57.1	2.7	52.1	5.8		
31	Chiappetta *et al*. [40]	11	12			15	10
32	Antonopulos *et al*. [41]	47.9	30.18	61.2	10.35		
% EWL results (12 months postconversion)							
		BMI 6 months RYGB		BMI 6 months SG		BMI 6 months MGB	
No	Study	Mean	SD	Mean	SD	Mean	SD
2	Abu-ghazla *et al.* [13]	52	44.3	69.7	39.2		
5	Moon *et al*. [16]	57.4	17	47.4	4.2		
6	Khoursheed *et al*. [17]	45.6	13.1	47.4	14.5		
7	Marin-Perez *et al*. [18]	59	20	35	20		
9	Carr *et al*. [20]	52.7	23.77	44.7	32.74		
10	Carandina *et al*. [21]	59.9	16.7	52.2	11.4		
11	Gonzalez-Heredia *et al*. [22]	46	25	64.4	20.6		
12	Castro *et al*. [23]	49.8	13.7	46.1	0		
13	Angrisani *et al*. [24]	65.8	27.1	67.2	54		
14	Ngiam *et al*. [25]	46.3	17.9	58.7	4.5		
16	Pawan *et al*. [27]	54.5	7	76.5	5.4	73.6	4.8
18	Creange *et al*. [29]	23.1	9.3	17.3	10.3		
19	Avsar *et al*. [30]	70.1	24.3	56.1	33.8		
21	Rafols *et al*. [32]	66.6	30.4	59.1	24.5	74.4	28.9
22	Almalki *et al*.[33]	32.9	35.1			76.8	57.1
31	Chiappetta *et al*. [40]	22	18			29	13
32	Antonopulos *et al*. [41]	61.2	38.23	71.2	17.3		
33	Poublon *et al*. [42]	60	30.1			69	44.6
Long-term % EWL results							
		% EWL 24 months RYGB		% EWL 24 months SG		% EWL 24 months MGB	
No	Study	Mean	SD	Mean	SD	Mean	SD
5	Moon *et al*. [16]	62.4	19.6	65.6	34.5		
7	Marin-Perez *et al*. [18]	55	22	28	25		
9	Carr *et al*. [20]	47.9	29.79	42	29.67		
10	Carandina *et al*. [21]	70.2	16.7	59.9	14.4		
14	Ngiam *et al*. [25]	58.6	133.3	16.2	39.3		
16	Pawan *et al*. [27]	51.6	26.2	101.7	124.4	76.7	24.1
18	Creange *et al*. [29]	23.4	11.2	12.6	14.2		
33	Poublon *et al*. [42]	68.6	51.6			56.4	35.4
		% EWL 36 months RYGB		% EWL 36 months SG		% EWL 36 months MGB	
No	Study	Mean	SD	Mean	SD	Mean	SD
10	Carandina *et al*. [21]	68.3	17.6	65.6	13.1		
13	Angrisani *et al*. [24]	69.8	26.4	62.8	34.5		
18	Creange *et al*. [29]	22.7	12	15.4	9.4		
26	van Wezenbeek *et al*. [36]	71.7	23.8	56.6	24.4		
33	Poublon *et al*. [42]	46.5	35			58.3	36
		% EWL 48 months RYGB		% EWL 48 months SG		% EWL 48 months MGB	
No	Study	Mean	SD	Mean	SD	Mean	SD
10	Carandina *et al*. [21]	67.3	18.7	58.9	14.4		
18	Creange *et al*. [29]	22.3	13.2	13.2	11.9		

% EWL, extra weight loss percentage; df, difference; LAGB, laparoscopic adjustable gastric band; MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy; VBG, vertical band gastroplasty.

Operative time

(1) Comparison between gastric bypasses (RYGB and MGB) and SG (Fig. 10).

In 13 studies comparing the mean operative time between gastric bypass and SG, there was a significant difference for shorter operative time favoring SG, with significantly high heterogeneity percent (I^2=83%, P<0.00001) and overall effect of 11.10 (Table 15).

(1) Comparison between gastric bypasses (RYGB and MGB) (Fig. 11).

In four studies comparing the mean operative time between MGB and RYGB, there was a significant difference for shorter operative time favoring MGB, with nonsignificant no heterogeneity percent (I^2=0%, P=0.52) and overall effect of 12.88.

Length of hospital stay

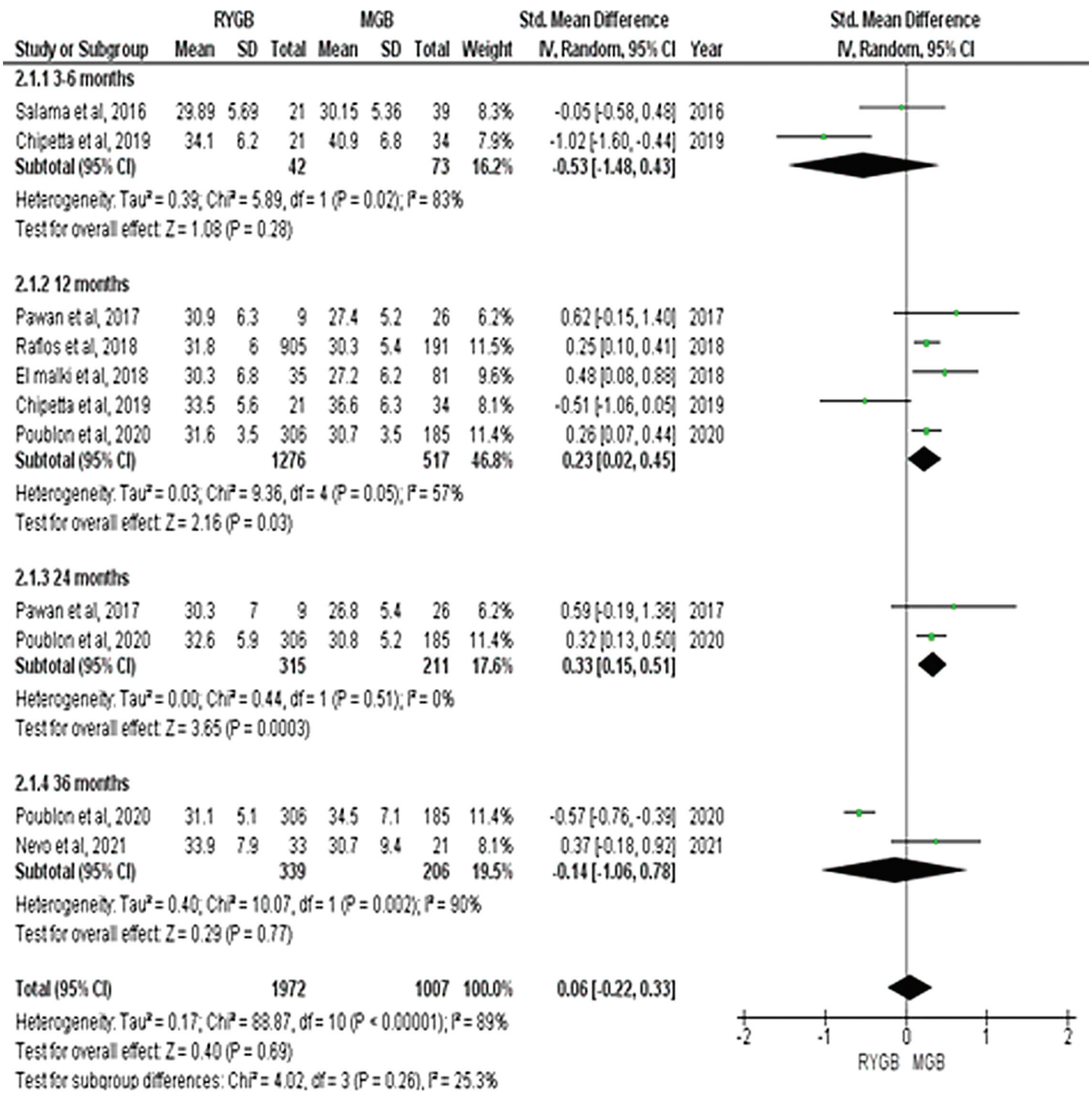
(1) Comparison between gastric bypasses (RYGB and MGB) and SG (Fig. 12).

