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Original Article

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Single Anastomosis Duodeno-Ileal Bypass (SADI) as a Second Step After Failed Sleeve Gastrectomy: Systematic Review and Meta-analysis

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Conflict of Interest
None of the authors have any conflict of interest.

ABSTRACT

Purpose: Our aim in this study is to assess single anastomosis duodeno-ileal bypass (SADI) as a salvage procedure following sleeve gastrectomy (SG), examining its technical feasibility, outcomes, and potential complications.

Materials and Methods: A systematic review and meta-analysis were conducted, drawing data from PubMed, Medline, and the Cochrane library. The analysis encompassed 14 studies, involving 1,066 patients. We evaluated operative time, comorbidity resolution (hypertension, dyslipidemia, diabetes), post-operative diarrhea incidence, excess weight loss (EWL) at six, twelve, and twenty-four months, and post-operative leak rates.

Results: SADI as a salvage procedure following SG yielded positive outcomes. Mean operative time was 125.98 minutes (95% CI 102.50–149.46, I^2=99%). Importantly, SADI led to comorbidity resolution in a notable proportion of cases: hypertension in 48% (95% CI 38–57%, I^2=44%), dyslipidemia in 55% (95% CI 40–69%, I^2=30%), and diabetes in 63% (95% CI 53–72%, I^2=30%) of patients. Post-operative diarrhea incidence was relatively low at 2% (95% CI 1–9%, I^2=75%). In terms of weight loss, SADI patients exhibited substantial EWL: 47.73% (95% CI 37.86–57.61, I^2=95%) at six months, 59.39% (95% CI 51.18–67.61, I^2=95%) at twelve months, and 23.84% (95% CI 5.76–41.92, I^2=100%). At twenty-four months. Furthermore, post-operative leak rate was relatively low, reported in only 1% (95% CI 0–5%, I^2=80%) of cases.

Conclusion: SADI as a salvage procedure post-SG demonstrates technical feasibility and marked effectiveness. It offers substantial comorbidity resolution, significant weight loss, and low post-operative complication rates, notably post-operative leaks. Further research should investigate the long-term impact of SADI on patient nutritional status to facilitate its broader adoption.

Keywords: Sleeve gastrectomy; Gastric bypass; Bariatric surgery; Weight reductions; Jejunoileal bypass

Author Contributions

Conceptualization: Ataya K, Bsat A, Tannir AH; Data curation: Ataya K, Bsat A, Tannir AH, Jaafareh AM, Formal analysis: Ataya K, Bsat A, Tannir AH, Jaafareh AM; Investigation: Ataya K, Bsat A, Tannir AH, Jaafareh AM; Methodology: Rabih A, Ataya K, Bsat A; Project administration: Ataya K, Jaafreg A; Resources: Ataya K, Bsat A, Tannir AH, Jaafareh AM; Supervision: Ataya K, Abi Saad G; Validation: Ataya K, Bsat A, Tannir AH, Rabih A; Visualization: Ataya K, Bsat A, Tannir AH, Jaafareh AM, Abi Saad G; Writing - original draft: Ataya K, Bsat A, Tannir AH, Jaafareh AM; Writing - review & editing: Ataya K, Bsat A, Tannir AH, Jaafareh AM, Rabih A

INTRODUCTION

Sleeve gastrectomy (SG) is the most commonly performed bariatric procedure globally, with a staggering 340,550 surgeries recorded in 2016, according to the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) [1]. It has been found to be a highly effective intervention for obesity for a considerable number of patients. Additionally, it has been deemed as an adequate modality for initial intervention in super-obese patients or high-risk patients [2]. If the reduction in weight following a SG proves to be insufficient or if there is a recurrence of weight gain, several alternative surgical solutions can be performed as a secondary measure to address these concerns and promote weight loss, including redo SG, sleeve plication, banding of the sleeve, gastric bypass and duodenal switch (DS) to address these concerns and promote weight loss [3].

