ELSEVIER

Surgery for Obesity and Related Diseases ■ (2023) 1–14

SURGERY FOR OBESITY AND RELATED DISEASES

ASMBS Guidelines/statements

Endoscopic sleeve gastroplasty and its role in the treatment of obesity: a systematic review

Salvatore Docimo, Jr., D.O., M.B.A., F.A.C.S., F.A.S.M.B.S.[a,*], Laura Aylward, Ph.D.[b], Vance L. Albaugh, M.D., Ph.D., F.A.C.S., F.A.S.M.B.S.[c], Cheguevara Afaneh, M.D.[d], Sofiane El Djouzi, M.D.[e], Mohamed Ali, M.D., F.A.C.S., F.A.S.M.B.S.[f], Maria S. Altieri, M.D., M.S.[g], Jonathan Carter, M.D., F.A.C.S., F.A.S.M.B.S.[h], for the American Society for Metabolic and Bariatric Surgery Clinical Issues Committee

[a]*Department of Surgery, Division of Gastrointestinal Surgery, University of South Florida, Tampa, Florida*
[b]*Rockefeller Neuroscience Institute, West Virginia University of Medicine, Morgantown, West Virginia*
[c]*Department of Metabolic Surgery, Pennington Biomedical Research Center, Metamor Institute, Baton Rouge, Louisiana*
[d]*Department of Surgery, Weill Cornell Medicine, New York-Presbyterian Hospital, New York, New York*
[e]*Bariatric, Gastrointestinal, and Hernia Surgery*
[f]*Department of Surgery, UC Davis Health, University of California, Davis, Davis, California*
[g]*University of Pennsylvania, Philadelphia, Pennsylvania*
[h]*Department of Surgery, University of California, San Francisco, San Francisco, California*

Received 15 August 2023; accepted 28 August 2023

Background

Obesity rates nearly tripled from 1975 to 2016 across the globe [1]. As obesity rates have increased, so have obesity-related co-morbidities such as cardiovascular disease, diabetes, hypertension, hyperlipidemia, obstructive sleep apnea, liver and kidney disease, and cancer [2–4]. To date, metabolic and bariatric surgery (MBS) remains the most effective treatment modality for patients with severe obesity [5], with laparoscopic sleeve gastrectomy (LSG) being the most prevalent bariatric procedure performed worldwide [6]. Although the safety profile of LSG is excellent, complications such as leaks, bleeding, strictures, gastroesophageal reflux disease (GERD), and Barrett esophagus can occur, which has fueled interest in alternative procedures [7–9]. Perhaps more importantly, patients with mild or moderate obesity, that is, patients with body mass index (BMI) of 35–40 kg/m^2 or 30–35 kg/m^2 with metabolic disease, have not, until recently, been eligible for MBS as a treatment option [10]. For such patients with earlier stages of obesity, effective and durable treatment options have been limited, opening the possibility of alternative procedures.

Endoscopic sleeve gastroplasty (ESG) is a stomach-sparing, per-oral endobariatric procedure that gained popularity as a treatment option for patients with obesity who do not fulfill eligibility criteria for established bariatric procedures [11]. ESG was first described in 2013 and has undergone various refinements, evolving first from many interrupted endoluminal stitches to several running stitches along the greater curvature of the stomach to plicate the anterior to the posterior walls in a U pattern with additional reinforcement stitches. ESG is designed to replicate a luminal version of a sleeve gastrectomy [12,13]. Key to the performance of ESG is the ability to create full-thickness surgical plications using an endoscopic device.

Since its introduction, ESG has been adopted throughout the world as a treatment option for patients with obesity. Most published studies regarding the effectiveness and safety profile of ESG have been single-center evaluations or systematic reviews [14]. However, a recent prospective, multicenter, randomized trial evaluated 209 patients and

* Correspondence: Salvatore Docimo, Jr., D.O., Department of Surgery, Division of Gastrointestinal Surgery, University of South Florida, 4202 East Fowler Avenue, Tampa, FL 33620.
E-mail address: Docimo@USF.edu (S. Docimo).

https://doi.org/10.1016/j.soard.2023.08.020

demonstrated significant excess weight loss (EWL) after ESG with 2 years of follow-up [15].

An alternative form of endoscopic sutured gastroplasty is the primary obesity surgery endolumenal (POSE) procedure. The POSE procedure has evolved over time, with the current iteration called POSE-2.0 [16]. POSE-2.0 involves placement of 3 circular sets of plications: 2 starting near the incisura and 1 at the fundus–body juncture. The circular plications are designed to limit gastric expansion during meals. Additional vertically arranged plications along the gastric body are then placed to restrict the stomach further [16].

In this statement, we summarize the peer-reviewed scientific literature related to ESG and POSE. For the purposes of this review, we considered ESG, POSE, and POSE-2.0 to be forms of "endoscopic sutured gastroplasty" and use this term to refer to these procedures collectively. Starting first with ESG, we review the indications, weight loss and metabolic outcomes, risk of GERD, and complications. We then review the published literature regarding POSE and POSE-2.0 outcomes. Finally, we discuss issues related to conversion of ESG or POSE to LSG or Roux-en-Y gastric bypass (RYGB) and consider the need to incorporate endoscopic sutured gastroplasty into a multidisciplinary bariatric program.

Methods

We conducted a systematic review based on the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA), as shown in Fig. 1 [17]. The systematic review included published articles in PubMed using the key search terms of "endoscopic sleeve," "endoscopic sleeve gastroplasty," endoscopic sleeve plication," "endoscopic bariatric procedures," "endoscopic procedures for weight loss," and "endoscopic sleeve gastroplasty AND laparoscopic sleeve gastrectomy." All duplicates were removed. After initial screening, a full-text copy of each article was obtained for review. References within the selected articles were then checked manually for additional relevant articles. Selected studies could be of any design. All studies were then evaluated based on inclusion and exclusion criteria: all studies with participants over the age of 18 years, a meta-analysis design, a randomized trial design, or a cohort study

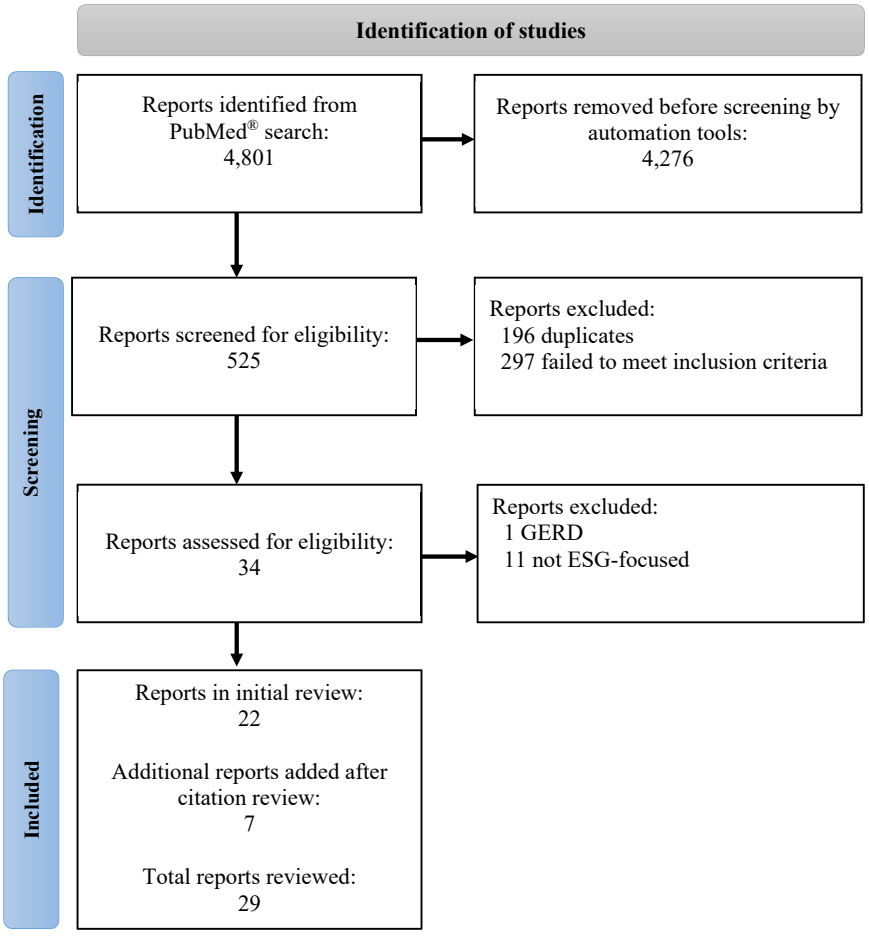

Fig. 1. Identification and Screening for Article Inclusion. GERD = gastroesophageal reflux disease, ESG = endoscopic sleeve gastroplasty.

design were included. All case reports, letters, comments, and animal and in vitro studies were excluded. A total of 4801 studies were screened. After removing duplicates, applying inclusion and exclusion criteria, and adding 5 studies from our review of citations, 27 studies were included in this review (Fig. 1). The characteristics of the 27 included studies are listed in Table 1.