In 15 studies comparing the mean length of hospital stay (days) between gastric bypass and SG, there was a significant difference for shorter stay favoring SG, with significantly high heterogeneity percent (I^2=81%, P<0.00001) and overall effect of 2.24 (Table 16).

(1) Comparison between gastric bypasses (RYGB and MGB) (Fig. 13).

In four studies comparing the mean length of hospital stay (days) between MGB and RYGB, there was no significant difference, with significantly high heterogeneity percent (I^2=89%, P<0.00001) and overall effect of 0.13.

Figure 7



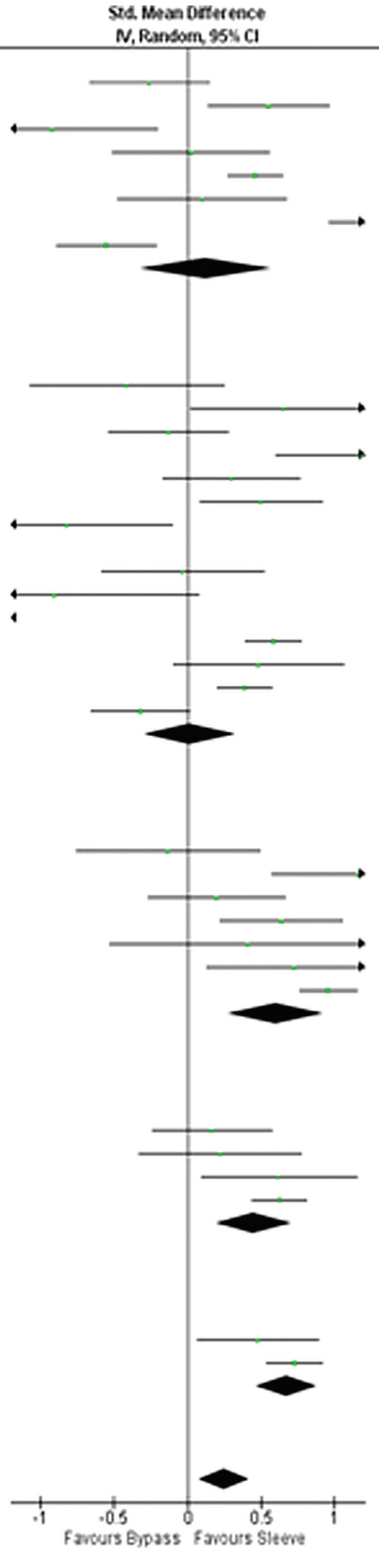
Subgroup meta-analysis for postoperative BMI between RYGB and MGB. MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass.

Overall incidence of postoperative major complications

(1) Comparison between gastric bypasses (RYGB and MGB) and SG (Fig. 14).
    (a) Early (<30 days):
    In 15 studies comparing the presence of early major complications within 30 days postoperatively between gastric bypass and SG, there was a significant difference for higher incidence favoring SG, with nonsignificant moderate heterogeneity percent (I^2=41%, P=0.06) and overall effect of 3.09.

Figure 8

Study or Subgroup	Bypass Mean	Bypass SD	Bypass Total	Sleeve Mean	Sleeve SD	Sleeve Total	Weight	Std. Mean Difference IV, Random, 95% CI	Year
3.1.1 3-6 Months									
Khourshed et al, 2013	42	13.1	53	45.6	14.5	42	3.1%	-0.26 [-0.67, 0.15]	2013
Caradina et al, 2014	45.2	14.2	74	37.4	13.8	34	3.1%	0.55 [0.14, 0.96]	2014
Gonzalez-Herida et al, 2014	36.2	19.4	12	53.04	17.3	26	2.3%	-0.92 [-1.64, -0.20]	2014
Castro et al, 2015	51	26.2	71	50.4	21.9	17	2.8%	0.02 [-0.51, 0.55]	2015
Creange et al, 2018	17.8	7.5	192	14.5	7	283	3.6%	0.46 [0.27, 0.64]	2018
Avsar et al, 2018	53.6	22.3	29	51.3	23.6	20	2.7%	0.10 [-0.47, 0.67]	2018
Khan et al, 2018	57.1	2.7	113	52.1	5.8	28	3.0%	1.41 [0.97, 1.86]	2018
Antonopulos et al, 2019	47.9	30.18	83	61.2	10.35	61	3.3%	-0.55 [-0.89, -0.22]	2019
Subtotal (95% CI)			**627**			**511**	**23.6%**	**0.12 [-0.32, 0.57]**	
Heterogeneity: Tau² = 0.36; Chi² = 71.90, df = 7 (P < 0.00001); I² = 90%									
Test for overall effect: Z = 0.54 (P = 0.59)									
3.1.2 12 Months									
Abu-ghazla et al, 2011	52	44.3	18	69.7	39.2	18	2.4%	-0.41 [-1.07, 0.25]	2011
Moon et al, 2013	57.4	17	41	47.4	4.2	13	2.5%	0.66 [0.02, 1.29]	2013
Khourshed et al, 2013	45.6	13.1	53	47.4	14.5	42	3.1%	-0.13 [-0.54, 0.28]	2013
Marin-perez et al, 2013	59	20	39	35	20	20	2.6%	1.18 [0.60, 1.77]	2013
Carr et al, 2014	52.7	23.77	64	44.7	32.74	25	2.9%	0.30 [-0.17, 0.76]	2014
Caradina et al, 2014	59.9	16.7	74	52.2	11.4	34	3.1%	0.50 [0.09, 0.91]	2014
Gonzalez-Herida et al, 2014	46	25	12	64.4	20.6	26	2.3%	-0.82 [-1.53, -0.11]	2014
Castro et al, 2015	49.8	13.7	71	46.1	0	17		Not estimable	2015
Angrisani et al, 2016	65.8	27.1	24	67.2	54	27	2.7%	-0.03 [-0.58, 0.52]	2016
Ngiam et al, 2016	46.3	17.9	9	58.7	4.5	9	1.7%	-0.90 [-1.89, 0.08]	2016
Pawan et al, 2017	64.05	5.9	35	76.5	5.4	17	2.3%	-2.13 [-2.85, -1.41]	2017
Creange et al, 2018	23.1	9.3	192	17.3	10.3	283	3.6%	0.58 [0.40, 0.77]	2018
Avsar et al, 2018	70.1	24.3	29	56.1	33.8	20	2.6%	0.48 [-0.10, 1.06]	2018
Raftos et al, 2018	70.5	29.65	1096	59.1	24.5	123	3.6%	0.39 [0.20, 0.58]	2018
Antonopulos et al, 2019	61.2	38.23	83	71.2	17.3	61	3.3%	-0.32 [-0.65, 0.01]	2019
Subtotal (95% CI)			**1840**			**735**	**38.6%**	**0.02 [-0.30, 0.33]**	
Heterogeneity: Tau² = 0.28; Chi² = 103.49, df = 13 (P < 0.00001); I² = 87%									
Test for overall effect: Z = 0.10 (P = 0.92)									
3.1.3 24 Months									
Moon et al, 2013	62.4	19.6	41	65.6	34.5	13	2.5%	-0.13 [-0.76, 0.49]	2013
Marin-Perez et al, 2013	55	22	39	28	25	20	2.6%	1.16 [0.58, 1.74]	2013
Carr et al, 2014	47.9	29.79	64	42	29.67	25	2.9%	0.20 [-0.27, 0.66]	2014
Caradina et al, 2014	70.2	16.7	74	59.9	14.4	34	3.1%	0.64 [0.22, 1.05]	2014
Ngiam et al, 2016	58.6	133.3	9	16.2	39.3	9	1.8%	0.41 [-0.53, 1.35]	2016
Pawan et al, 2017	64.15	25.15	35	10.17	124.4	17	2.6%	0.72 [0.13, 1.32]	2017
Creange et al, 2018	23.4	4.2	192	12.6	14.2	283	3.6%	0.96 [0.76, 1.15]	2018
Subtotal (95% CI)			**454**			**401**	**19.0%**	**0.60 [0.27, 0.93]**	
Heterogeneity: Tau² = 0.12; Chi² = 20.12, df = 6 (P = 0.003); I² = 70%									
Test for overall effect: Z = 3.59 (P = 0.0003)									
3.1.4 36 Months									
Caradina et al, 2014	68.3	17.6	74	65.6	13.1	34	3.1%	0.16 [-0.24, 0.57]	2014
Angrisani et al, 2016	69.8	26.4	24	62.8	34.5	27	2.7%	0.22 [-0.33, 0.77]	2016
Wezenbeek et al, 2016	22.7	12	115	15.4	9.4	16	2.8%	0.62 [0.09, 1.15]	2016
Creange et al, 2018	71.7	23.8	192	56.6	24.4	283	3.6%	0.62 [0.44, 0.81]	2018
Subtotal (95% CI)			**405**			**360**	**12.1%**	**0.45 [0.19, 0.71]**	
Heterogeneity: Tau² = 0.03; Chi² = 5.37, df = 3 (P = 0.15); I² = 44%									
Test for overall effect: Z = 3.43 (P = 0.0006)									
3.1.5 48 Months									
Caradina et al, 2014	67.3	18.7	74	58.9	14.4	34	3.1%	0.48 [0.07, 0.89]	2014
Creange et al, 2018	22.3	13.2	192	13.2	11.9	283	3.6%	0.73 [0.54, 0.92]	2018
Subtotal (95% CI)			**266**			**317**	**6.6%**	**0.67 [0.46, 0.88]**	
Heterogeneity: Tau² = 0.01; Chi² = 1.20, df = 1 (P = 0.27); I² = 17%									
Test for overall effect: Z = 6.33 (P < 0.00001)									
Total (95% CI)			**3592**			**2324**	**100.0%**	**0.25 [0.07, 0.42]**	
Heterogeneity: Tau² = 0.21; Chi² = 250.53, df = 34 (P < 0.00001); I² = 86%									
Test for overall effect: Z = 2.79 (P = 0.005)									
Test for subgroup differences: Chi² = 14.62, df = 4 (P = 0.006), I² = 72.6%									