The DS has been shown to be the most effective adjunct surgical procedure to SG for optimizing weight loss in the surgical treatment of morbid obesity and its associated health problems. However, it is currently not widely used in bariatric surgeries due to its technical complexity and the potential for long-term complications. In an effort to simplify the DS technique, Sanchez-Pernaute introduced the DS with one anastomosis in 2007 [4]. This single-anastomosis duodeno-ileal (SADI) bypass has been suggested as a viable substitute to the traditional DS technique. It offers the benefit of a less complicated procedure from a technical perspective, and the possibility of decreased morbidity [1].

SADI-S is an operation that effectively removes the Roux limb in favor of a single anastomosis duodenal ileostomy. Additionally, it lengthens the common channel up to three meters and performs the sleeve over a 40 French bougie. This procedure is easily reproducible and ensures successful outcomes. Surgeons can opt to perform the SG first and then proceed with conversion only if a failure or technical challenge is identified. This is made possible thanks to the staging techniques after SG. To the best of our knowledge, this is the first metanalysis conducted to determine if SADI-S is a safe and efficient option for patients who have failed SG.

MATERIALS AND METHODS

1. Study design

This investigation was conducted as a meta-analysis, registered in PROSPERO (CRD42023450417), and with strict adherence to a previously established methodology agreed upon by all contributing authors of the research, in conjunction with adherence to the directives outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines(**Fig. 1**) A comprehensive exploration of the literature was conducted in order to ensure a meticulous and thorough analysis.

2. Statistical analysis

Regarding the categorical outcomes, we evaluated the odds ratio and the 95% confidence interval (95% CI) utilizing the random-effects model (Mantel-Haenszel statistical method). Continuous outcomes were determined by utilizing the weighted mean difference and its 95% CI with random-effects (inverse variance statistical method) models. We opted for the random-effects model.

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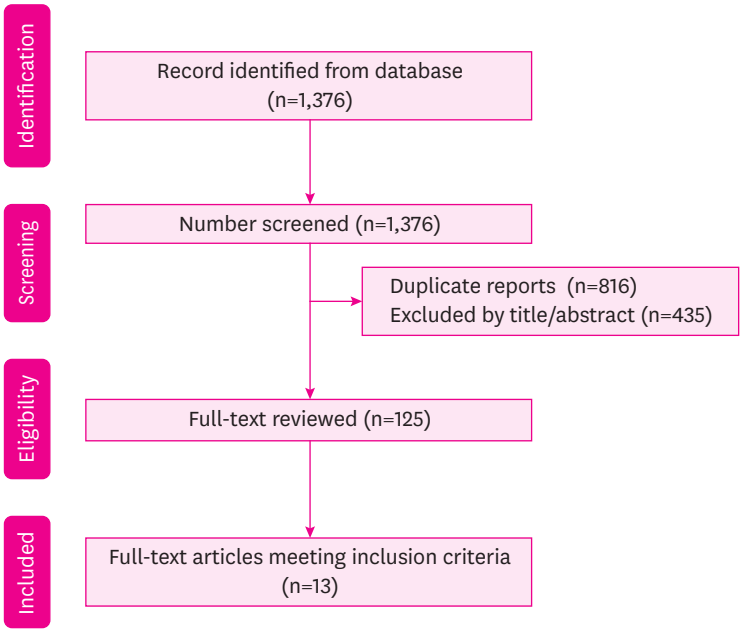

Fig. 1. PRISMA flow diagram of the articles included in this review.
PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

3. Literature search strategy

A comprehensive literature search was conducted in order to ensure a meticulous and thorough analysis. We searched PubMed, Medline, Scopus (Elsevier), and the Cochrane Central Register using various combinations of the following terms in multiple different combinations: ''SADI-S,'' ''SINGLE anastomosis,'' ''sleeve gastrectomy,'' ''weight regain,'' ''failed sleeve,'' ''duodenal switch,'' and "duodeno-ileal''. The inclusion criteria were as follows: any article reporting outcomes of SADI-S after failed SG, and articles published in English from 2007 to 2023.

