



# Strategies to Manage Obesity: Endoscopic Bariatric and Metabolic Therapies

REVIEW

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## ABSTRACT

Over the past two decades, numerous endoscopic bariatric and metabolic therapies (EBMTs) have been developed with the goal of providing additional effective and safe tools for the treatment of obesity. These treatments are an ultra-minimally invasive option for patients with class I, class II, and class III obesity. Many of these EBMTs can be utilized as primary therapies for treatment-naïve patients or as a treatment for weight regain after bariatric surgery. While the role of EBMTs is not to compete with bariatric surgery, which provides the most effective treatment of obesity, they provide greater weight loss than lifestyle modifications and pharmacotherapy; additionally, when combined with pharmacotherapy, they may help achieve surgical weight loss without the risk of invasive surgery. This review summarizes the most currently available EBMTs, including intragastric balloons (IGBs), endoscopic sleeve gastroplasty (ESG), and endoscopic surgical revision procedures for treating obesity.

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## INTRODUCTION

Worldwide, the prevalence of obesity continues to increase along with the development of multiple associated comorbid conditions such as hypertension, hyperlipidemia, diabetes, obstructive sleep apnea, and coronary artery disease.<sup>1</sup> Approximately one-third of the global population has obesity. Although the United States (US) has recently seen a decrease in the rate of obesity for the first time in more than three decades, the prevalence overall remains around 40%.<sup>2</sup> While lifestyle modifications remain the foundation of all weight management strategies, diet and exercise alone often result in limited weight loss and difficulty maintaining clinically significant results. Alternative treatment strategies including pharmacotherapy, more specifically glucagon-like peptide 1 (GLP-1) and dual GLP-1/glucose-dependent insulinotropic polypeptide (GIP) receptor agonists, have seen a tremendous increase in popularity and use over the last decade; however, high costs, variable reimbursement, and unclear decisions regarding duration of treatment remain. Although bariatric procedures including sleeve gastrectomy or roux-en-Y gastric bypass (RYGB) provides the most effective and durable weight loss results, less than 1% of eligible patients with morbid obesity typically undergo the surgery.<sup>3,4</sup>

Despite increased adoption of pharmacotherapy and durability of bariatric surgery, obesity and associated comorbid conditions remain a serious public health concern. More available treatments that are both effective and safe are required to curb the rising rate of obesity. Endoscopic bariatric and metabolic therapies, termed EBMTs, have emerged as a minimally invasive treatment strategy to help mitigate these concerns, providing both a highly effective and incredibly safe option for patients with obesity.<sup>5</sup> These endoscopic therapies are designed to not only decrease weight but also improve comorbid conditions.<sup>6,7</sup> This review provides an outline of currently available endoscopic treatments for obesity.

## ENDOSCOPIC METABOLIC AND BARIATRIC THERAPIES

Multiple endoscopic bariatric therapies are available (Table 1), with several approved by the US Food and Drug Administration (FDA) and others undergoing further testing prior to more widespread use. In general, these treatments are entirely endoscopic and classified as outpatient procedures, so that patients can be discharged the same day. They provide a less-invasive treatment option compared to bariatric surgery and result in greater

weight loss compared with traditional or more novel pharmacotherapy (Figure 1).

## PATIENT EVALUATION AND SELECTION

Within the spectrum of traditional weight management, EBMTs provide a viable option for treatment-naïve patients with class I obesity or higher (defined as having a body mass index, or BMI,  $\geq 30$  kg/m<sup>2</sup>), patients in need of additional weight reduction on concomitant pharmacotherapy, and those with recurrent weight gain after bariatric surgery. These endoscopic therapies are designed to not only decrease weight but also to improve comorbid conditions. The American Society for Gastrointestinal Endoscopy and the American Society for Metabolic and Bariatric Surgery have defined thresholds regarding safety and efficacy for EBMTs (Table 2).<sup>8-10</sup> Metrics include excess weight loss (EWL) and total weight loss (TWL). EWL is calculated as (preoperative weight minus weight at 12-month follow-up)/(preoperative weight minus ideal body weight) x 100. TWL is calculated as (preoperative weight minus weight at 12-month follow-up)/(preoperative weight) x 100.