Indications for ESG

There was no consensus in the literature regarding the appropriate BMI indications for endoscopic sutured gastroplasty procedures. For patients with obesity who otherwise met the eligibility criteria for MBS, some investigators believed that endoscopic sutured procedures should be performed as a first-line therapy, before MBS. Other investigators believed that the role of endoscopic sutured procedures should be limited to patients who are overweight (BMI = 25–29.9 kg/m^2) or have class I obesity (BMI = 30–34.9 kg/m^2) and do not meet the BMI eligibility requirements for MBS [13]. Adding to the debate, the indications for MBS recently changed to include patients with lower BMIs, in recognition of the very favorable safety profile and effectiveness of MBS in this population [10]. Current indications for MBS include patients with BMIs of >35 kg/m^2 and patients with BMIs of >30 kg/m^2 with concurrent metabolic disease, lower than the previous 1991 consensus cutoffs of BMIs of >40 kg/m^2 or >35 kg/m^2 with metabolic disease [10]. Hence many patients who historically have sought endoscopic sutured procedures because they were ineligible for MBS are now eligible for MBS under current guidelines [10].

A consensus meeting was organized and gathered Brazilian gastroenterologists and surgeons certified to perform ESG in order to make recommendations regarding the indications for ESG [18]. Forty-seven endoscopists, with a mean number of cases for each expert at 87 ESGs and a combined experience of 1828 cases, established the consensus panel. The following points were agreed on: (1) no maximum age for ESG provided adequate clinical status exists (97% agreement), (2) no consensus for minimum age for ESG (44% voted for >12 yr of age if cleared by a psychologist, endocrinologist, and pediatrician, and 39% voted for >16 yr of age), (3) ideal BMI range for ESG was 30–40 kg/m^2 (100% agreement), (4) minimum BMI for ESG of 27 kg/m^2 (73% agreement), and (5) no maximum BMI provided adequate clinical status exists (100% agreement). With regard to absolute contraindications, the panel concluded that patients with gastric ulcers in the body or fundus (even with no signs of bleeding), congestive gastropathy (high risk of bleeding), gastric polyposis, gastric or esophageal varices, or uncontrolled psychological disease should be excluded from ESG. Mild or moderate gastritis, previous nonbariatric gastric surgery, hyperplastic or benign polyps, and *Helicobacter pylori* infection were not considered as contraindications. It is important to note that the recommendations provided by the consensus panel were only clinical guidelines and that a specific patient's suitability for ESG depended on that patient's clinical circumstance. Therefore, the panel recommended a thorough evaluation by a healthcare professional to determine whether ESG was the right choice for an individual patient [18].

The Brazilian consensus statement aligned with currently published data on ESG indications. Beran et al. [19] published a 2022 meta-analysis comparing 3413 ESG patients with 3362 LSG patients. The mean BMI was 34.9 ± 10.2 kg/m^2 in the ESG group, within the range recommended by the Brazilian consensus panel. Beran et al. [19] also recommended that ESG should be considered as a treatment for patients with class I (BMI = 30–34.9 kg/m^2) and class II (BMI = 35–39.9 kg/m^2) obesity as well as for patients who are poor candidates for or unwilling to undergo MBS. Abu Dayyeh et al. [15] published the Multicenter ESG Randomized Interventional Trial (MERIT) in 2022, a prospective, randomized trial that compared ESG with lifestyle modifications (ESG group) with lifestyle modifications alone (control group) and was limited to patients with class I or class II obesity. The authors concluded that ESG offered an alternative to LSG that could be safely performed in patients with lower BMIs, offering an effective alternative for those wishing to avoid or who do not meet the indications for surgery. GBD 2015 Obesity Collaborators [20] also pointed out that patients with class I and class II obesity were the highest contributors to the global disease burden with regard to co-morbidities and overall mortality, emphasizing the importance of treating obesity this population. Singh et al. [14] published a systematic review and meta-analysis in 2020 evaluating 1859 patients undergoing ESG. Most studies included in this meta-analysis used a BMI of >30 kg/m^2 as the inclusion criterion, with the weighted mean BMI prior to ESG being 36 kg/m^2 [14]. A 2020 study published by Neto et al. [21] evaluated 233 patients who underwent ESG and used class I and class II obesity as the primary indication. Neto et al. [21] also noted that the percentage of excess BMI loss was significantly greater among patients with class I obesity than among those with class II obesity at 6 (51.1% versus 43.7%) and 12 months (60.2% versus 49.2%), supporting an indication for ESG in patients with a BMI of 30–35 kg/m^2.

Though most studies reported on ESG outcomes among patients with BMIs ranging from 30–40 kg/m^2, some studies have been published demonstrating its use in patients with class III obesity (BMI >40 kg/m^2). Fayad et al. [22] retrospectively compared ESG with LSG and noted a median BMI of 43 kg/m^2 (range, 30.2–65.6 kg/m^2) in the ESG group. Hedjoudje et al. [23] performed a systematic review and meta-analysis regarding the safety and efficacy of ESG and noted that some studies reported a baseline BMI of up to 43 kg/m^2. Though these reports suggest that ESG is effective for patients with class III obesity, the majority of

Table 1
Characteristics of studies included in this review.

Author	Year	Study design	Type	Number of patients	Age (yr), mean	Sex	Follow-up (mo.)
Devière et al. [57]	2008	Cohort study	Multicenter	21	44	4 men (19%) 17 women (81%)	6
Abu Dayyeh et al. [13]	2013	Pilot feasibility	Single center	4	37	1 man (25%) 3 women (75%)	3
Miller et al. [42]	2017	RCT	Multicenter	44	38	10 men (23%) 34 women (77%)	12
Sullivan et al. [41]	2017	Randomized, sham-controlled trial	Multicenter	POSE: 221 Control: 111	POSE: 44 Control: 45	POSE: 26 men (12%) 195 women (88%) Control: 10 men (9%) 101 women (91%)	12
Kumar et al. [58]	2018	Cohort study	Multicenter	77	41	18 men (23%) 59 women (77%)	12
Alqahtani et al. [43]	2019	Retrospective analysis	Single center	20 ESG to LSG	40	4 men (20%) 16 women (80%)	12
Cohen et al. [59]	2019	Systematic review	Multicenter	—	Not reported	Not reported	6
Fayad et al. [22]	2019	Case-matched study	Single center	54 ESG 83 LSG	ESG: 48 LSG: 47	ESG group: 23 men (43%) 31 women (57%) LSG group: 24 men (29%) 59 women (71%)	6
García and Velázquez [45]	2019	Cohort study	Multicenter	21	40	3 men (14%) 18 women (86%)	3
Gys et al. [31]	2019	Systematic review and meta-analysis	Multicenter	2475 from 22 studies	4	Not reported	13
Khan [60]	2019	Meta-analysis	Multicenter	1149 from 12 studies	Not reported	Not reported	12
de Miranda Neto et al. [32]	2020	Systematic review and meta-analysis	Multicenter	2170 patients from 11 studies	42	393 men (18%) 1777 women (82%)	18
Fiorillo et al. [26]	2020	Cohort study	Single center	23 patients in the ESG group and 23 patients in the LSG group	ESG: 41 LSG: 37	ESG: 7 men (30%) 16 women (70%) LSG: 6 men (26%) 17 women (74%)	6
Hedjoudje et al. [23]	2020	Systematic review and meta-analysis	Multicenter	1772 from 8 studies	38	1110 men (63%) 662 women (37%)	24 max.
Jalal et al. [28]	2020	Systematic review and meta-analysis	Multicenter	1451 ESG and 203 LSG from 5 studies	Not reported	Not reported	12–24
Li et al. [61]	2020	Meta-analysis	Multicenter	1542 patients from 9 studies	Not reported	Not reported	12
Mohan et al. [29]	2020	Systematic review and meta-analysis	Multicenter	1815 patients from 8 ESG and 2179 patients from 7 LSG studies	Not reported	Men: 25% Women: 75%	12
Neto et al. [21]	2020	Cohort study	Multicenter	233	41	63 men (27%) 170 women (73%)	12
Singh et al. [14]	2020	Systematic review and meta-analysis	Multicenter	1859 patients from 8 studies	42	332 men (18%) 1527 women (82%)	24
Marincola et al. [30]	2021	Systematic review and meta-analysis	Multicenter	2188 patients from 16 studies	ESG: 39 LSG: 35	Men: 20% Women: 80%	12
Lopez-Nava et al. [48]	2021	Retrospective analysis	Single center	75 POSE-2	49.3 (10.2)	Men: 50% Women: 50%	12
Alqahtani et al. [27]	2022	Cohort study	Single center	3018 with ESG and 3018 with LSG	ESG: 33.8 ± 9.6 LSG: 33.9 ± 9.7	ESG: 2686 women (89%) LSG: 2686 women (89%)	36
Beran et al. [19]	2022	Meta-analysis	Multicenter	3413 with ESG and 3362 with LSG from 7 studies	34.9 ± 10.2	87% women	6–36
Brunaldi et al. [12]	2022	Narrative review	Multicenter	N/A	N/A	N/A	N/A