The exclusion criteria included: meeting abstracts, reviews, case reports, clinical guidelines and articles related to other bariatric surgeries, revision, or conversion procedures.

4. Data extraction

Data were extracted from each included study, including demographics such as sample size for each group, age, sex, preoperative body mass index (BMI), and comorbidities, as well as perioperative outcomes including, mean operative time, mean hospital stay, incidence of intraoperative and postoperative complications and remission of comorbidities. The data extraction process was carried out by two investigators, KA and AA, who ensured data validity by reaching a consensus through comparison. R software version 4.3.1 was employed for data analysis.

5. Quality and publication bias evaluation

The Newcastle-Ottawa Quality Assessment Scale (**Table 1**) was used as an evaluation tool to assess non-randomized controlled trials (non-RCTs) [1,2,4-14]. The scale's range varies from 0 to 9 stars. Studies evaluated with a score equal to or higher than 5 were considered to have adequate methodological quality and were included. Non-RCTs were found in the literature for inclusion. Two investigators (KA and AB) independently rated the included studies and the final decision was reached by consensus.

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Table 1. The Newcastle-Ottawa Scale for assessing the quality of nonrandomized studies

Study	Selection quality (4)	Comparability (2)	Outcome measures and analysis (3)	Total score
Bashah et al. [5]	4	2	3	9
Dijkhorst et al. [6]	4	2	3	9
Moon et al. [7]	4	2	2	8
Sánchez-Pernaute et al. [2]	4	2	3	9
Admella et al. [4]	4	2	3	9
Sánchez-Pernaute et al. [8]	4	2	3	9
Andalib et al. [9]	4	2	2	8
Liagre et al. [1]	4	2	3	9
Salama et al. [10]	4	2	2	8
Zaveri et al. [11]	4	2	3	9
Osorio et al. [12]	4	2	3	9
Balibrea et al. [13]	4	2	3	9
Barajas-Gamboa et al. [14]	4	2	2	8

RESULTS

A total of 13 studies were included in this meta-analysis (**Table 2**), comprising 1,001 patients. Among these patients 77.6% where female while 22.7% were male. The studies were published between 2014 and 2023 and originated from the United States, Canada, Spain, Netherlands, France and Qatar. The mean patient age was 42.56, ranging between 35±15.56 and 48.4±11. The mean BMI before revision was 46.88, ranging between 39.20±6.2 and 56.32±7.62. Comorbidities were mentioned in all the studies and included: hypertension (48.12%), diabetes (29.47%) and dyslipidemia (27.81%).

Operative time was reported in six studies (**Fig. 2A**). The pooled mean operative time was 125.98 minutes (95% CI 102.50–149.46, I^2=99%). The resolution of hypertension was tracked and reported in nine studies (**Fig. 2B**). Pooled mean rate of hypertension resolution was 48% (95% CI 38–57%, I^2=44%). A total of six incidences of perioperative bleeding were reported in five articles (**Fig. 2C**), with a pooled incidence rate of 1% (95% CI 0–1%, I^2 = 0%). Postoperative diarrhea was reported as a complication in four articles (**Fig. 2D**), with an incidence rate of 2% (95% CI 1–9%, I^2=75%).