Subgroup meta-analysis for postoperative % EWL between gastric bypass and sleeve gastrectomy. % EWl, extra weight loss percentage.

(b) Late (>30 days):
In seven studies comparing presence of late major complications after 30 days postoperatively between gastric bypass and SG, there was no significant difference, with significantly moderate heterogeneity percent (I^2=55%, P=0.04) and overall effect of 0.59.

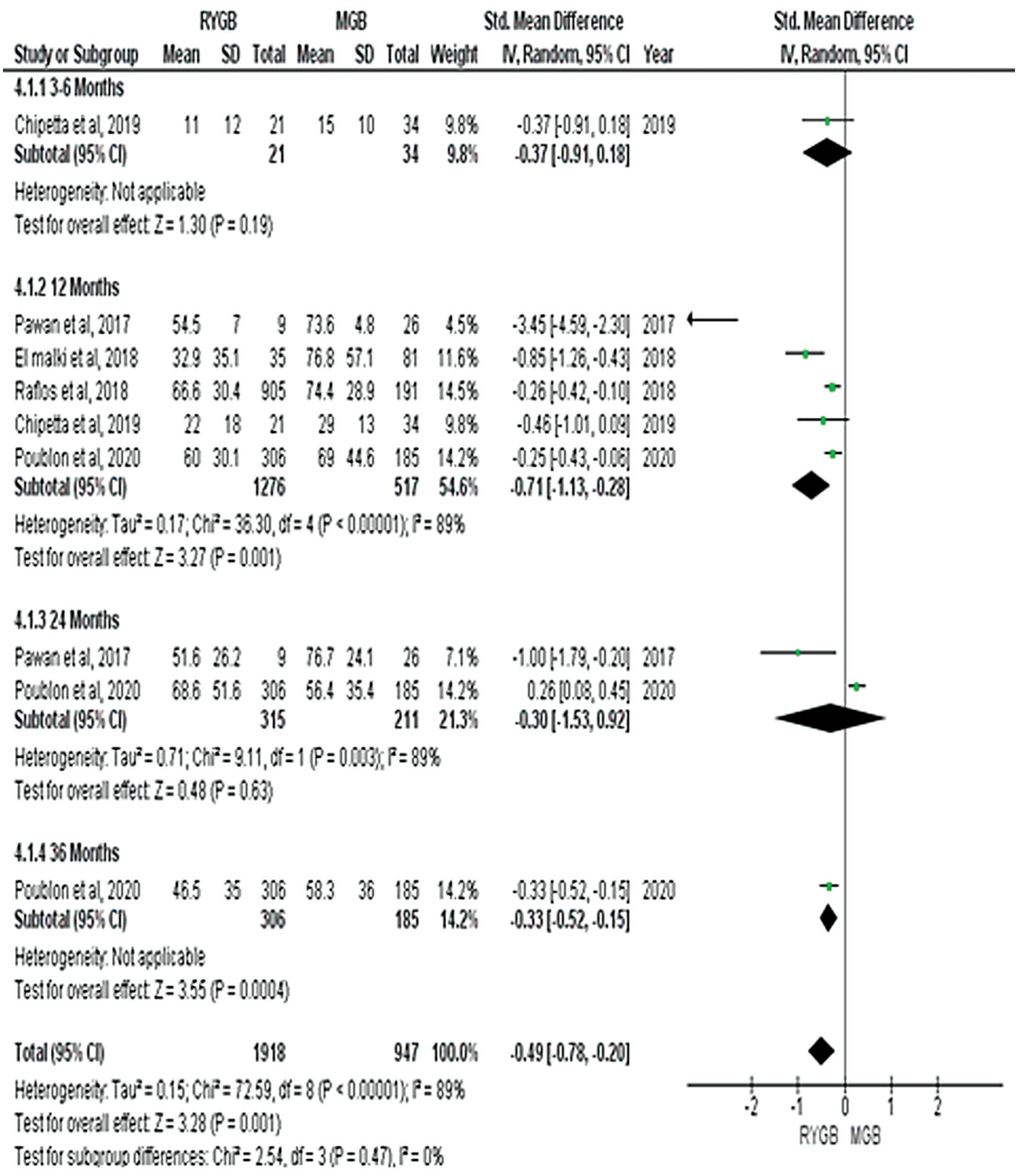
(c) Overall analysis:
The overall analysis for postoperative major complications between gastric sleeve and gastric bypass showed that there was a nonsignificant difference, with significantly moderate heterogeneity percent (I^2=66%, P<0.00001) and overall effect of 1.09.

(2) Comparison between gastric bypasses (RYGB and MGB) (Fig. 15).

(a) Early (<30 days):
In four studies comparing presence of early major complications within 30 days postoperatively between RYGB and MGB, there was a nonsignificant difference, with nonsignificant no heterogeneity percent (I^2=0%, P=0.42) and overall effect of 1.81.

(b) Late (>30 days):
In two studies comparing the presence of late major complications after 30 days postoperatively in RYGB and MGB, there was no significant difference, with

Figure 9



Subgroup meta-analysis for postoperative % EWL between RYGB and MGB. % EWl, extra weight loss percentage; MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass.

nonsignificant no heterogeneity percent (I^2=0%, P=0.54) and overall effect of 0.03.

(c) Overall analysis:

The overall analysis for postoperative major complications between RYGB and MGB showed that there was a nonsignificant difference, with nonsignificant no heterogeneity percent (I^2=0%, P=0.45) and overall effect of 1.31.

Table 17

Overall rates of postoperative leakage and major bleeding complications

(1) Comparison between gastric bypasses (RYGB and MGB) and SG (Fig. 16).

(a) Leakage:

In 12 studies comparing the presence of rates of leakage and major bleeding complications between gastric bypass and SG, there was no significant difference, with a significantly moderate heterogeneity percent (I^2=48%, P=0.04) and overall effect of 0.99 (Table 17).

(1) Major bleeding:

In 10 studies comparing presence of major bleeding incidence between gastric bypass and SG, there was no significant difference, with a significantly moderate heterogeneity percent (I^2=77%, $P<0.0001$) and overall effect of 0.50.

(1) Overall analysis:

The overall analysis for postoperative incidence of major bleeding and leakage between gastric sleeve and gastric bypass showed that there was a nonsignificant difference, with significantly moderate heterogeneity percent (I^2=66%, $P<0.00001$) and overall effect of 1.27.