(*continued on next page*)

Table 1 (*continued*)

Author	Year	Study design	Type	Number of patients	Age (yr), mean	Sex	Follow-up (mo.)
Abu Dayyeh et al. [15]	2022	RCT	Multicenter	ESG: 85 Control: 124	ESG: 47 Control: 46	ESG: 9 men (12%) 68 women (88%) Control: 18 men (16%) 92 women (84%)	12
Singh et al. [33]	2022	Systematic review and meta-analysis	Multicenter	613 from 7 studies	42	Women: 80% Men: 20%	Up to 15
Lopez-Nava et al. [16]	2023	Prospective	Multicenter	44	45 ± 9.7	Women: 61% Men: 39%	24

RCT = randomized, controlled trial; POSE = primary obesity surgery endoluminal procedure; ESG = endoscopic sleeve gastroplasty; LSG = laparoscopic sleeve gastrectomy.

published data evaluated outcomes in patients undergoing ESG with class I and class II obesity. Currently, data for the use of ESG in patients with class III obesity are sparse and warrant further investigation.

In addition to treating patients with obesity, some practitioners advocate for ESG as a safe and effective option for individuals who are not candidates for MBS due to medical or surgical contraindications or who are at high risk for complications from MBS due to age, prior operations, medical co-morbidities, or other factors. A recent study showed that ESG was a safe and effective option for individuals who were at high risk for complications from bariatric surgery [14]. Additionally, ESG does not require incisions, making it an attractive option for individuals who want to avoid abdominal scars. Endoscopic gastroplasty may be indicated for individuals who have psychological factors that prevent them from undergoing traditional MBS; for example, a 2017 study showed that ESG was a safe and effective option for individuals who had anxiety or fear of surgery [24]. Finally, ESG may be an effective weight loss option for individuals with metabolic disorders such as diabetes, dyslipidemia, and hypertension. One study showed that ESG resulted in significant weight loss and improved metabolic parameters in individuals with metabolic syndrome [25].

Taken in sum, most published studies on ESG used an indication of initial BMI ranging from 30–40 kg/m^2 across a broad range of ages and co-morbidities. There were relatively sparse data for patients with lower BMIs (27–30 kg/m^2), patients with higher BMIs (>40 kg/m^2), or patients deemed too high of a risk for MBS. Additional research is needed to define the role of ESG in these subsets of patients.

Weight Loss After ESG

One randomized trial, the Multicenter ESG Randomized Interventional Trial (MERIT), randomized 85 participants to ESG and 124 to a control group consisting of lifestyle modification [15]. After 52 weeks, the ESG group experienced 49% EWL compared with 3% EWL in the control group ($P < .0001$) [15]. After controlling for age, sex, baseline BMI, hypertension, and type 2 diabetes, those in the ESG group experienced 45% EWL compared with 13% EWL in the control group ($P < .0001$). Mean percentage of total body weight loss (TBWL) was 13.6% ± 8.0% for the ESG group and .8% ± 5.0% for the control group ($P < .0001$). At 104 weeks, 41 (68%) of 60 participants in the ESG group maintained 25% or more of EWL [15]. This trial demonstrated superiority of ESG over lifestyle modification regarding weight loss.

Two studies have compared outcomes of ESG with those of LSG directly [26,27]. Fiorillo et al. [26] studied 23 pairs of patients matched by age, sex, preoperative weight, and co-morbidities to compare outcomes of ESG versus LSG in patients with a BMI of >40 kg/m^2 or a BMI of >35 kg/m^2 with metabolic disease. Patients who underwent LSG had 55% EWL after 6 months, more than patients who underwent ESG and experienced 40% EWL ($P = .01$) [26]. TBWL also was superior for LSG (19% TBWL) compared with ESG (13% TBWL) at 6 months ($P = .03$) [26]. In a much larger series of patients, Alqahtani et al. [27] performed a propensity score–matched comparison of 3108 pairs of patients with an initial mean BMI of 33 kg/m^2 and compared ESG with LSG. The %EWL at 12, 24, and 36 months after ESG was 77% ± 25%, 75% ± 48%, and 60% ± 57%. In comparison, the %EWL at 12, 24, and 36 months after LSG was increased: 95% ± 21%, 94% ± 31%, and 74% ± 35%, respectively ($P < .001$). During the first 30 days after the procedure, 32% of ESG patients visited an ambulatory clinic compared with only 18% of LSG patients ($P < .001$). Co-morbidity remission rates after ESG versus LSG were not significantly different at 64% versus 82% for diabetes, 66% versus 64% for dyslipidemia, and 51% versus 46% for hypertension, respectively. Adverse events occurred in .5% of ESG patients (bleeding in 10 patients, 4 patients with perigastric collections, and 4 patients with pleural effusions) compared with .3% in the LSG group (6 patients with bleeding and 4 patients with a staple-line leak). During the study, 80 ESG (2.7%) patients were converted to an LSG due to insufficient

weight loss or weight gain after an average of 10 months. Twenty-eight (.9%) ESG patients underwent an endoluminal revision at a mean of 19 months. No LSG patients underwent a weight-related revision during the study period [27]. Taken together, these 2 studies showed that for patients with obesity eligible for either procedure, LSG produced increased weight loss versus ESG without an associated increase in adverse events or complications.

The outcomes of ESG also have been the subject of 8 systematic reviews and meta-analyses, 1 systematic review, and 3 meta-analyses. The earliest systematic review and meta-analysis was published in 2019, and the most recent was published in 2022. Of the 8 systematic reviews and meta-analyses, only 3 included direct comparisons between ESG and LSG [28–30]. In the first systematic review, Jalal et al. [28] reported a pooled %TBWL of 14.2% for ESG versus 23.5% for LSG at 6 months ($P < .001$). At 12 months, %TBWL was 15.2% for ESG and 29.3% for LSG [28]. The review also found that ESG had a lower complication rate, between 2.0% and 2.7%, whereas, comparatively, LSG had a complication rate between 9.2% and 16.9%. In a second review, Mohan et al. [29] summarized 8 studies of ESG in 1815 patients and found %TBWL to be 17.1% at 12 months, significantly less than LSG in 2179 patients who experienced a mean %TBWL of 30.5% ($P = .001$). All adverse events, bleeding, and GERD were significantly lower with ESG when compared with LSG [29]. The third systematic review was conducted by Marincola et al. [30] and included 16 studies with 1429 LSG patients and 759 ESG patients, both groups with a similar mean initial BMI of 34 kg/m^2 [30]. The review found that LSG patients lost, on average, 18% more excess body weight than ESG patients did after 12 months (80% EWL after LSG versus 62% EWL after ESG; $P = .0001$). In contrast to the other systematic reviews, no difference in safety profile was shown between LSG and ESG [30]. Taken as a whole, these systematic reviews reported better weight loss after LSG than after ESG and came to different conclusions as to whether ESG was associated with fewer complications. The remaining 5 systematic reviews and meta-analyses did not include direct comparisons of ESG and LSG [14,23,31–33].

Weight loss outcomes for each included study are summarized in Table 2. Most studies reported weight loss for 18 months of follow-up or less, several studies reported 2-year postoperative weight loss, and the longest follow-up was in a study that reported 3-year weight loss outcomes (Table 2). Most studies were conducted in patients with a starting BMI in the 30–40 kg/m^2 range. %TBWL after 12 months averaged between 13% and 20% across the studies. For studies with follow-up at 2 and 3 years, most reported that the initial weight loss achieved by ESG was sustained (Table 2).

Several authors have investigated the mechanisms of weight loss after ESG. Abu Dayyeh et al. [24] studied 25 patients who underwent ESG and evaluated satiation with a nutrient drink test, evaluated ESG emptying with a gastric emptying study, and measured serum glycemic and hormone changes 2 weeks before and 3 months after the procedure. The study demonstrated delayed gastric emptying after ESG: 32% of a meal was retained in the fundus at 4 hours after ingestion compared to 5% in the preprocedural assessment. With regard to satiation, patients stopped their meals 24 minutes earlier at 3 months compared with before ESG ($P = .01$). The study also noted a 59% decrease in caloric intake in the nutrient drink test ($P = .003$). Interestingly, no statistically significant changes in leptin, glucagon-like peptide 1, and peptide YY levels were noted [24]. In summary, this study showed that ESG resulted in delayed gastric emptying and early satiety without additional hormonal effects.