Table 2. Characteristics of studies included in the meta-analysis

Study ID	Type of study	Journal	Country	Data published	Patients	Male	Female	Mean age	Mean BMI after sleeve	Hyper-tension	Diabetes	Dyslipid-emia
Bashah et al. [5]	Retrospective	Obesity surgery	Qatar	2020	7	2	5	38±9.0	43.7±7.1	4	8	NA
Dijkhorst et al. [6]	Retrospective	Obesity surgery	Netherlands	2021	63	10	53	43.6±10.6	44.9±6.2	30	13	5
Moon et al. [7]	Retrospective	Obesity surgery	USA	2019	9	4	5	41.1±6.4	53.4±9.7	5	4	5
Sánchez-Pernaute et al. [2]	Retrospective	Surgery for obesity and related diseases	Spain	2015	16	4	12	41±11	56.32±7.62	10	9	10
Admella et al. [4]	Cohort	Cirugica espanola	Spain	2021	40	12	28	44.6±10.6	40.1±6.1	13	10	10
Sánchez-Pernaute et al. [8]	Retrospective	Surgery for obesity and related diseases	Spain	2020	51	16	35	41±11	53±8.5	21	19	35
Andalib et al [9]	Retrospective	Surgical endoscopy	Canada	2021	7	2	5	35±15.56	46.6±7.04	1	0	1
Liagre et al. [1]	Retrospective	Obesity surgery	France	2021	106	26	80	46.2±11.7	41.5±6.1	NA	NA	NA
Salama et al. [10]	Retrospective	Surgical endoscopy	Qatar	2023	42	12	30	38.0±9.0	45.9±10.3	4	8	NA
Zaveri et al. [11]	Retrospective	Obesity surgery	USA	2019	96	NA	NA	44.8±11.3	42.8±9.2	45	24	20
Osorio et al. [12]	Cohort	Obesity surgery	Spain	2021	46	13	33	48.4±11.3	39.20±6.2	15	11	13
Balibrea et al. [13]	Prospective	Obesity surgery	Spain	2017	30	8	22	47.83 (30–59)	51.9 (38.5–71)	18	14	16
Barajas-Gamboa et al. [14]	Retrospective cohort	Surgical endoscopy	USA	2023	488	118	370	43.1±11.5	51.4±9.7	266	163	138

NA = not available.

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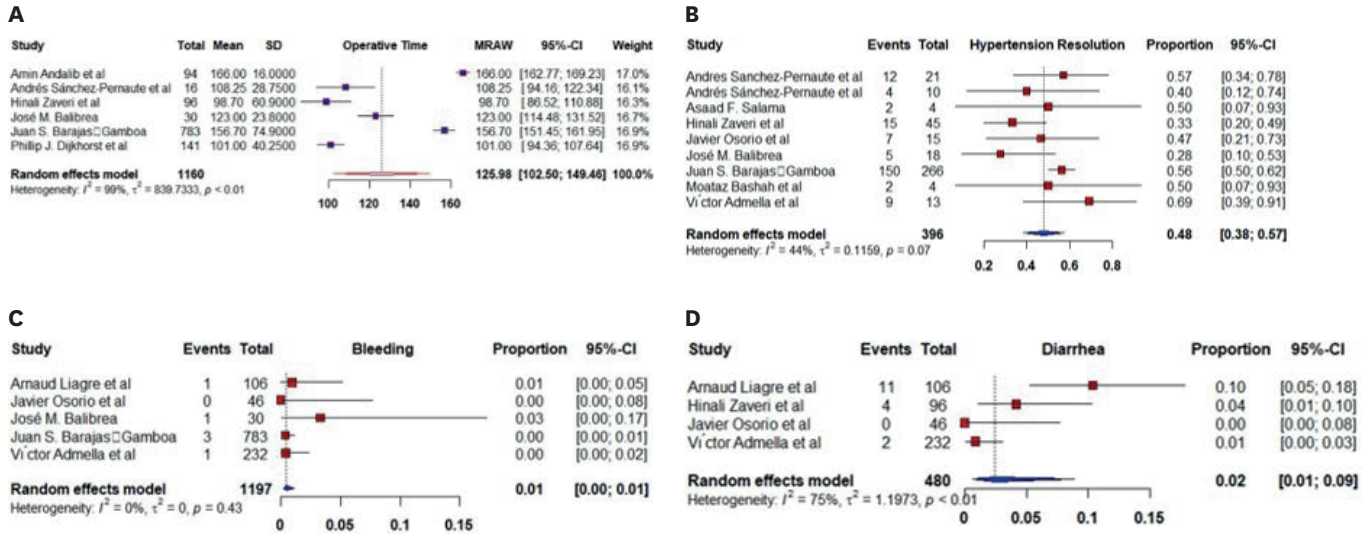

Fig. 2. Forest plot of (A) mean operative time, (B) rate of hypertension resolution, (C) incidence of perioperative bleeding, (D) incidence of postoperative diarrhea. SD = standard deviation, CI = confidence interval.