(1) Comparison between gastric bypasses (RYGB and MGB) (Fig. 17).

(a) Leakage:

In four studies comparing the presence of rates of leakage and major bleeding complications between RYGB and MGB, there was no significant difference, with a nonsignificant no heterogeneity percent (I^2=0%, P=0.58) and overall effect of 0.13.

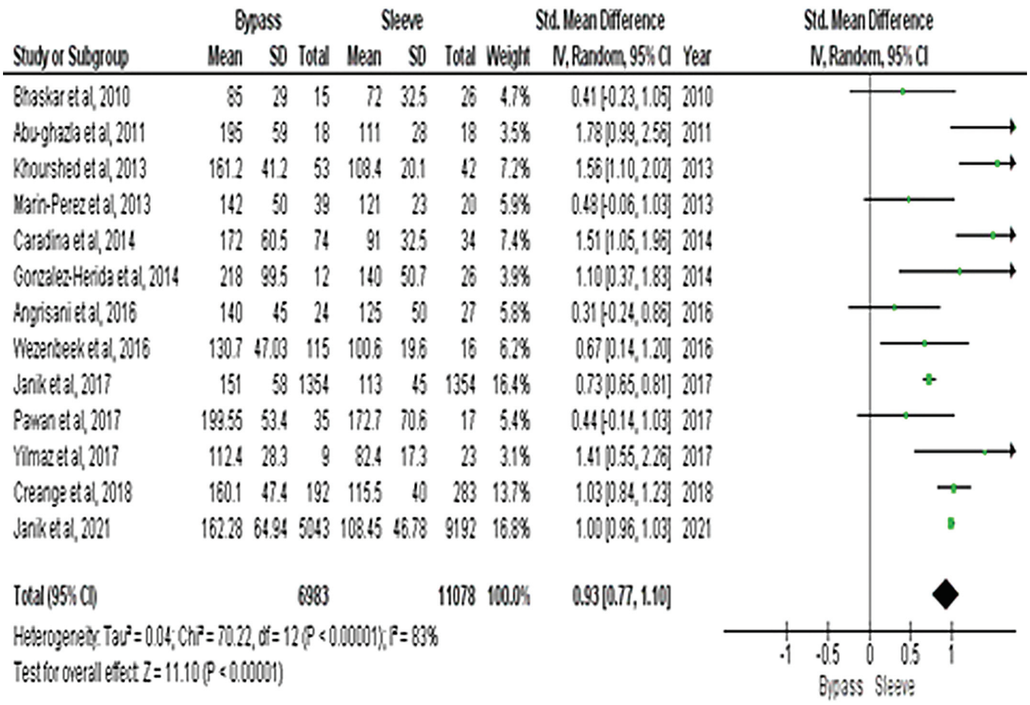
(1) Major bleeding:

In three studies comparing presence of major bleeding incidence between RYGB and MGB, there was no significant difference, with a nonsignificant no heterogeneity percent (I^2=0%, P=0.52) and overall effect of 1.0.

(1) Overall analysis:

The overall analysis for postoperative incidence of major bleeding and leakage between RYGB and

Figure 10



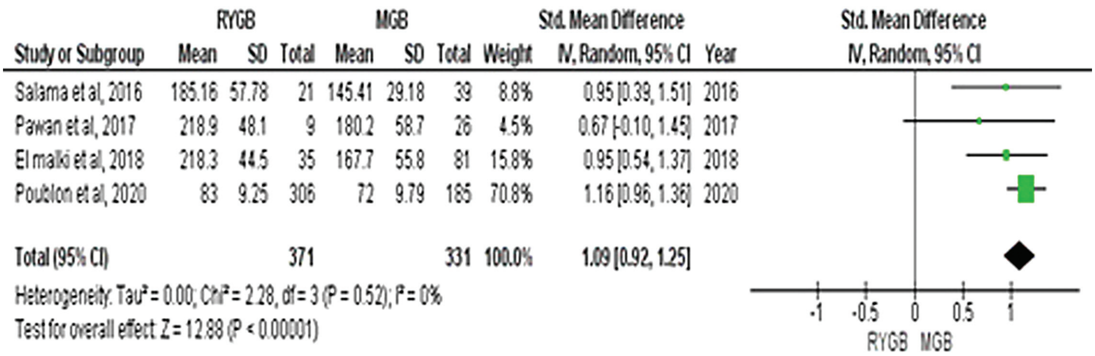
Meta-analysis for mean operative time between gastric bypass and sleeve gastrectomy.

Table 15 Operative time

		RYGB		SG		MGB	
No	Study	Mean	SD	Mean	SD	Mean	SD
1	Bhaskar *et al*. [12]	85	29	72	32.5		
2	Abu-ghazla *et al.* [13]	195	59	111	28		
6	Khoursheed *et al*. [17]	161.2	41.2	108.4	20.1		
7	Marin-Perez *et al*. [18]	142	50	121	23		
10	Carandina *et al*. [21]	172	60.5	91	32.5		
11	Gonzalez-Heredia *et al*. [22]	218.4	99.5	140	50.7		
13	Angrisani *et al*. [24]	140	45	125	50		
16	Pawan *et al*. [27]	218.9	48.1	172.7	70.6	180.2	58.7
17	Janik *et al*. [28]	151	58	113	45		
18	Creange *et al*. [29]	160.1	47.4	115.5	40		
22	Almalki *et al*. [33]	218.3	44.5			167.7	55.8
24	Janik *et al*. [35]	162.28	64.94	108.45	46.78		
25	Salama and Sabry [4]	185.16	57.78			145.41	29.18
26	van Wezenbeek *et al*. [36]	130.7	47.03	100.6	19.6		
29	Yilmaz *et al*. [39]	112.4	28.3	82.4	17.3		
33	Poublon *et al*. [42]	83	9.25			72	9.75

MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy.

Figure 11



Meta-analysis for mean operative time between RYGB and MGB. MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass.

MGB showed that there was a nonsignificant difference, with a nonsignificant no heterogeneity percent (I^2=0%, P=0.71) and overall effect of 0.72.

Table 18

Discussion

Restrictive bariatric operations such as LAGB, VBG, and SG are commonly used because they are technically simple, low risk, and have satisfactory medium-term outcomes [44]. LAGB and VBG were common bariatric treatments in the late 1990s. Initially, good outcomes were reported, with weight loss of 54–58% [45]. Extended follow-up, on the contrary, revealed considerable failure rates (20–56%) [46]. Pouch dilatation or slippage is the most common cause of failure. Band erosion, tubing leakage, or port site issues (inversion, hernia, or discomfort) are all possible reasons [47].

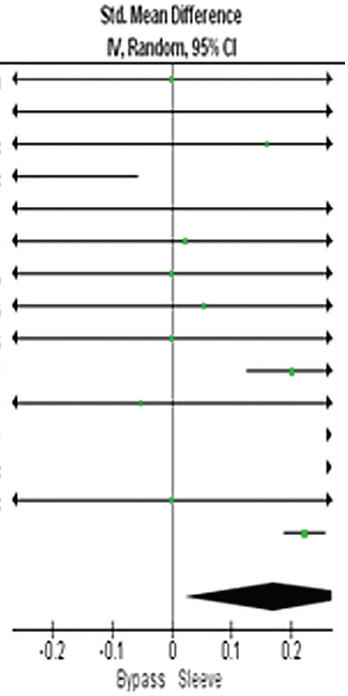
In 1987, DeMeester conducted the first SG as part of his biliopancreatic diversion with duodenal switch (BPD-DS) procedure [48]. The effect of SG is thought to be due to ghrelin restriction and decrease caused by the ablation of orexigenic cells, as well as hastened stomach emptying [49]. It was initially employed as a two-step technique for the superobese, but it resulted in good weight loss and comorbidity resolution with minimal complication rates [50]. As a result, LSG is becoming more popular as a stand-alone operation, with promising long-term results [51].