Metabolic Disease Improvement After ESG

In addition to weight loss outcomes, some studies have reported the effect of ESG on metabolic disease. The outcomes are summarized in Table 3. The majority of the published studies did not report metabolic outcomes. With regard to dyslipidemia, improvements in serum cholesterol and lipid levels were reported in 25%–64% of patients across the studies. In 1 study, dyslipidemia resolved in 64% of ESG patients, similar to the effect of LSG (also 64% resolution) [27]. Several studies reported the effect of ESG on hypertension, with most reporting a beneficial effect. For example, Alqahtani et al. [27] reported that hypertension improved in 51% of patients after ESG and in 46% of patients after LSG. Finally, most studies reviewed showed improvement in diabetes after ESG. Remission of diabetes occurred in 64% of patients after ESG and 82% of patients after LSG according to Alqahtani et al. [27]. Other reports similarly showed improvement in diabetes after ESG (Table 3). Taken in sum, the available published results of ESG show a beneficial effect on obesity-related metabolic disease.

GERD After ESG

GERD is common in patients with obesity and can resolve following weight loss [34–36]. A number of studies have reported consistently low rates of de novo GERD after ESG. Beran et al. [19] performed a meta-analysis of 3413 ESG and 3352 LSG patients. The incidence of new-onset GERD was significantly lower after ESG compared with LSG (1.3% versus 17.9%, respectively; relative risk [RR] = .10; 95% CI, .02–.53; $P = .006$). Abu Dayyeh et al. [15], at the conclusion of their randomized clinical trial with ESG patients, noted that GERD symptoms did not worsen in the ESG group compared with the control group, as measured by a validated monthly questionnaire. Fiorillo et al. [26] performed a quality-of-life evaluation in 23 ESG and 23 LSG patients and noted that 7 of 23 LSG

Table 2
Weight loss after endoscopic sleeve gastroplasty for the reviewed studies,

Study	Mean BMI before ESG (kg/m^2)	Net change in BMI (kg/m^2)	%EWL	%TBWL
Devière et al. (2008) [57]	43.3 ± 5.0	–4.8	1 mo: 16.2% 3 mo: 22.6% 6 mo: 24.4%	Not reported
Abu Dayyeh et al. (2013) [13]	35.9	N/A	N/A	N/A
Miller et al. (2017) [42]	36.2 ± 3.3	Not reported	6 mo: 45.5% 12 mo: 18.1%	6 mo: 12.7% 12 mo: 13.0%
Sullivan et al. (2017) [41]	36.0 ± 2.4	6 mo: –2.4 12 mo: –1.7	6 mo: 22.3% 12 mo: 16.0%	5.0% ± 7.0%
Kumar et al. (2018) [58]	36.1 ± .6	Not reported	Not reported	6 mo: 16.2% ± .7% 12 mo: 17.4% ± 1.1%
Alqahtani et al. (2019) [43]	35.0 ± 4.0	Not reported	12 mo: –5%	3 mo: 7.7% ± 3.5%
Cohen et al. (2019) [59]	No pooled data	No pooled data	No pooled data	No pooled data
Fayad et al. (2019) [22]	43.07, range: 30.2-65.6	1 mo: –9.4% 6 mo: –17.2%	Not reported	6 mo: ESG: 17.1% ± 6.5% LSG: 23.6% ± 7.6%
García and Velázquez (2019) [45]	Standard: 40.3 ± 4.0 18-plication: 47.4 ± 4.1	Not reported	Standard POSE: 41.2% ± 15.1% 18-plication POSE: 35.9% ± 8.4%	Standard POSE: 14.9% ± 5.1% 18-plication POSE: 16.9% ± 4.4%
Gys et al. (2019) [31]	Not reported	Not reported	ESG: 68.3% ± 3.8% POSE: 44.9% ± 2.1%	Not reported
Khan (2019) [60]	Not reported	Not reported	6 mo: ESG: 49.7% POSE: 43.8% 12 mo: ESG: 52.8% POSE: 44.9%	6 mo: ESG: 16.0% POSE: Not Reported 12 Mo: ESG: 17.4% POSE: Not Reported
de Miranda Neto et al. (2020) [32]	35.8	Not reported	12 mo: 60% 18 mo: 73%	12 mo: 16.1% 18 mo: 16.8%
Fiorillo et al. (2020) [26]	39.5	Not reported	ESG: 39.9% (17.5%–58.9%) LSG: 54.9% (46.2%–65%)	ESG: 13.4% (7.8%–20.9%) LSG: 18.8% (17.6%–21.8%)
Hedjoudje et al. (2020) [23]	Not reported	18–24 mo: 6.5	18–24 mo: 66.9%	18–24 mo: 17.1%
Jalal et al. (2020) [28]	Not reported	Not reported	Not reported	6 mo: ESG: 13.7%–15.2% LSG: 23.5%–23.6%
Li et al. (2020) [61]	Not reported	Not reported	12 mo: 59.1%	12 mo: 16.1%
Mohan et al. (2020) [29]	Not reported	Not reported	ESG: 63% LSG: 69.3%	ESG: 17.1% LSG: 30.5%
Neto et al. (2020) [21]	34.7	Not reported	Not reported	19.7%
Singh et al. (2020) [14]	35.8	Not reported	12 mos: 61.8% 24 mo: 60.4%	12 mo: 16.4% 24 mo: 20.0%
Marincola et al. (2021) [30]	34.7 ± 4.7	Not reported	12 mo: ESG: 62.2% LSG: 80.3%	Not reported
Lopez-Nava et al. (2021) [28]	38.2 kg/m^2	7 kg/m^2 (SD, 4.3 kg/m^2)	Not reported	17.8% (SD, 9.5%),
Alqahtani et al. (2022) [27]	32.5 ± 3.1	36 mo: ESG: –4.5 ± 4.0 LSG: –7.2 ± 3.5	36 months: ESG: 59.7% ± 57.1% LSG: 74.3% ± 35.2%	36 mo: ESG: 14.0% ± 12.1% LSG: 18.8% ± 7.5%
Beran et al. (2022) [19]	33.7 ± 4.8	Not reported	ESG: 66.7% ± 28.7%, 6 mo 71.04% ± 24.6%, 12 mo LSG: 76.6% ± 31.3%, 6 mo 94.9% ± 20.6%, 12 mo	ESG: 15.2% ± 6.3%, 6 mo 19.1% ± 7.9%, 12 mo 16.4% ± 10.1%, 24 mo LSG: 18.8% ± 7.5%, 6 mo 28.9% ± 8.2%, 12 mo 22.3% ± 8.3%, 24 mo
Brunaldi et al. (2022) [12]	33.3 ± 4.5	Not reported	Not reported	18%–20%, 18 mo
Abu Dayyeh et al. (2022) [15]	35.5 ± 2.6	Not reported	12 mo: 49.2%	12 mo: 13.6%

(continued on next page)

Table 2 (*continued*)

Study	Mean BMI before ESG (kg/m^2)	Net change in BMI (kg/m^2)	%EWL	%TBWL
Singh et al. (2022) [33]	36.66	Not reported	12 mo: 48.9%	12 mo: 12.7%
Lopez-Nava et al. (2023) [16]	37 ± 2.1	Not reported	Not reported	12 mo: 15.7% ± 6.8%

BMI = body mass index; ESG = endoscopic sleeve gastroplasty; %EWL = percent excess weight loss; %TBWL = percent total body weight loss; LSG = laparoscopic sleeve gastrectomy; POSE = primary obesity surgery endoluminal procedure.

patients (31%) developed postoperative GERD and daily proton-pump-inhibitor use, whereas none of the 23 ESG patients complained of postprocedure GERD symptoms nor reported proton-pump-inhibitor use ($P = .004$) [26]. Similarly, Fayad et al. [22] performed a case-matched study between 54 ESG patients and 83 LSG patients. New-onset GERD was 1.9% after ESG, significantly lower than the 14.5% rate in the LSG group ($P < .05$). Furthermore, a 2020 systematic review and meta-analysis of 8 studies including 1815 patients reported that the pooled rate of de novo GERD after ESG was .4% (95% CI, .1–1.1) and after LSG was 5.8% (95% CI, 3.5–9.3; $P = .001$) [29]. In summary, these studies agreed that GERD after ESG was less common than GERD after LSG.