Diabetes resolution was reported in 10 of the 13 including studies (**Fig. 3A**). Analysis of the rate of diabetes resolution revealed a pooled estimate rate of 63% (95% CI 53–72%, I^2=30%). On the other hand, the resolution of dyslipidemia was reported in seven studies (**Fig. 3B**), with a pooled estimated incidence of 55% (95% CI 40–69%, I^2=30%).

The percentage of excess weight loss (EWL), defined as [baseline weight (after sleeve)−follow up weight (after sadi)×100/[(initial weight after sleeve)−(Ideal weight,)] was reported at six- and 12-month post-procedure in four (**Fig. 4A**) and six (**Fig. 4B**) studies, respectively. Mean pooled EWL was 47.73% (95% CI 37.86–57.61, I^2=95%) at six months and 59.39% (95% CI 51.18–67.61, I^2=95%) at 12 months. Total weight loss (TWL), defined as [initial weight (after sleeve)−(follow up weight after sadi)×100], at two years post-procedure was reported in eight studies (**Fig. 4C**). The pooled mean percentage TWL was 23.84% (95% CI 5.76–41.92, I^2=100%).

The duration of hospital stay was reported in six studies (**Fig. 5A**), with a mean duration of 2.36 days (95% CI 1.22–3.49 days, I^2=80%). Postoperative leak rate was reported in six studies (**Fig. 5B**), revealing a total of 18 incidents of leak, in turn resulting in a pooled incidence of 1% (95% CI 0–5%, I^2=80%).

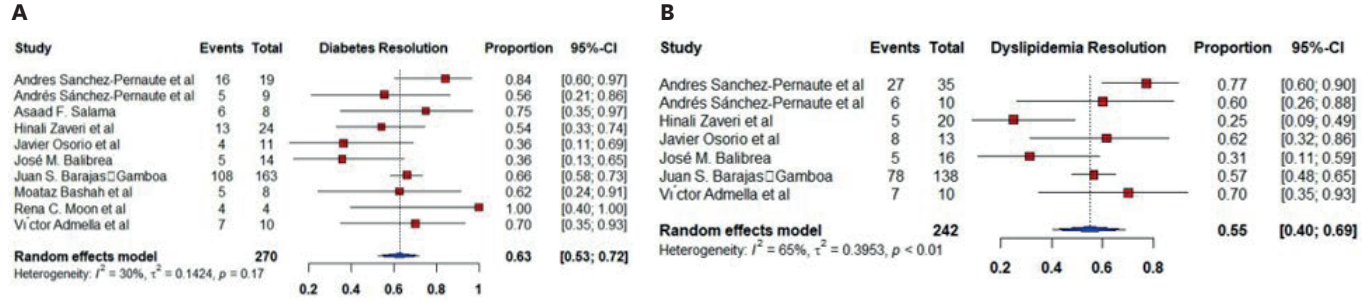

Fig. 3. Forest plot of (A) postoperative resolution of diabetes, (B) postoperative resolution of dyslipidemia. CI = confidence interval.