## PRIMARY PROCEDURES FOR TREATMENT-NAÏVE PATIENTS

Primary therapies are defined as treatment-naïve individuals (ie, those individuals with no history of prior bariatric surgery) while nonprimary therapies are considered for patients with weight recurrence after bariatric surgery. As a primary treatment, EBMTs have the ability to reach a greater number of patients compared with bariatric surgery, including patients with class I obesity (BMI 30.0-34.9 kg/m<sup>2</sup>) or patients with a BMI  $\geq 35$  kg/m<sup>2</sup> who may not wish to undergo bariatric surgery or are poor surgical candidates. This is ideal since many patients may begin to develop obesity-associated comorbid conditions prior to qualifying or becoming eligible to undergo bariatric surgery. With early intervention, there may be a reduction in the development of associated comorbid conditions like heart disease, hypertension, diabetes, and obstructive sleep apnea. For patients with class I obesity or greater and no history of prior bariatric surgery (ie, treatment-naïve patients), available EBMTs should achieve at least 25% EWL with an adverse event profile  $< 5\%$ .<sup>8-10</sup>

## TREATMENT FOR WEIGHT REGAIN AFTER BARIATRIC SURGERY

For patients with a history of bariatric surgery, up to 30% may experience clinically significant weight regain (defined as  $> 15\%$  from nadir weight).<sup>11</sup> For those with clinically significant weight regain due to an enlarged gastric pouch or dilated gastrojejunal anastomosis, EBMTs can serve as an alternative to invasive surgical revision with comparable

EBMTs	INDICATIONS	PLACEMENT DURATION	ADVANTAGES	DISADVANTAGES	TWL	ADVERSE EVENT RATE
<b>Intragastric balloons (IGBs)</b>	Class I-III obesity (BMI 30-40 kg/m <sup>2</sup> ) ≥ one obesity-associated comorbid condition	4-12 months	<ul style="list-style-type: none"> <li>Easily placed and removed</li> <li>Some IGBs do not require endoscopic placement</li> <li>Widely adopted globally</li> </ul>	<ul style="list-style-type: none"> <li>Tolerability</li> <li>Durability</li> <li>Weight regain when removed</li> </ul>	7-14%	2%
<b>Endoscopic suturing</b>	Treatment naïve: Class I-III obesity (BMI 30-50 kg/m <sup>2</sup> )  Weight regain after bariatric surgery: Class I-III obesity (BMI 30-50 kg/m <sup>2</sup> )	Semi-permanent	<ul style="list-style-type: none"> <li>Full-thickness technique</li> <li>Durability</li> </ul>	<ul style="list-style-type: none"> <li>Procedural complexity</li> </ul>	15-25%  8-12%	< 2%
<b>Gastric plication</b>	Treatment naïve: Class I-III obesity (BMI 30-50 kg/m <sup>2</sup> )  Weight regain after bariatric surgery: Class I-III obesity (BMI 30-50 kg/m <sup>2</sup> )	Semi-permanent	<ul style="list-style-type: none"> <li>Full-thickness technique</li> <li>Durability</li> </ul>	<ul style="list-style-type: none"> <li>Procedural complexity</li> </ul>	15-25%  8-12%	< 2%
<b>Duodenal mucosal resurfacing</b>	Patients with poorly-controlled type II diabetes (typically HbA1c > 7.5% based upon literature)	One-time treatment	<ul style="list-style-type: none"> <li>Restore insulin sensitivity and promote weight loss</li> </ul>	<ul style="list-style-type: none"> <li>Modest weight loss</li> <li>Fluoroscopy required</li> <li>More data required</li> </ul>	2-8%	< 2%
<b>Duodenal-jejunal bypass liner (Endobarrier)</b>	Patients with poorly-controlled type II diabetes (typically HbA1c > 7.5% based upon literature)	12 months	<ul style="list-style-type: none"> <li>Weight loss and significant reduction in HbA1c</li> </ul>	<ul style="list-style-type: none"> <li>Fluoroscopy required</li> <li>Risk of hepatic abscesses</li> <li>More data required</li> </ul>	12-20%	< 5%