The effect of SG on weight loss, hypertension, type 2 diabetes mellitus, and dyslipidemia has received a lot of

Figure 12

Study or Subgroup	Bypass Mean	Bypass SD	Bypass Total	Sleeve Mean	Sleeve SD	Sleeve Total	Weight	Std. Mean Difference IV, Random, 95% CI	Year
Bhaskar et al, 2010	3	2.5	15	3	2	26	4.1%	0.00 [-0.64, 0.64]	2010
Abu-ghazla et al, 2011	3.9	1.5	18	4.3	1.4	18	3.9%	-0.27 [-0.93, 0.39]	2011
Marin-Perez et al, 2013	5	7	39	4	4	20	5.1%	0.16 [-0.38, 0.70]	2013
Moon et al, 2013	1.2	0.4	41	1.5	0.5	13	4.0%	-0.70 [-1.33, -0.06]	2013
Gonzalez-Herida et al, 2014	2.64	1	12	3	1	26	3.6%	-0.35 [-1.04, 0.34]	2014
Caradina et al, 2014	7.1	18.5	74	6.7	15	34	7.2%	0.02 [-0.38, 0.43]	2014
Castro et al, 2015	6	6.25	71	6	1.25	17	5.3%	0.00 [-0.53, 0.53]	2015
Wezenbeek et al, 2016	4.1	5.8	115	3.8	2.2	16	5.3%	0.05 [-0.47, 0.58]	2016
Angrisani et al, 2016	3	0.5	24	3	2	27	5.0%	0.00 [-0.55, 0.55]	2016
Janik et al, 2017	2.3	2.8	1354	1.8	2.1	1354	14.9%	0.20 [0.13, 0.28]	2017
Pawan et al, 2017	5.33	3.3	35	5.7	11.4	17	4.7%	-0.05 [-0.63, 0.53]	2017
Yilmaz et al, 2017	6.7	1.4	9	4.2	1.1	23	2.2%	2.05 [1.11, 2.99]	2017
Creange et al, 2018	3.33	1.78	192	2.11	1.2	283	12.3%	0.83 [0.64, 1.02]	2018
Khan et al, 2018	3	0.5	113	3	1	28	7.1%	0.00 [-0.41, 0.41]	2018
Janik et al, 2021	2.05	1.53	5043	1.63	2.04	9192	15.3%	0.22 [0.19, 0.26]	2021
Total (95% CI)			**7155**			**11094**	**100.0%**	**0.17 [0.02, 0.32]**	

Heterogeneity: Tau² = 0.04; Chi² = 71.99, df = 14 (P < 0.00001); I² = 81%
Test for overall effect: Z = 2.24 (P = 0.03)



Meta-analysis for mean length of hospital stay between gastric bypass and sleeve gastrectomy.

attention in the literature [52]. However, modification is required. SG had not yet received enough attention. Patients receiving VBG or AGB procedures are aware that after surgery, there is a significant rate of revision. The question that arises is whether we should convert SG at the same rate according to the VBG or LAGB technique. This is an important query that requires an answer. [53].

Restrictive operations are more likely to result in weight increase over time, especially if patients have some risk factors (age over 45 years, BMI >50 kg/m^2, eating habits maintenance, and absence of medical follow-up). To evaluate the results, Deitel and Greeinstein advise using the percentage of excess BMI decrease. As a result, if it exceeds 65%, it is termed great; decent if it is between 50 and 65%; and failure if it is less than 50% [54].

There are two scenarios in which weight regain may occur:

(1) Patients who do not have a larger gastric volume. This is a rare occurrence (around 10%), and it mainly happens in persons with eating disorders who eat a high-calorie soft or liquid diet. A malabsorptive method, such as a duodenal switch or a gastric bypass, is the best revisional surgery. The small intestine's enhanced production of ghrelin as a compensation for the excision of the gastric fundus plays a poorly understood role in the technique's failure [49].
(2) Excessive pressure on the gastric remnant induced by excessive food intake, recurrent vomiting, or distal obstruction causes patients with increased stomach volume to dilate gradually over time. Furthermore, the characteristics of the stomach wall may differ, allowing for a bigger dilatation in certain patients than in others [55].

Failure after bariatric surgery is defined as losing less than 50% of EWL during 18–24 months or having a BMI of more than 35 [56].

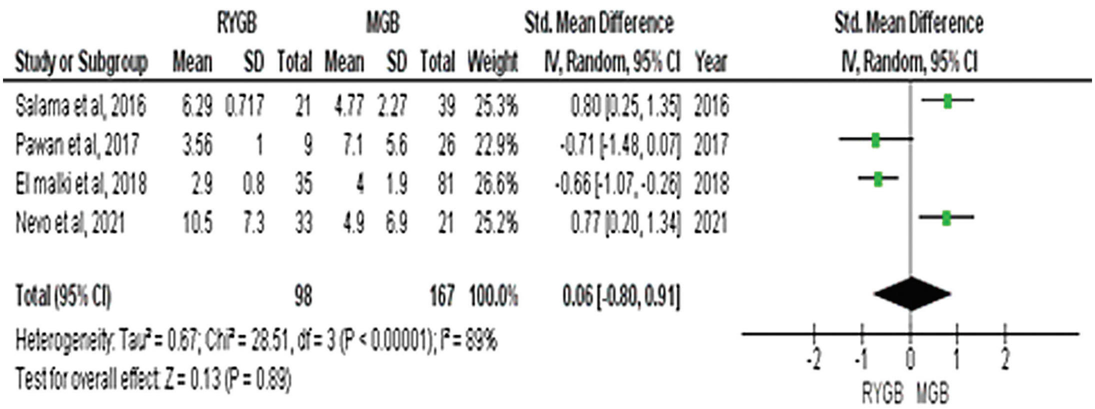
There are three different terms describing the procedures after primary restrictive operation failure. First one is 'revision' which means an operation that corrects or adjusts the anatomy of a bariatric procedure to improve the outcome in circumstances when the anatomy differs from what was intended or if it had previously been modified and has not resulted in the desired outcome. This also contains manipulation of a gadget that does not result in reversal or conversion. Second term is named 'conversion,' which means changing the anatomy of a bariatric procedure to that of a another, well-known bariatric procedure, and last one is 'reversal,' meaning an operation that restores the GI tract's native anatomy [57].

Table 16 Length of hospital stay

		RYGB		SG		MGB	
No	Study	Mean	SD	Mean	SD	Mean	SD
1	Bhaskar *et al*. [12]	3	2.5	3	2		
2	Abu-ghazla *et al*. [13]	3.9	1.5	4.3	1.4		
5	Moon *et al*. [16]	1.2	0.4	1.5	0.5		
7	Marin-Perez *et al*. [18]	5	7	4	4		
10	Carandina *et al*. [21]	7.1	18.5	6.7	15		
11	Gonzalez-Heredia *et al*. [22]	2.64	1	3	1		
12	Castro *et al*. [23]	6	6.25	6	1.25		
13	Angrisani *et al*. [24]	3	0.5	3	2		
16	Pawan *et al*. [27]	3.56	1	5.7	11.4	7.1	5.6
17	Janik *et al*. [28]	2.3	2.8	1.8	2.1		
18	Creange *et al*. [29]	3.33	1.78	2.11	1.2		
20	Khan *et al*. [31]	3	0.5	3	1		
22	Almalki *et al*. [33]	2.9	0.8			4	1.9
24	Janik *et al*. [35]	2.05	1.53	1.63	2.04		
25	Salama and Sabry [4]	6.29	0.717			4.77	2.27
26	van Wezenbeek *et al*. [36]	4.1	5.8	3.8	2.2		
27	Nevo *et al*. [37]	10.5	7.3			4.9	6.9
29	Yilmaz *et al*. [39]	6.7	1.4	4.2	1.1		

MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy.

Figure 13



Meta-analysis for mean length of hospital stay between RYGB and MGB. MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass.

SG, RYGB, OAGB-MGB, single-anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S), and BPD-DS are all common revision surgeries. There are no guidelines or assertions of agreement regarding the preferred method of revision [44].