Why ESG does not seem to create de novo GERD symptoms when LSG does [35,37] remains an open question. Some authors believe that ESG avoids GERD because of its preservation of the angle of His, autonomic nerves, and antrum [38–40]. Others theorize that the lower incidence of de novo GERD after ESG is grounded in the fact that the anatomic restriction and shortening of the stomach after ESG cause no alteration to the esophagogastric junction. With respect to GERD, ESG seems to be fundamentally different from LSG, an operation that has been shown to reduce gastric compliance, increase gastric intraluminal pressure, and disrupt the anatomy of the esophagogastric insertion [26]. Many proponents of ESG stress the low incidence of GERD following the procedure as a primary benefit over LSG.

Complications after ESG

Complications after ESG include both procedure- and device-related complications. Both procedure- and device-related complications have the potential to cause serious adverse events in clinical practice. The technique of ESG involves full-thickness bites of the stomach wall that can inadvertently injure structures touching the stomach, unseen to the endoscopist. If the spleen, liver, diaphragm, or vessels feeding the stomach are injured, bleeding can occur. Moreover, patients with undiagnosed hiatal hernia can have the stomach touching pericardium and pleura, predisposing these patients to complications like pneumothorax, pleural effusion, or pericardial injury. As such, complications after ESG include intraluminal, intraperitoneal, or intrathoracic bleeding, esophageal or gastric perforation, organ injury (e.g., spleen, liver, or lung), anesthetic complications, and abscess formation. Less serious adverse events include nausea, pain, and de novo GERD. Table 4 provides a summary of ESG adverse events for the included studies.

The MERIT trial prospectively enrolled 209 patients across 9 centers and gave some of the best estimates of procedural complications, including abscess, pain, bleeding, pleural effusion, pneumonitis, and shoulder pain [15]. In the MERIT trial, 19% (177 of 927) of patients reported diarrhea, constipation, or dehydration. Another 66% (612 of 927) reported early pain, heartburn, nausea, or vomiting; the majority of these events resolved within 7 days. Consistent with previously reported safety profiles, 76% (718 of 927) of reported events were of mild severity, and only 2% (20 of 927) were severe. Severe events included abdominal abscess (1 patient), severe abdominal pain (3 patients), bloody stools (1 patient), esophageal mucosal tear (1 patient), severe nausea (4 patients), severe nausea and vomiting (1 patient), pleural effusion (1 patient), pneumonitis (1 patient), shortness of breath (1 patient), severe sore throat (1 patient), and severe vomiting (1 patient). Six of 150 participants (4%) required hospital admission [15]. Collectively, all patients experiencing serious adverse events fully recovered [15]. Another large trial, the ESSENTIAL Trial [41], enrolled 332 patients across 11 centers and demonstrated a total overall adverse-event rate of approximately 88% (293 of 332), though the severe adverse event rate was 9.5% after ESG versus 8.1% after a sham procedure. Similar to the MERIT trial and other noncontrolled studies, the most common adverse events were pain, nausea, and vomiting. In terms of procedure-related severe events, however, the ESSENTIAL trial had 1 case of extragastric bleeding that was identified after the procedure and required transfusion. Additionally, a perihepatic abscess developed in 1 other patient requiring hospitalization, antibiotics, and percutaneous drainage [41]. A third randomized, controlled trial, MILEPOST, included an ESG arm of 34 patients and 10 patients in a control/lifestyle arm [42]. Similar to the ESSENTIAL trial, there was a low incidence of adverse events, with only 2 minor postoperative bleeding events and no other reported procedural complications.

In addition to randomized, controlled trials, Alqahtani et al. [43] published the largest experience of consecutive ESG procedures and reported a total complication rate of 92%, as in the ESSENTIAL trial. Most reported complications were nausea and nonsevere abdominal pain [43].

Table 3
Co-morbidity resolution after endoscopic sleeve gastroplasty for the reviewed studies.

Study	Dyslipidemia resolution	Hypertension resolution	Diabetes improvement	GERD improvement
Devière et al (2008) [57]	Not reported	Resolved in 4 of 8 patients	Mean HbA1C decreased from 7.6% to 6.6%	Not reported
Abu Dayyeh et al. (2013) [13]	Not reported	Not reported	Not reported	Not reported
Miller et al. (2017) [42]	Not reported	Not reported	Not reported	Not reported
Sullivan et al. (2017) [41]	POSE: 35.7 (35/98) Sham: 32.4% (12/37)	POSE: 19.4% (19/98) Sham: 12.5% (5/40)	POSE: 56.3% (9/16) Sham: 10.0% (1/10)	POSE: 19.4% (19/98) Sham: 12.5% (5/40)
Kumar et al. (2018) [58]	Not reported	Not reported	Not reported	Not reported
Alqahtani et al. (2019) [46]	N/A	N/A	N/A	N/A
Cohen et al. (2019) [59]	Not reported	Not reported	Not reported	Not reported
Fayad et al. (2019) [22]	Not reported	Not reported	Not reported	Not reported
García and Velázquez (2019) [45]	Not reported	Not reported	Not reported	Not reported
Gys et al. (2019) [31]	Not reported	Not reported	Not reported	Not reported
Khan (2019) [60]	Not reported	Not reported	Not reported	Not reported
de Miranda Neto et al. (2020) [32]	Not reported	Not reported	Not reported	Not reported
Fiorillo et al. (2020) [26]	Not reported	ESG: 2 of 3 patients improved LSG: 3 of 7 patients improved	ESG: 1 of 2 patients improved LSG: 2 of 3 patients improved	ESG: 2 patients GERD improved; no de novo GERD LSG: No patient had baseline GERD; 7 developed de novo GERD
Hedjoudje et al. (2020) [23]	Not reported	Not reported	Not reported	Not reported
Jalal et al. (2020) [28]	Not reported	Not reported	Not reported	Not reported
Li et al. (2020) [61]	Not reported	Not reported	Not reported	Not reported
Mohan et al. (2020) [29]	Not reported	Not reported	Not reported	ESG: .4% LSG: 5.8%
Neto et al. (2020) [21]	Not reported	Not reported	Not reported	Not reported
Singh et al. (2020) [14]	56.3% in remission (from 1 study)	All patients in remission (from 1 study)	76.5% in remission, remaining improved (from 1 study)	Not reported
Marincola et al. (2021) [30]	Not reported	Not reported	Not reported	Not reported
Lopez-Nava et al. (2021) [28]	Not reported	Not reported	Not reported	Not reported
Alqahtani et al. (2022) [27]	ESG: 64.3% LSG: 63.8%	ESG: 50.5% LSG: 45.8%	ESG: 64.3% LSG: 82.3	NA
Beran et al. (2022) [19]	N/A	ESG: 51% LSG: 46%	ESG: 64% LSG: 82%	N/A
Brunaldi et al. (2022) [12]	ESG: 25%	ESG: 69.2%	ESG: 87.5%	ESG: 100%
Abu Dayyeh et al. (2022) [15]	ESG: 40%	ESG: 67%	ESG: 92%	No worse
Singh et al. (2022)	Not reported	Not reported	Not reported	Not reported
Lopez-Nava et al. (2023) [16]	Not reported	Not reported	.8 reduction in HgbA1C	Not reported

GERD = gastroesophageal reflux disease; HbA1C = hemoglobin A1C; POSE = primary obesity surgery endoluminal procedure; ESG = endoscopic sleeve gastroplasty; LSG = laparoscopic sleeve gastrectomy.

Another study reported that severe adverse events were infrequent in adolescent and pediatric patients, with similar complication rates to adults [44]. Procedure-related complications from the adult series by Alqahtani et al. [43] demonstrated 7 instances of bleeding, 2 transfusions, 5 patients with fever, and 4 patients with abdominal fluid collection and pleural effusions. Smaller trials noted few or no adverse events, underscoring the importance of larger data sets to detect accurate complication rates overall [13,21,45].

Several meta-analyses have estimated rates of severe adverse events after ESG ranging from .8% to 2.84% [14,23,28,32,33]. Similar to published randomized, controlled trials, the most common procedure-related severe adverse events include nausea and vomiting, pain, gastrointestinal bleeding, and abscess. In summary, the results of these prospective trials and meta-analyses agree that mild, self-limiting symptoms were common early after ESG but that serious adverse events or complications requiring intervention were uncommon.

Table 4
Complications after endoscopic sleeve gastroplasty for the reviewed studies.