**Table 1** Summary table of endoscopic bariatric and metabolic therapies (EBMTs). BMI: body mass index; HbA1c: hemoglobin A1c; TWL: total weight loss

weight loss and an improved adverse event profile. Similar to primary procedures, EBMTs are performed on an outpatient basis with individuals discharged the same day. For nonprimary EBMTs, these treatments should achieve at least 5% TWL and have a very low risk of serious adverse events (< 5%).<sup>8-10</sup>

## INTRAGASTRIC BALLOON

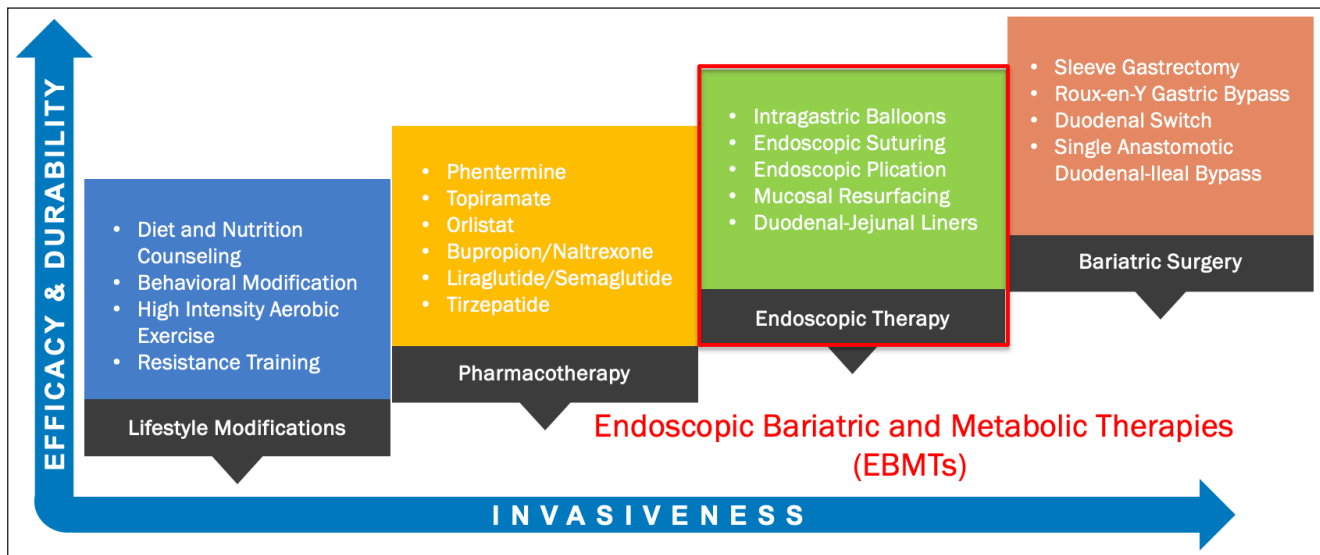
An endoscopically placed intragastric balloon (IGB) is a restrictive gastric procedure that works by limiting the volume of the stomach with a space-occupying balloon. This in turn results in early satiety, delayed gastric emptying,

a decrease in fundic accommodation, and a reduction in oral intake. For most IGBs, the deflated balloon is initially placed endoscopically and subsequently inflated with air or a saline solution. Balloon volumes may be titrated based on patient tolerance and goals. While some IGBs vary, these EBMTs can remain in place up to 6 to 12 months depending on the type and then removed endoscopically. The FDA has approved several intragastric balloons for adults with a BMI ranging from 30 to 35 kg/m<sup>2</sup>; however, these devices may also be used in adults with a BMI ≥ 35 kg/m<sup>2</sup> as a bridge to surgery or surgical alternative if the patient is otherwise a poor surgical candidate. Available devices include Orbera (Boston Scientific Corporation), Obalon (Obalon Therapeutics Inc.), Spatz3 (Spatz Medical), and

### ASGE AND ASMBS SUMMARY RECOMMENDATIONS FOR EBMTs

- I. For primary obesity therapies in patients with obesity class I, II, and III, a minimum goal of 25% excess weight loss at 12 months
- II. For nonprimary EBMTs including metabolic therapy, bridging to surgery, and early intervention, a goal of ≥ 5% total weight loss
- III. For serious adverse events, ≤ 5% is recommended for all EBMTs

**Table 2** American Society for Gastrointestinal Endoscopy (ASGE) and American Society for Metabolic and Bariatric Surgery (ASMBS) recommendations for endoscopic bariatric and metabolic therapies (EBMTs).