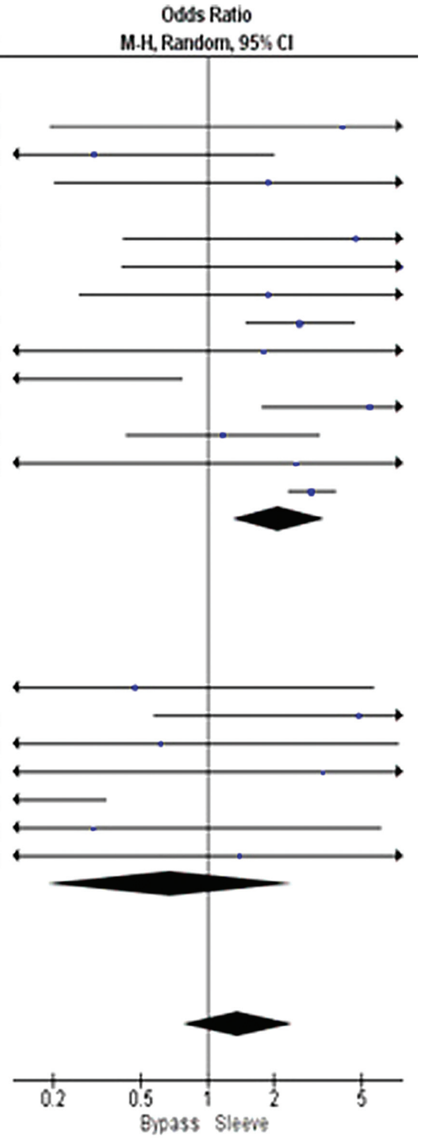
The current study finds an evidence of BMI reduction and/or less surgical complications following revisional surgeries (LRYGB, mini gastric bypass-one-anastomosis gastric bypass (MGB-OAGB), and LSG) after failed restrictive bariatric surgeries.

VBG was once a limiting treatment that is now very rarely used. However, bariatric surgeons frequently have to deal with patients who have had a failed VBG, which is routinely done in the open approach. The most common reason for VBG revision is weight gain, which can occur owing to a breakdown of the staple line or because patients learned to eat food that disintegrates quickly, evading the procedure's restrictive feature. In such circumstances, the initial step in the modification should be to remove the VBG band. Gastrogastrostomy can help patients with restricted symptoms who are not interested in undergoing further bariatric surgery. However, individuals are quite likely to acquire weight as a result of the operation [58].

In relation to LAGB, failure symptoms range from technical faults in the band instrumentation, such as leaks from the pipe connecting the band to the port, to

Figure 14

Study or Subgroup	Bypass Events	Bypass Total	Sleeve Events	Sleeve Total	Weight	Odds Ratio M-H, Random, 95% CI	Year
9.1.1 early							
Stefanidis et al, 2013	0	25	0	23		Not estimable	2013
Khourshed et al, 2013	2	53	0	42	2.7%	4.13 [0.19, 88.30]	2013
Marin-perez et al, 2013	2	39	3	20	5.2%	0.31 [0.05, 2.01]	2013
Caradina et al, 2014	4	74	1	34	4.2%	1.89 [0.20, 17.54]	2014
Ngiam et al, 2016	0	9	0	9		Not estimable	2016
Yeung et al, 2016	2	32	1	72	3.7%	4.73 [0.41, 54.20]	2016
Pawan et al, 2017	6	35	0	17	2.9%	7.71 [0.41, 145.38]	2017
Yilmaz et al, 2017	2	9	3	23	4.9%	1.90 [0.26, 13.87]	2017
Janik et al, 2017	44	1354	17	1354	10.5%	2.64 [1.50, 4.65]	2017
Qiu et al, 2018	3	16	0	3	2.5%	1.81 [0.07, 43.99]	2018
Avsar et al, 2018	1	29	6	20	4.3%	0.08 [0.01, 0.76]	2018
Creange et al, 2018	14	192	4	283	8.1%	5.49 [1.78, 16.93]	2018
Antonopulos et al, 2019	11	83	7	61	8.6%	1.18 [0.43, 3.24]	2019
Alsabah et al, 2020	1	46	0	38	2.5%	2.54 [0.10, 64.12]	2020
Janik et al, 2021	172	5043	108	9192	11.5%	2.97 [2.33, 3.79]	2021
Subtotal (95% CI)		**7039**		**11191**	**71.5%**	**2.12 [1.31, 3.41]**	
Total events	264		150				
Heterogeneity: Tau² = 0.21; Chi² = 20.46, df = 12 (P = 0.06); I² = 41%							
Test for overall effect: Z = 3.09 (P = 0.002)							
9.1.2 late							
Abu-ghazla et al, 2011	1	18	2	18	3.6%	0.47 [0.04, 5.71]	2011
Marin-Perez et al, 2013	8	39	1	20	4.4%	4.90 [0.57, 42.34]	2013
Moon et al, 2013	2	41	1	13	3.6%	0.62 [0.05, 7.39]	2013
Ngiam et al, 2016	1	9	0	9	2.4%	3.35 [0.12, 93.83]	2016
Wezenbeek et al, 2016	18	115	10	16	8.0%	0.11 [0.04, 0.34]	2016
Yeung et al, 2016	0	32	3	72	2.8%	0.31 [0.02, 6.09]	2016
Avsar et al, 2018	2	29	1	20	3.7%	1.41 [0.12, 16.66]	2018
Subtotal (95% CI)		**283**		**168**	**28.5%**	**0.68 [0.19, 2.45]**	
Total events	32		18				
Heterogeneity: Tau² = 1.55; Chi² = 13.37, df = 6 (P = 0.04); I² = 55%							
Test for overall effect: Z = 0.59 (P = 0.55)							
Total (95% CI)		**7322**		**11359**	**100.0%**	**1.38 [0.78, 2.44]**	
Total events	296		168				
Heterogeneity: Tau² = 0.72; Chi² = 55.40, df = 19 (P < 0.0001); I² = 66%							
Test for overall effect: Z = 1.09 (P = 0.27)							
Test for subgroup differences: Chi² = 2.65, df = 1 (P = 0.10), I² = 62.3%							



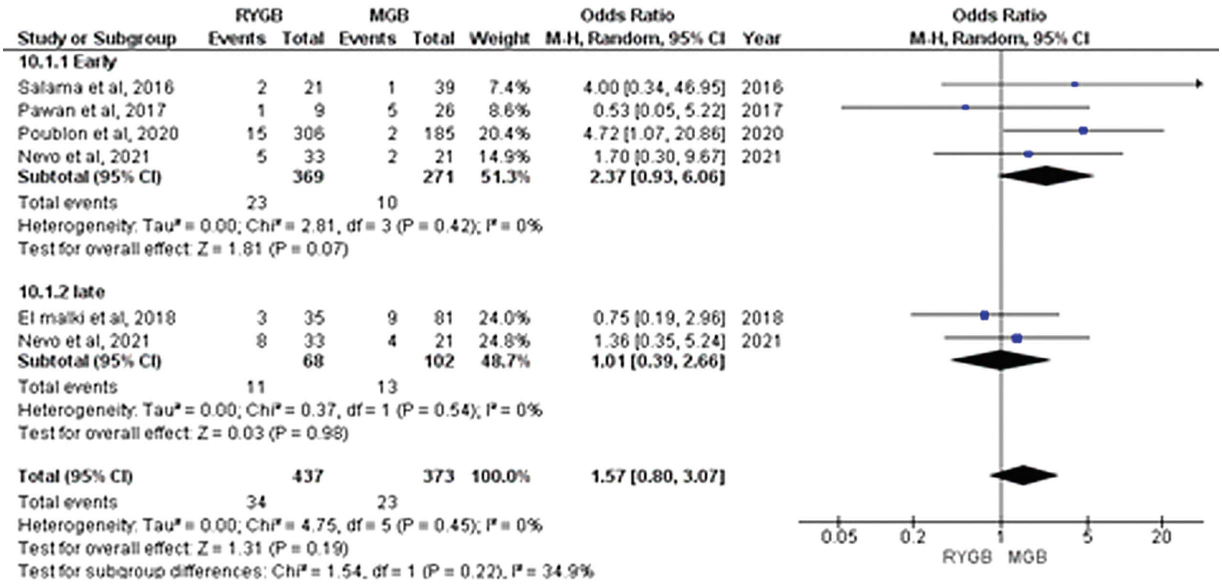
Meta-analysis for incidence of postoperative major complications between gastric bypass and sleeve gastrectomy.

slippage, which necessitates removal of the band or weight regain. Patients who have solely technical problems with their band may benefit from a band replacement or even a port replacement, depending on the situation [59]. Although removing the band relieves restrictive sensations, it is strongly linked to weight gain. The band replacement procedure is frequently associated with a significant complication rate of up to 20% [60].