Study	Adverse events	Serious complications
Devière et al (2008) [57]	37 total adverse events	No complications
Abu Dayyeh et al. (2013) [13]	75% nausea 75% abdominal pain 25% GERD development	25% hospitalization rate due to nausea
Miller et al. (2017) [42]	No intraoperative complications No device- or procedure-related serious adverse events Minor throat pain, minor abdominal pain, and 2 minor bleeds that resolved within 24 hr	No serious adverse events
Sullivan et al. (2017) [41]	.5% bleeding 1.8% nausea .5% pain 1.8% vomiting	—
Kumar et al. (2018) [58]	—	No serious adverse events
Alqahtani et al. (2019) [46]	1 patient with pleural effusion not requiring drainage	—
Cohen et al. (2019) [59]	—	2%–10% serious adverse events (pooled data)
Fayad et al. (2019) [22]	De novo GERD after ESG: 1.9% (14.5% after LSG)	5.2% adverse events after ESG (16.9% after LSG)
García and Velázquez (2019) [45]	—	—
Gys et al. (2019) [31]	—	1% major adverse events with no mortality
Khan (2019) [60]	22%–25% abdominal pain 13%–14% nausea and vomiting	—
de Miranda Neto et al. (2020) [32]	1.5% mild adverse events 1.7% moderate adverse events	.8% severe adverse events
Fiorillo et al. (2020) [26]	No ESG patients developed postprocedural GERD symptoms or reported PPI use, whereas 7 of 23 patients (31%) of the LSG group developed postoperative GERD and reported daily PPI use	—
Hedjoudje et al. (2020) [23]	1.1% pain or nausea requiring hospitalization .56% upper gastrointestinal bleeding .48% perigastric leak or collection .06% pulmonary embolism .06% pneumoperitoneum	2.2% rate of serious adverse events (pooled data)
Jalal et al. (2020) [28]	2.0%–2.7% complication rate after ESG 9.2%–16.7% complication rate after LSG	—
Li et al. (2020) [61]	72% mild adverse events	1% serious adverse events
Mohan et al. (2020) [29]	De novo GERD: ESG: .4% LSG: 5.8% All adverse events: ESG: 2.9% LSG: 11.8% Bleeding: ESG: 1.1% LSG: 2.6%	—
Neto et al. (2020) [21]	1 patient experienced bleeding during the procedure that was managed with sclerotherapy	—
Singh et al. (2020) [14]	—	2.26% pooled rate of significant adverse events
Marincola et al. (2021)	Difference in mean rate of adverse events for ESG versus LSG: .19% ± .37; $P = .2056$	—
Lopez-Nava et al. (2021) [28]	2 patients with a hemoglobin drop (>2 g/dL) 24 hr	2 patients, gastric perforation (grade 3) was caused by the jaws of the g-prox device
Alqahtani et al. (2022) [27]	ESG: 32% visited clinic LSG: 18% visited clinic ($P < .001$ versus ESG)	ESG: .5% LSG: .3%
Beran et al. (2022) [19]	De novo GERD ESG: 1.3% LSG: 17.9% ($P = .006$)	No significant difference in serious adverse events
Brunaldi et al. (2022) [12]	2.4% readmission rate 1.1% pain and nausea	2.2% serious adverse events
Abu Dayyeh et al. (2022) [15]	—	2% serious adverse events; no mortality

(continued on next page)

Table 4 (*continued*)

Study	Adverse events	Serious complications
Singh et al. (2022) [33]	—	2.8% serious adverse events: GI bleeds, extragastric bleeding, hepatic abscess, severe pain, severe nausea, severe vomiting
Lopez-Nava et al. (2023) [16]	None reported	None reported

GERD = gastroesophageal reflux disease; ESG = endoscopic sleeve gastroplasty; LSG = laparoscopic sleeve gastrectomy; PPI = proton-pump inhibitor; GI = gastrointestinal.

Clinical Outcomes of POSE and POSE-2.0

POSE and POSE-2.0 are similar to ESG in that all are endoscopic bariatric procedures that involve full-thickness plication of the stomach wall but differ in their anatomic placement of plication sutures, as described previously. Weight loss outcomes after POSE and POSE-2.0 have been described.

Miller et al. [42] compared outcomes 12 months after POSE with those of a control group employing diet and exercise guidance. The study randomized 44 participants at a 3:1 ratio; there were 34 participants in the POSE group and 10 in the control group. After controlling for baseline BMI, patients in the POSE group had 13% TBWL at 12 months compared with 5% TBWL in the control group ($P < .01$). No serious device- or procedure-related adverse events occurred. The ESSENTIAL trial randomized 332 patients at a 2:1 ratio to POSE or sham treatment [41]. Participants were blinded to treatment assignment until the 12-month follow-up. Both groups lost an average of 7.0% ± 7.4% TBWL in the lead-in phase of the trial; after that, patients who received ESG lost 5.0% ± 7.0% TBWL versus 1.4% ± 5.6% in the sham group ($P < .0001$) [41]. Recently, Lopez Nava et al. [16] published a multicenter trial of POSE-2.0 in which 44 patients with an average BMI of 37 ± 2 kg/m^2 underwent POSE-2.0. Mean TBWL at 12 months was 15.7% ± 6.8%. Repeat assessment at 24 months in 26 patients showed fully intact plications. No serious adverse events occurred in this trial [16].

Although less has been written about POSE and POSE-2.0, Singh et al. [33] conducted a systematic review of POSE with a meta-analysis. A total of 7 studies including 613 patients were reviewed, including the 2 randomized trials mentioned previously. Pooled mean EWL was 49% (95% CI, 42%–55%) at 12–15 months after POSE, and pooled mean TBWL was 13% (95% CI, 8.1%–17.2%) after 12–15 months. The incidence of serious adverse events was 2.8% and included bleeding, hepatic abscess, severe pain, severe nausea, and severe vomiting [33]. In summary, POSE and POSE-2.0 are alternatives to ESG with a similar published weight loss at 1 year and a similar published risk of serious complications when compared with ESG.

Conversion of ESG or POSE to Other Bariatric Procedures

ESG has become one of the most common endobariatric procedures performed [46]. Comparative studies have demonstrated the short-term weight loss after ESG to be approximately 15% of total weight [47]. However, some intermediate-term results have demonstrated weight regain [48]. The most common factors associated with weight loss following ESG included initial BMI, adherence with follow-up, age, and early postprocedural weight loss following ESG [46]. As a result, some patients after ESG will seek conversion to sleeve gastrectomy, gastric bypass, or other bariatric procedure because of weight regain or poor initial weight response.

Revisional surgery following ESG or POSE is feasible, but there are several technical concerns [43]. Alqahtani et al. [46] published the largest study evaluating ESG-to-LSG conversions and recommended the following specific considerations. First, imaging studies are needed to assess the size and shape of the plicated stomach. This information can be helpful when determining the choice of revisional procedure. Second, because ESG is performed using a suturing technique with metal T-fasteners, it is important to know where the fasteners are located, lest the unsuspecting surgeon staple across one. Sometimes the fasteners can be buried in the wall of the stomach. The use of endoscopy is the key to avoid stapling across the fasteners on the intraluminal side, and complete removal of fasteners can be performed with an upper endoscopy ahead of time, prior to the conversion procedure. Alternatively, endoscopy can be performed as the first step of a single-stage laparoscopic conversion. Alqahtani et al. [43] described a single-stage revision that combined a laparoscopic-endoscopic approach with the aim of locating anchors and sutures in preparation for safe stapling of the stomach. Starting with endoscopy, Alqahtani et al. [43] removed any suture or anchor using endoscopic scissors if the T-fastener was judged to come within the planned LSG staple line. Then, during laparoscopy, exteriorized anchors visible on the serosal side of the gastric wall were removed. [43] Adhesions between the gastric wall and adjacent structures are expected and may need to be lysed prior to conversion. Only after laparoscopic and endoscopic fastener removal and lysis are complete can the subsequent bariatric procedure be performed in the usual manner [43].

A small series of ESG conversions have been published. Alqahtani et al. [43] reported a 1.2% rate of conversion to LSG (16 of 1665 ESG patients). The mean age and BMI at the time of ESG were 40 ± 6 years and 35 ± 4 kg/m^2,

respectively. The time between the initial ESG and conversion to LSG averaged 11 months, with a range of 5–18 months. The mean BMI at the time of LSG conversion was 35.2 ± 3.8 kg/m^2, and 11 patients (55%) gained more weight than they lost after ESG. Notably, all patients who underwent conversion were noted to have had disrupted sutures, with complete disruption occurring in 35% of patients [43]. Additionally, 2 case studies of ESG conversion to LSG have been described in which endoscopy was used to remove all visible suture and anchor devices prior to LSG [49]. Interestingly, exteriorized anchoring devices on the anterior wall of the stomach were also noted during LSG [49].

With regard to ESG conversion to RYGB, Beitner and Hopkins [50] described a 59-year-old man with a BMI of 36 kg/m^2 at initial ESG who underwent a repeat ESG due to weight regain. Intraoperative e*sophagogastroduodenoscopy* was performed with no complications noted. The authors also converted 6 ESG patients to RYGB to use the suture-free tissue at the angle of His and avoid intraluminal suture cinches [50].