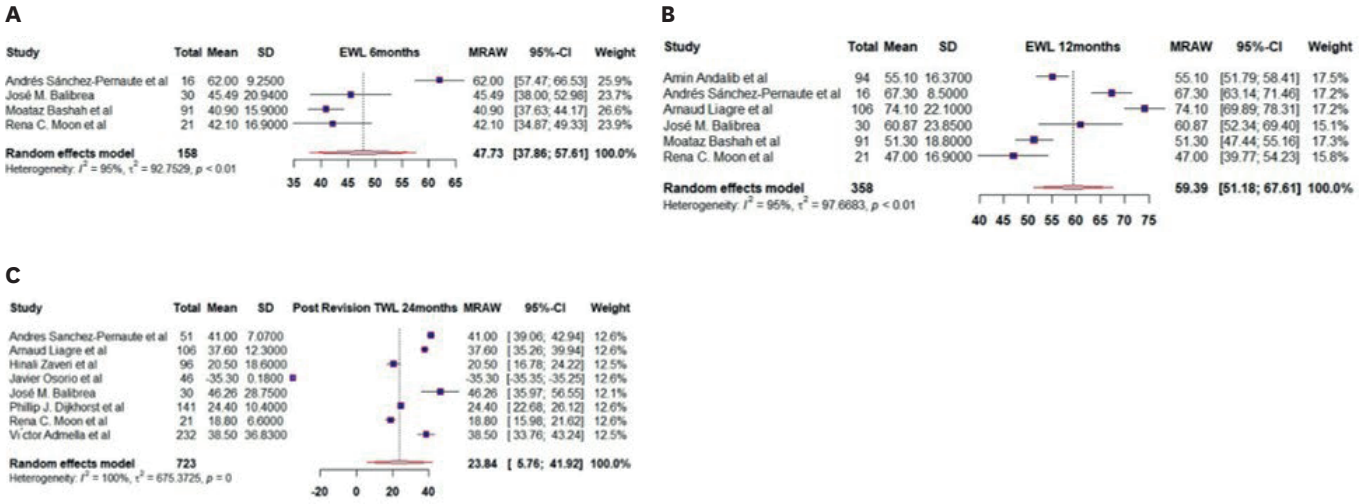

Fig. 4. Forest plot of (A) EWL at 6 months, (B) EWL at 12 months, TWL at 24 months post-operative.
SD = standard deviation, CI = confidence interval, EWL = excess weight loss, TWL = total weight loss.

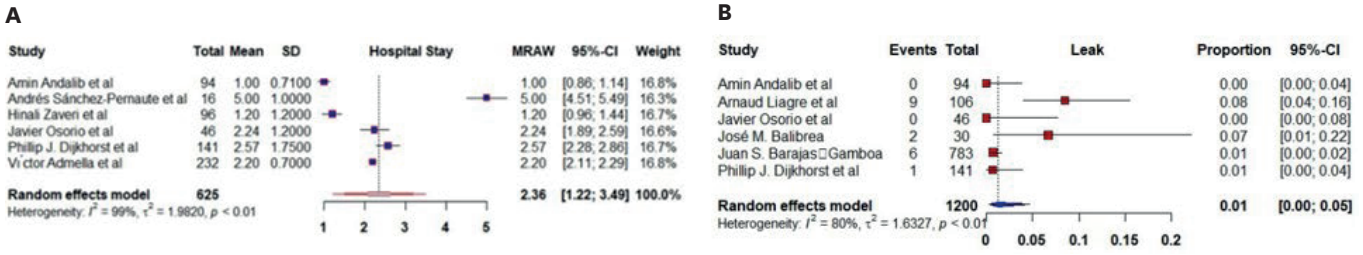

Fig. 5. Forest plot for (A) length of hospital stay, (B) pooled incidence rate of post-operative anastomotic leak.
SD = standard deviation, CI = confidence interval.

DISCUSSION

To this day, there remains a lack of literature addressing the most advantageous surgical approach to undertake in the circumstance of SG failure. However, this has become an increasingly relevant issue as the obesity epidemic continues to worsen and, as a result, the demand for bariatric surgery and subsequent need for revisional bariatric surgery increases. Commonly performed revisional bariatric surgeries after SG include redo SG, biliopancreatic diversion, DS, duodeno-jejunal bypass, one-anastomosis gastric bypass and SADI bypass [15]. To our knowledge, this is the first metanalysis conducted to delineate the outcomes of single anastomosis duodeno-ileal bypass as a prospective alternative for weight reduction following SG [6]. One trend in bariatric surgery is to simplify procedures, leading to the creation of one-anastomosis surgery options such as one anastomosis gastric bypass (OAGB) as an alternative to Roux en Y gastric bypass (RYGB) and SADI as an alternative to DS [1].