After demonstrating its success in weight reduction and comorbidity improvement, the LSG was eventually employed as a stand-alone treatment, and it is today the most widely done bariatric procedure in the United States [61]. In other trials, however, the revision rate can reach up to 11%, whether due to insufficient weight loss or severe gastroesophageal reflux illness (GERD). There are several revision alternatives, and the most appropriate technique is determined by the need for the change. Those with severe reflux may benefit from bypass procedures, whereas patients with a dilated sleeve may benefit from re-SG [62].

The overall criteria for conversion were inadequate weight loss (mean incidence=45.8%), weight rebound (mean incidence=42.10%), and GERD (mean incidence=11%) in our review. Consequently, there were no significant difference in age, sex, or preconversion BMI, except for preconversion BMI for patients who had RYGB. The mean time for conversion was 54.68, 52.09, and 38.5 months for RYGB, LSG, and MGB, respectively.

Figure 15



Meta-analysis for incidence of postoperative major complications between RYGB and MGB. MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass.

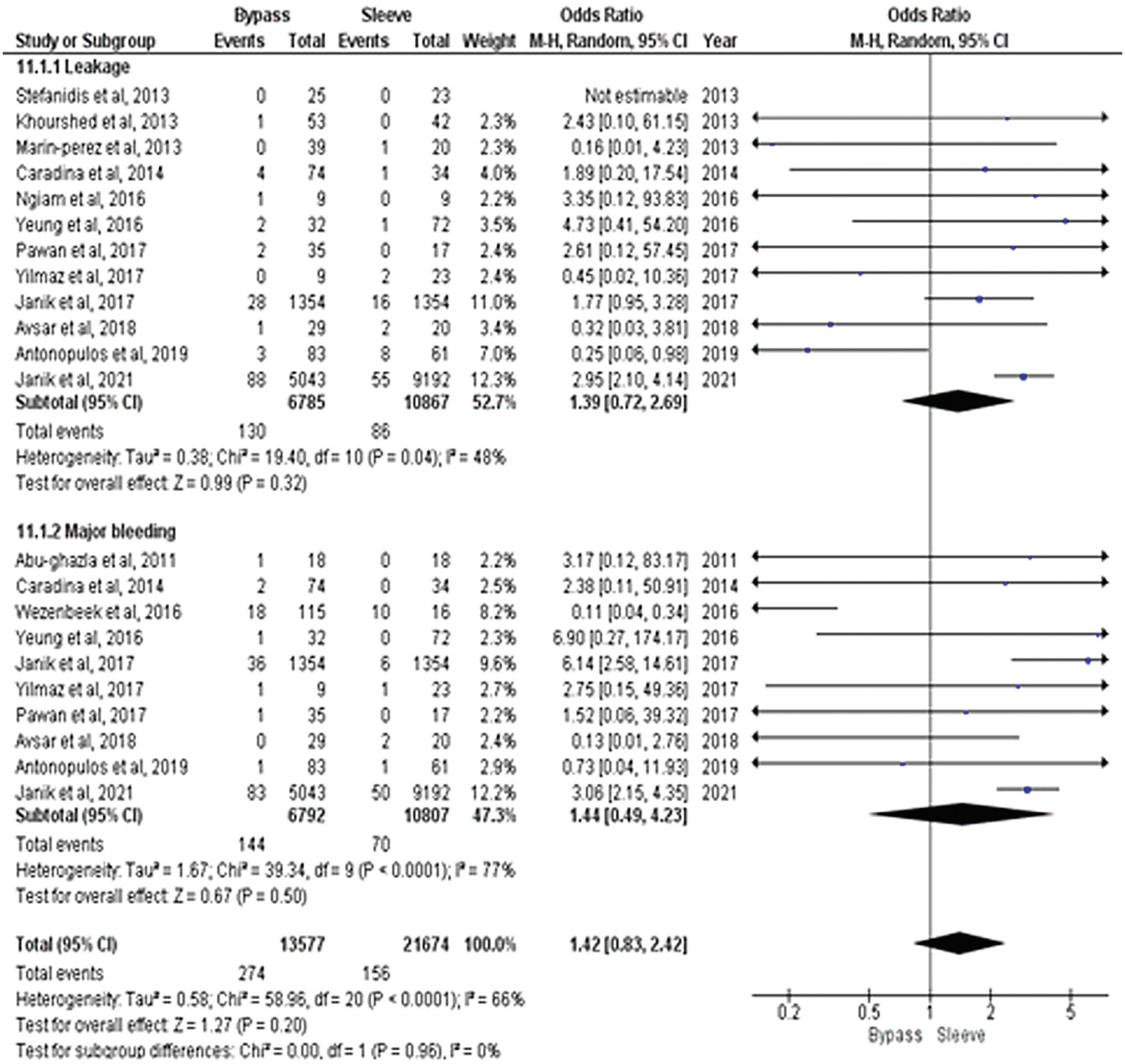
Table 17 Rate of postoperative complications

No	Study	Early major RY	Early major SG	Early major MGB	Late major RY	Late major SG	Late major MGB
2	Abu-ghazla *et al.* [13]				1	2	
5	Moon *et al.* [16]				2	1	
6	Khoursheed *et al.* [17]	2	0				
7	Marin-Perez *et al.* [18]	2	3		8	1	
8	Stefanidis *et al.* [19]	0	0				
10	Carandina *et al.* [21]	4	1				
14	Ngiam *et al.* [25]	0	0		1	0	
15	Yeung *et al.* [26]	2	1		0	3	
16	Pawan *et al.* [27]	1	0	5			
17	Janik *et al.* [28]	44	17				
18	Creange *et al.* [29]	14	4				
19	Avsar *et al.* [30]	1	6		2	1	
22	Almalki *et al.* [33]				3		9
23	Qiu *et al.* [34]	3	0				
24	Janik *et al.* [35]	172	108				
25	Salama and Sabry [4]	2		1			
26	van Wezenbeek *et al.* [36]				18	10	
27	Nevo *et al.* [37]	5		2	8		4
29	Yilmaz *et al.* [39]	2	3				
32	Antonopulos *et al.* [41]	11	7				
33	Poublon *et al.* [42]	15		2			
34	Al-Sabah *et al.* [43]	1	0				

LAGB, laparoscopic adjustable gastric band; MGB, mini gastric bypass; RCT, randomized clinical trial; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy; VBG, vertical band gastroplasty.

It is generally known that individuals who have undergone previous restrictive operations and have had a poor response to weight loss can benefit from a gastric bypass conversion [63]. Although RYGB has been shown to be effective as a revisional technique, OAGB-MGB has recently been advocated as a revisional procedure [64]. Kermansaravi *et al* [65] used OAGB-MGB as an LSG conversion in 77

Figure 16



Meta-analysis for incidence of postoperative leakage and major bleeding between gastric bypass and sleeve gastrectomy.