Based on this experience, it seems prudent to first obtain a preoperative swallow evaluation to determine the width and size of the ESG stomach before consideration of conversion. This information may help the patient and surgeon decide which bariatric procedure to perform and whether additional steps, such as hiatal hernia repair, will be needed. Additionally, endoscopic evaluation to identify and remove sutures and T-fasteners and evaluate the shape of the stomach is needed prior to laparoscopic conversion either as a separate procedure performed ahead of time or as the initial step in a 1-stage conversion [19,51].

Importance of Offering ESG in a Multidisciplinary Setting

Patients with obesity coached by a multidisciplinary team involving nutritionists, mental health professionals, and other supports have been associated with better weight loss outcomes after bariatric surgery [52,53]. Additionally, patient adherence to postoperative appointments has also been associated with greater weight loss, emphasizing the need to treat patients with obesity longitudinally [54]. Furthermore, a multidisciplinary approach to bariatric surgery has also been shown to improve decision making and standardization of care [55,56]. For instance, Rebibo et al. [56] reviewed 816 patients who underwent a multidisciplinary evaluation. Overall, 776 patients (70.6%) were approved for bariatric surgery, 13.3% required further evaluation prior to bariatric surgery, and 11 patients (1%) were refused bariatric surgery. The complication rate in the 776 patients approved for surgery was 10.1%. For the 11 patients who were refused surgery, 7 underwent surgery at another center without multidisciplinary meetings, and 4 (57%) postoperative complications occurred [56]. Considering the published data demonstrating improved weight loss outcomes and an association between multidisciplinary care and a decrease in surgical complications, the introduction of ESG or POSE into one's practice should take place within a comprehensive multidisciplinary bariatric program, preferably a bariatric center of excellence.

Summary

1. The majority of peer-reviewed studies reported the use of endoscopic sleeve gastroplasty (ESG) for patients with a body mass index (BMI) of 30–40 kg/m^2. There were sparse outcome data for patients with a BMI of >40 or <30 kg/m^2. ESG may also be indicated for patients wishing to avoid surgical scars or patients with prohibitively high surgical risk from prior abdominal operations, age, co-morbid disease, or other factors.
2. Across multiple studies, ESG produced an average total body weight loss of 13%–20% at 12 months of follow-up. In comparative studies, this weight loss was significantly less than the weight loss observed after laparoscopic sleeve gastrectomy. For studies with follow-up at 2 and 3 years, most reported that the initial weight loss achieved by ESG was sustained. These findings met the criteria set forth by the ASGE/ASMBS Task Force on Endoscopic Bariatric Therapy [5].
3. ESG was associated with improvements in metabolic disease. The risk of de novo gastroesophageal reflux disease (based on postoperative symptom surveys) after ESG was reported to be <3% across multiple studies.
4. The most common complications after ESG were nausea, vomiting, and abdominal pain, all typically resolving within 7 days. Serious adverse events, such as bleeding or abscess formation, occurred in 2%–3% of patients across most studies.
5. POSE and POSE-2.0 represent alternative endoluminal plication procedures to ESG; the published weight loss at 1 year and complication rates have been similar to those of ESG.
6. Conversion of ESG to laparoscopic Roux-en-Y gastric bypass or laparoscopic sleeve gastrectomy has been reported, with experts recommending a preoperative swallow evaluation first, followed by an endoscopic evaluation to remove T-fasteners. Endoscopy can be performed ahead of time or as the initial step in a 1-stage conversion.
7. Obesity is a chronic disease best treated in a multidisciplinary setting. As such, endoluminal sutured gastroplasty procedures should be performed within a multidisciplinary bariatric program that provides longitudinal support of patients with obesity over time, ideally in a center accredited by the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program.

Disclosures

Cheguevara Afaneh is a paid consultant with Intuitive Surgical and W.L. Gore. Mohamed Ali received consultation honoraria from Stryker and Olympus.

References

[1] World Health Organization [Internet]. Geneva, Switzerland: WHO; 2019 [updated 2021 Jun 9; cited 2019 Dec 6]. Obesity and overweight; [about 1 screen]. Available from: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.

[2] Pi-Sunyer X. The medical risks of obesity. Postgrad Med 2009;121(6):21–33.

[3] Brown AM, Yang J, Zhang X, Docimo S, Pryo AD, Spaniolas K. Bariatric surgery lowers the risk of major cardiovascular events. Ann Surg 2022;276(5):e417–24.

[4] Goldberg I, Nie L, Yang J, et al. Impact of bariatric surgery on the development of diabetic microvascular and macrovascular complications. Surg Endosc 2021;35(7):3923–31.

[5] ASGE/ASMBS Task Force on Endoscopic Bariatric Therapy. A pathway to endoscopic bariatric therapies. Surg Obes Relat Dis 2011;7(6):672–82.

[6] English WJ, DeMaria EJ, Brethauer SA, Mattar SG, Rosenthal RJ, Morton JM. American Society for Metabolic and Bariatric Surgery estimation of metabolic and bariatric procedures performed in the United States in 2016. Surg Obes Relat Dis 2018;14(3):259–63.

[7] Bolckmans R, Roriz-Silva R, Mazzini GS, Altieri MS, Docimo S, Campos GM. Long-term implications of GERD after sleeve gastrectomy. Curr Surg Rep 2021;9(3):7.

[8] Qumseya BJ, Qumsiyeh Y, Ponniah SA, et al. Barrett's esophagus after sleeve gastrectomy: a systematic review and meta-analysis. Gastrointest Endosc 2021;93(2):343–352.e2.

[9] Yeung KTD, Penney N, Ashrafian L, Darzi A, Ashrafian H. Does sleeve gastrectomy expose the distal esophagus to severe reflux? A systematic review and meta-analysis. Ann Surg 2020;271(2):257–65.

[10] Eisenberg D, Shikora SA, Aarts E, et al. 2022 American Society for Metabolic and Bariatric Surgery (ASMBS) and International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO): indications for metabolic and bariatric surgery. Surg Obes Relat Dis 2022;18(12):1345–56.

[11] Brunaldi VO, Neto MG. Endoscopic techniques for weight loss and treating metabolic syndrome. Curr Opin Gastroenterol 2019;35(5):424–31.

[12] Brunaldi VO, Neto MG. Endoscopic sleeve gastroplasty: a narrative review on historical evolution, physiology, outcomes, and future standpoints. Chin Med J (Engl) 2022;135(7):774–8.

[13] Abu Dayyeh BK, Rajan E, Gostout CJ. Endoscopic sleeve gastroplasty: a potential endoscopic alternative to surgical sleeve gastrectomy for treatment of obesity. Gastrointest Endosc 2013;78(3):530–5.

[14] Singh S, Hourneaux de Moura DT, Khan A, Bilal M, Ryan MB, Thompson CC. Safety and efficacy of endoscopic sleeve gastroplasty worldwide for treatment of obesity: a systematic review and meta-analysis. Surg Obes Relat Dis 2020;16(2):340–51.

[15] Abu Dayyeh BK, Bazerbachi F, Vargas EJ, et al. Endoscopic sleeve gastroplasty for treatment of class 1 and 2 obesity (MERIT): a prospective, multicentre, randomised trial. Lancet 2022;400(10350):441–51.

[16] Lopez Nava G, Arau RT, Asokkumar R, et al. Prospective Multicenter Study of the Primary Obesity Surgery Endoluminal (POSE 2.0) procedure for treatment of obesity. Clin Gastroenterol Hepatol 2023;21(1):81–89.e4.

[17] Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71.

[18] Neto MG, Silva LB, de Quadros LG, et al. Brazilian consensus on endoscopic sleeve gastroplasty. Obes Surg 2021;31(1):70–8.

[19] Beran A, Matar R, Jaruvongvanich V, et al. Comparative effectiveness and safety between endoscopic sleeve gastroplasty and laparoscopic sleeve gastrectomy: a meta-analysis of 6775 individuals with obesity. Obes Surg 2022;32(11):3504–12.

[20] GBD 2015 Obesity Collaborators. Health effects of overweight and obesity in 195 countries over 25 years. N Engl J Med 2017;377(1):13–27.

[21] Neto MG, Moon RC, de Quadros LG, et al. Safety and short-term effectiveness of endoscopic sleeve gastroplasty using overstitch: preliminary report from a multicenter study. Surg Endosc 2020;34(10):4388–94.

[22] Fayad L, Adam A, Schweitzer M, et al. Endoscopic sleeve gastroplasty versus laparoscopic sleeve gastrectomy: a case-matched study. Gastrointest Endosc 2019;89(4):782–8.

[23] Hedjoudje A, Abu Dayyeh BK, Cheskin LJ, et al. Efficacy and safety of endoscopic sleeve gastroplasty: a systematic review and meta-analysis. Clin Gastroenterol Hepatol 2020;18(5):1043–1053.e4.

[24] Abu Dayyeh BK, Acosta A, Camilleri M, et al. Endoscopic sleeve gastroplasty alters gastric physiology and induces loss of body weight in obese individuals. Clin Gastroenterol Hepatol 2017;15(1):37–43.e1.