In 2007, Pennestrì et al. [16] described the SADI-S technique, which involves replacing the Roux-en-Y reconstruction of the original BPD-DS with a Billroth II-type one-loop duodenoileal anastomosis. The main challenge was determining the appropriate length of the common channel. Initially, a common limb of 200 cm was used, but the length has been increased to 250/300 cm, with common limbs as long as 300 cm being used [16].

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This study showed that EWL after SADI at six months was 47.73% (95% CI 37.86–57.61, I^2=95%) and increased to 59.84% (95% CI 58.03–61.65, I^2=95%) at 12 months. These findings were also demonstrated by Yashkov et al. [17] and Zaveri et al. [11], who reported an EWL% of 77% and 68.6% for SADI at 12 months, respectively. Salama et al's [10] publication reported a significantly higher TWL percentage in patients who underwent SADI-S compared to OAGB—mini-gastric bypass. The SADI-S cohort demonstrated a TWL% of 30.0 ± 18.4, while the OAGB-MGB group had a TWL% of 19.4±16.3. Our analysis revealed a TWL% of 24.11% (95% CI 8.16–40.06, I^2=100%) at two years. Thus, our findings are in line with other articles in the literature, suggesting more effective weight loss results with single-anastomosis duodenal bypass compared to other procedures.

Aside from weight and BMI, the resolution of obesity-related diseases, such as diabetes and dyslipidemia, is an important outcome of bariatric procedures. This meta-analysis revealed pooled rate of resolution of diabetes in 63% (95% CI 53–72%, I^2=30%) and resolution of dyslipidemia in 55% (95% CI 40–69%, I^2=65%) of cases that underwent revisional SADI-S. Andalib et al. [18] reported similar findings of 60–83% resolution of diabetes in patients who underwent revisional SADI-S. One of the primary benefits of this intervention modality is that it greatly simplifies any of the previous derivative procedures and can be specifically tailored and personalized to meet the unique needs of each patient, based on their BMI and associated metabolic comorbidities [19]. SADI-S encompasses all potential mechanisms involved in ameliorating diabetes, including a moderate reduction in caloric intake due to a moderate gastric restriction, duodeno-pancreatic bypass, undigested chyme rapidly entering the distal intestine, selective fat malabsorption, and sustained weight loss in the short term. Therefore, it is understandable why all diabetic patients have achieved complete resolution of their condition by the sixth month following surgery, without requiring specific therapy or diet, and are able to maintain normal levels of glycosylated hemoglobin [20].

Perhaps, the primary reason for surgeons' reluctance to adopt the LSADI-S into their practice is related to the potential long-term sequelae. Whilst this particular procedure has led to a significant decrease in the occurrence of ulcers and internal hernias when compared to RYGB, it has not completely eradicated these complications. One of the feared complications of SADI-S is bile reflux as a result of the Billroth II reconstruction, which eliminates the pyloric barrier. In addition, the risk of malnutrition is still a point of controversy for this procedure. Brown et al. [21] reported a relatively high rate of malnutrition (8%) following SADI-S when the common limb was 200 cm. In addition, Zaveri et al. [11] demonstrated deficiencies in calcium, albumin, total protein vitamin B12 and vitamin D in patients who underwent SADI-S over a two-year follow up. This was managed by extending the common limb to 250–300 cm. A two-year follow up study by Marincola et al. [22] reported Vitamin D and folate nutritional deficiency post-SADI in 31.82% and 9.09% of patients, respectively. These findings underscore the importance of regular nutritional checkups on patients who undergo these revisional bariatric procedures, especially since many obese patients suffer from micronutrient deficiencies even prior to undergoing bariatric surgery. In addition, larger and more comprehensive follow-up studies should be performed to establish protocols for nutritional assessment and management for patients who undergo these revisional bariatric procedures.

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CONCLUSION

Single anastomosis duodenal-ileal bypass as a revisional bariatric procedure following SG is a technically feasible and safe procedure with excellent outcomes related to weight loss and obesity-related illnesses. Nonetheless, further studies are needed with longer follow-up periods to better understand the outcomes, complications and limitations of this procedure and thus better delineate the place of this procedure in the armamentarium of the bariatric surgeon.

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