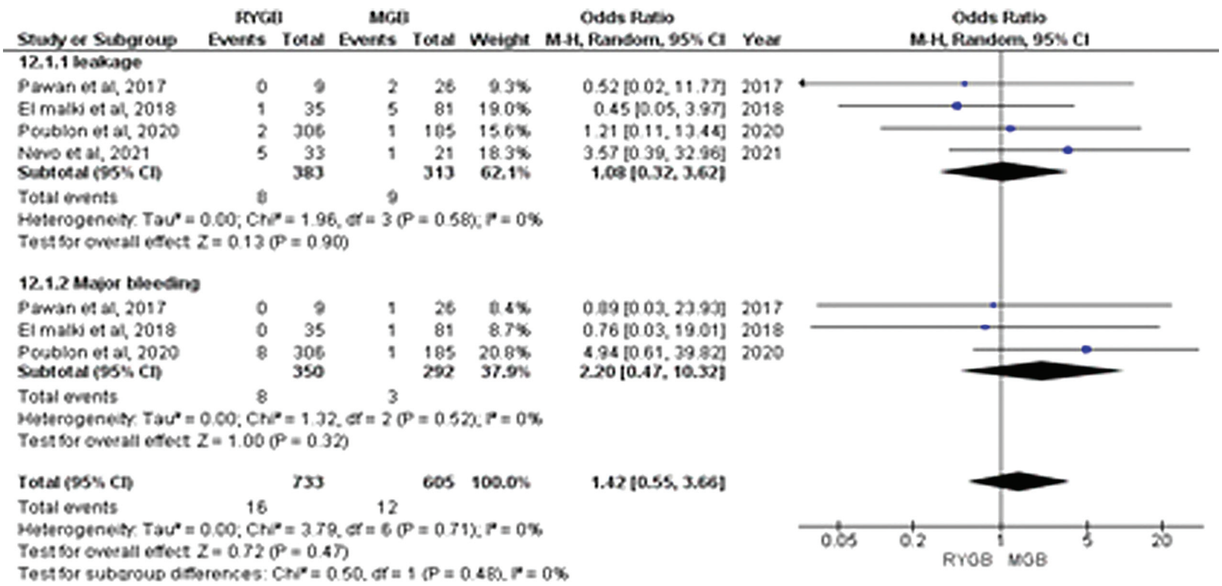
patients, with a low complication rate (3.9%) and an average EWL of 84.1% at 24 months. In a prospective trial of 56 patients who received OAGB-MGB as a revision of SG, Jamal *et al*. [66] discovered an EWL percent of more than 25% at 19 months and 58% at 50-month follow-up, with no mortality or short-term problems.

Because of its proven success as a primary surgery, OAGB-MGB is becoming increasingly popular, and it is now the third most commonly performed primary bariatric surgical operation worldwide [67].

Our meta-analysis showed no significant difference regarding postoperative BMI changes between gastric bypasses (RYGB+MGB) and SG; however, MGB compared with RYGB had a better decrease of BMI in 24 months, with no significant difference between them regarding the overall analysis. On the contrary, 24-, 36-, and 48-month postoperative % EWL was lower in SG than gastric bypasses, with overall significant better decrease. Conversely, when we compared RYGB with MGB at 12 months after conversion, there was more % EWL for RYGB, with significant overall difference.

In addition, the clinical results of Magouliotis *et al.* [68] on % EWL after 24 months backed up our ultimate judgment. Magouliotis *et al.* [68], Sharples *et al.* [69], and Zhou *et al.* [70] conducted meta-analyses that found no statistical difference in % EWL at 12 months, contrary to our findings. Sharples *et al.* [69] claimed that after 24 months, there was no statistical difference in % EWL. This

Figure 17



Meta-analysis for incidence of postoperative leakage and major bleeding between RYGB and MGB. MGB, mini gastric bypass; RYGB, Roux-en-Y gastric bypass.

Table 18 Rate of postoperative leakage and major bleeding complications

		Leakage			Major bleeding		
No	Study	RYGB	SG	MGB	RY	SG	MGB
2	Abu-ghazla *et al.* [13]	0	1		1	0	
6	Khoursheed *et al.* [17]	1	0				
7	Marin-Perez *et al.* [18]	0	1				
8	Stefanidis *et al.* [19]	0	0		0	0	
10	Carandina *et al., 2014* [21]	4	1		2	0	
14	Ngiam *et al.* [25]	1	0				
15	Yeung *et al.* [26]	2	1		1	0	
16	Pawan *et al.* [27]	0	0	2	0	0	1
17	Janik *et al.* [28]	28	16		36	6	
19	Avsar *et al.* [30]	1	2		0	2	
22	Almalki *et al., 2018* [33]	1		5	0		1
24	Janik *et al.* [35]	88	55		83	50	
27	Nevo *et al.* [37]	5		1			
29	Yilmaz *et al., 2017* [39]	0	2		1	1	
32	Antonopulos *et al.* [41]	3	8		1	1	
33	Poublon *et al.* [42]	2		1	8		1

LAGB, laparoscopic adjustable gastric band; MGB, mini gastric bypass; No, number of patients; RCT, randomized clinical trial; RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy; VBG, vertical band gastroplasty.

meta-analysis showed a significant shorter operation time and length of stay for SG in comparison with gastric bypasses, whereas comparing RYGB and MGB, the later had a significant shorter operation time, with no difference regarding length of stay.

The early major complications, in our meta-analysis, were more evident in patients who had sleeve than gastric bypasses. It is tough to make firm conclusions; however, the greater complication rate after LSG could imply that the stomach tissue (e.g. scar tissue) needs time to heal following banding. There is a scarcity of literature on one-step or two-step revisions, but in a recent systematic review, Dang *et al.* [71] concluded that with equal morbidity rates, one-step and two-step revisional bariatric procedures are both safe alternatives. However, both SG and gastric bypasses had no significant difference regarding postoperative leakage and major bleeding.

The lack of randomized trials in the current literature about the examined topic is a major limitation of this study. We were only able to look at retrospective articles; therefore, it cannot be regarded definitive. A controlled randomized trial may provide a solution to the inquiry concerning the various forms of the benefits of revision surgery. Another significant issue that needs to be aware of is the possibility of a distinction (and as a result, there is a difference in weight reduction after revision) between the two groups. Finally, clinical studies are needed to be focused on different causes for revision surgeries to clarify if there is any relation between the indications and outcomes of the revision surgeries.

Recommendations

(1) Excessive pressure on the gastric remnant induced by excessive food intake, recurrent vomiting, or distal obstruction causes patients with increased stomach volume to dilate gradually over time.
(2) Patients who do not have a larger gastric volume. This is a rare occurrence (around 10%), and it mainly happens in persons with eating disorders who eat a high-calorie soft or liquid diet. A malabsorptive method, such as a duodenal switch or a gastric bypass, is the best revisional surgery.
(3) Our meta-analysis found no significant differences in postoperative BMI reductions between gastric bypasses (RYGB+MGB) and SG, although MGB had a greater BMI decrease in 24 months than RYGB, with no significant differences in the total study.
(4) At 24, 36, and 48 months after surgery, SG had a lower EWL percent than gastric bypasses, with a much greater total reduction. When we compared RYGB with MGB at 12 months after conversion, RYGB had a higher EWL percent, with a significant overall difference.
(5) There was no significant difference between bypasses and SG regarding major complications such as leakage and major bleeding.
(6) A controlled randomized trial may provide a solution to the inquiry concerning the various forms of the benefits of revision surgery.
(7) There is a difference in weight reduction after revision according to the cause for revision.

Conclusion

(1) Restrictive operations are more likely to result in weight increase over time, especially if patients have some risk factors (age over 45 years, BMI >50 kg/m^2, eating habits maintenance, and absence of medical follow-up).
(2) To evaluate the results, Deitel and Greeinstein advise use the percentage of excess BMI decrease. As a result, if it exceeds 65%, it is termed great; decent if it is between 50 and 65%; and failure, if it is less than 50%.
(3) SG, RYGB, OAGB-MGB, SADI-S, and BPD-DS are all common revision surgeries, with no guidelines or assertions of agreement regarding the preferred method of revision.
(4) The overall criteria for conversion were inadequate weight loss (mean incidence=45.8%), weight rebound (mean incidence=42.10%), and GERD (mean incidence=11%) in our review.
(5) There was no significant difference in age, sex, or preconversion BMI, except for preconversion BMI for patients who had RYGB. The mean time for conversion was 54.68, 52.09, and 38.5 months for RYGB, LSG, and MGB, respectively.
(6) Our meta-analysis showed no significant difference regarding postoperative BMI changes between gastric bypasses (RYGB +MGB) and SG; however, MGB compared with RYGB had a better decrease of BMI at 24 months, with no significant difference between them regarding the overall analysis.
(7) The 24-, 36-, and 48-month postoperative % EWL was lower in SG than gastric bypasses, with overall significant better decrease. Conversely, when we compared RYGB with MGB at 12 months after conversion, there was more % EWL for RYGB, with significant overall difference.
(8) The study showed a significant shorter operation time and length of stay for SG in comparison with gastric bypasses, whereas when comparing RYGB and MGB, the later had a significant shorter operation time, with no difference regarding length of stay.
(9) The early major complications, in our meta-analysis, were more evident in patients who had sleeve than gastric bypasses.
(10) Both SG and gastric bypasses as revisional operations had no significant difference regarding postoperative leakage and major bleeding.

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Conflicts of interest

There are no conflicts of interest.

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