[25] Lopez-Nava G, Galvão M, da Bautista-Castaño I, Jimenez A, De Grado T, Fernandez-Corbelle J. Endoscopic sleeve gastroplasty for the treatment of obesity. Endoscopy 2014;47(5):449–52.

[26] Fiorillo C, Quero G, Vix M, et al. 6-month gastrointestinal quality of life (QoL) results after endoscopic sleeve gastroplasty and laparoscopic sleeve gastrectomy: a propensity score analysis. Obes Surg 2020;30(5):1944–51.

[27] Alqahtani AR, Elahmedi M, Aldarwish A, Abdurabu HY, Alqahtani S. Endoscopic gastroplasty versus laparoscopic sleeve gastrectomy: a noninferiority propensity score–matched comparative study. Gastrointest Endosc 2022;96(1):44–50.

[28] Jalal MA, Cheng Q, Edye MB. Systematic review and meta-analysis of endoscopic sleeve gastroplasty with comparison to laparoscopic sleeve gastrectomy. Obes Surg 2020;30(7):2754–62.

[29] Mohan BP, Asokkumar R, Khan SR, et al. Outcomes of endoscopic sleeve gastroplasty; how does it compare to laparoscopic sleeve gastrectomy? A systematic review and meta-analysis. Endosc Int Open 2020;8(4):E558–65.

[30] Marincola G, Gallo C, Hassan C, et al. Laparoscopic sleeve gastrectomy versus endoscopic sleeve gastroplasty: a systematic review and meta-analysis. Endosc Int Open 2021;9(1):E87–95.

[31] Gys B, Plaeke P, Lamme B, et al. Endoscopic gastric plication for morbid obesity: a systematic review and meta-analysis of published data over time. Obes Surg 2019;29(9):3021–9.

[32] de Miranda Neto AA, de Moura DTH, Ribeiro IB, et al. Efficacy and safety of endoscopic sleeve gastroplasty at mid term in the management of overweight and obese patients: a systematic review and meta-analysis. Obes Surg 2020;30(5):1971–87.

[33] Singh S, Bazarbashi AN, Khan A, et al. Primary obesity surgery endoluminal (POSE) for the treatment of obesity: a systematic review and meta-analysis. Surg Endosc 2022;36(1):252–66.

[34] Chang P, Friedenberg F. Obesity and GERD. Gastroenterol Clin North Am 2014;43(1):161–73.

[35] Singh M, Lee J, Gupta N, et al. Weight loss can lead to resolution of gastroesophageal reflux disease symptoms: a prospective intervention trial. Obesity 2013;21(2):284–90.

[36] Naeem Z, Yang J, Park J, et al. A step in the right direction: trends over time in bariatric procedures for patients with gastroesophageal reflux disease. Obes Surg 2020;30(11):4243–9.

[37] Campos GM, Mazzini GS, Altieri MS, Docimo S, DeMaria EJ, Rogers AM. ASMBS position statement on the rationale for performance of upper gastrointestinal endoscopy before and after metabolic and bariatric surgery. Surg Obes Relat Dis 2021;17(5):837–47.

[38] Bazerbachi F, Abu Dayyeh BK. The pressure is on! Endoscopic sleeve gastroplasty versus laparoscopic sleeve gastrectomy: toward better patient allocation beyond pygmalionism. Gastrointest Endosc 2019;89(4):789–91.

[39] Burgerhart JS, Schotborgh CAI, Schoon EJ, et al. Effect of sleeve gastrectomy on gastroesophageal reflux. Obes Surg 2014;24(9):1436–41.
[40] Toro JP, Lin E, Patel AD, et al. Association of radiographic morphology with early gastroesophageal reflux disease and satiety control after sleeve gastrectomy. J Am Coll Surg 2014;219(3):430–8.
[41] Sullivan S, Swain JM, Woodman G, et al. Randomized sham-controlled trial evaluating efficacy and safety of endoscopic gastric plication for primary obesity: The ESSENTIAL trial of the POSE Procedure. Obesity 2017;25(2):294–301.
[42] Miller K, Turró R, Greve JW, Bakker CM, Buchwald JN, Espinós JC. MILEPOST Multicenter Randomized Controlled Trial: 12-month weight loss and satiety outcomes after POSE SM vs. medical therapy. Obes Surg 2017;27(2):310–22.
[43] Alqahtani AR, Elahmedi M, Alqahtani YA, Al-Darwish A. Laparoscopic sleeve gastrectomy after endoscopic sleeve gastroplasty: technical aspects and short-term outcomes. Obes Surg 2019;29(11):3547–52.
[44] Alqahtani A, Elahmedi M, Alqahtani YA, Al-Darwish A. Endoscopic sleeve gastroplasty in 109 consecutive children and adolescents with obesity: two-year outcomes of a new modality. Am J Gastroenterol 2019;114(12):1857–62.
[45] García RG, Velázquez JV. Reinforced POSE: the 18-plication solution. Obes Surg 2019;29(11):3443–7.
[46] Alqahtani A, Al-Darwish A, Mahmoud AE, Alqahtani YA, Elahmedi M. Short-term outcomes of endoscopic sleeve gastroplasty in 1000 consecutive patients. Gastrointest Endosc 2019;89(6):1132–8.
[47] Novikov AA, Afaneh C, Saumoy M, et al. Endoscopic sleeve gastroplasty, laparoscopic sleeve gastrectomy, and laparoscopic band for weight loss: how do they compare? J Gastrointest Surg 2018;22(2):267–73.
[48] Lopez-Nava G, Asokkumar R, Bautista-Castaño I, et al. Endoscopic sleeve gastroplasty, laparoscopic sleeve gastrectomy, and laparoscopic greater curve plication: do they differ at 2 years? Endoscopy 2021;53(3):235–43.
[49] Alhayo S, Devadas M. Laparoscopic sleeve gastrectomy following multiple failed endoscopic sleeve gastroplasties. J Surg Case Rep 2019;2019(12):rjz315.
[50] Beitner M, Hopkins G. Conversion of endoscopic sleeve gastroplasty to laparoscopic Roux-en-Y gastric bypass. Surg Obes Relat Dis 2020;16(4):590–1.
[51] Bellorin O, Senturk JC, Cruz MV, Dakin G, Afaneh C. Predictive factors for developing GERD after sleeve gastrectomy: is preoperative endoscopy necessary? J Gastrointest Surg 2022;26(5):1015–20.
[52] Spaniolas K, Kasten KR, Celio A, Burruss MB, Pories WJ. Postoperative follow-up after bariatric surgery: effect on weight loss. Obes Surg 2016;26(4):900–3.
[53] Shilton H, Gao Y, Nerlekar N, Evennett N, Ram R, Beban G. Pre-operative bariatric clinic attendance is a predictor of post-operative clinic attendance and weight loss outcomes. Obes Surg 2019;29(7):2270–5.
[54] Martens K, Pester BD, Hecht LM, et al. Adherence to post-operative appointments is associated with weight loss following bariatric surgery. Obes Surg 2021;31(12):5494–6.
[55] Bullen NL, Parmar J, Gilbert J, Clarke M, Cota A, Finlay IG. How effective is the multidisciplinary team approach in bariatric surgery? Obes Surg 2019;29(10):3232–8.
[56] Rebibo L, Maréchal V, De Lameth I, et al. Compliance with a multidisciplinary team meeting's decision prior to bariatric surgery protects against major postoperative complications. Surg Obes Relat Dis 2017;13(9):1537–43.
[57] Devière J, Ojeda Valdes G, Cuevas Herrera L, et al. Safety, feasibility and weight loss after transoral gastroplasty: First human multicenter study. Surg Endosc 2008;22(3):589–98. Erratum in: Surg Endosc. 2008;22(3):599.
[58] Kumar N, Abu Dayyeh BK, Lopez-Nava Breviere G, et al. Endoscopic sutured gastroplasty: procedure evolution from first-in-man cases through current technique. Surg Endosc 2018;32(4):2159–64.
[59] Cohen RV, Oliveira da Costa MV, Charry L, Heins E. Endoscopic gastroplasty to treat medically uncontrolled obesity needs more quality data: A systematic review. Surg Obes Relat Dis 2019;15(7):1219–24.
[60] Khan Z, Khan MA, Hajifathalian K, et al. Efficacy of endoscopic interventions for the management of obesity: a meta-analysis to compare endoscopic sleeve gastroplasty, aspireAssist, and primary obesity surgery endolumenal. Obes Surg 2019;29(7):2287–98.
[61] Li P, Ma B, Gong S, Zhang X, Li W. Efficacy and safety of endoscopic sleeve gastroplasty for obesity patients: a meta-analysis. Surg Endosc 2020;34(3):1253–60.