**Figure 1** Treatment spectrum of obesity: lifestyle modifications, pharmacotherapy, endoscopic treatment, and bariatric surgery.

Eclipse (Allurion Technologies), although no head-to-head studies have compared their effectiveness. Some literature has supported the belief that fluid-filled balloons are associated with greater weight loss; however, gas-filled balloons are typically better tolerated and with lower side-effect profiles. Importantly, intra-gastric balloons are only indicated as a primary treatment and are not to be used in patients with a history of foregut surgery.

Overall, IGBs have been shown to be more effective than lifestyle modifications alone and can result in EWL of about 25%, depending on the manufacturer.<sup>12,13</sup> Mean TWL is between 7% and 14% at 6 to 12 months based on a landmark technical review and meta-analysis by the American Gastroenterology Association, although tolerability concerns have been raised, with early removal occurring in 9% of patients due to nausea and vomiting but with low risk for serious adverse events.<sup>14,15</sup> Importantly, marked improvements in the incidence of diabetes, metabolic syndrome, and dyslipidemias as well as multiple other comorbid conditions have been observed 12 months following placement of IGBs.<sup>16</sup> Intra-gastric balloons are contraindicated in patients with a history of gastrointestinal surgery, bleeding diathesis, gastric ulcers, large hiatal hernias (typically defined as > 4 cm), active *Helicobacter pylori* infection, and pregnancy. Tolerability issues and lack of insurance reimbursement have limited the use of IGBs in the US.<sup>17</sup>

## ENDOSCOPIC SLEEVE GASTROPLASTY

Endoscopic suturing has become the most commonly performed EBMT in the US. Initial attempts at endoscopic gastric volume reduction were first explored in the 2000s

with variations of the surgical vertical banded gastroplasty and surgical gastric imbrication. In June of 2022, the FDA approved the first endoscopic suturing system for endoscopic sleeve gastrectomy (ESG) to specifically treat obesity.<sup>18,19</sup> Unlike IGBs, which are only possible for treatment-naïve patients and are contraindicated in patients with any gastric surgery, endoscopic suturing can be used as a primary and nonprimary treatment modality. As a primary therapy, ESG can be performed using an endoscopic suturing or endoscopic plication technique.

## ENDOSCOPIC SUTURING

Endoscopic suturing using the Apollo OverStitch endoscopic suturing system (Boston Scientific) is an FDA-approved treatment for obesity and is characterized as a restrictive minimally invasive procedure that reduces the capacity of the stomach by approximately 70% to 80%. This is achieved endoscopically by using full-thickness sutures from the greater incisure to the proximal stomach, working along the greater curvature. The ESG procedure uses an endoscopic suturing device, which has received FDA approval as a minimally invasive procedure to facilitate weight loss for adults with obesity (BMI 30-50 kg/m<sup>2</sup>) who have been unable to lose weight or maintain weight loss through more conservative measures such as diet and exercise.

In the pivotal MERIT (Endoscopic sleeve gastroplasty for treatment of class I and II obesity) trial, which was a randomized, sham-controlled study by Abu Dayyeh et al., ESG was found to be a highly effective and safe procedure compared with lifestyle modifications.<sup>20</sup> In this study of 209 patients with an average BMI of 35.5 kg/m<sup>2</sup>, patients with ESG demonstrated significantly greater weight loss (TWL at 12 months: 13.6% versus 0.8%) with greater improvement

in obesity-related comorbidities including diabetes (92% vs 15%), hypertension (67% vs 40%), metabolic syndrome (83% vs 35%), and non-alcoholic fatty liver disease (83% vs 35%). Patients with poorly controlled diabetes who underwent ESG also demonstrated a significant reduction in hemoglobin A1c of -1.8% vs +0.2% in the lifestyle intervention arm.

Another study by Sharaiha et al. found that patients who underwent ESG demonstrated a TWL of 17.6% and 20.9% at 12 and 24 months, respectively.<sup>21</sup> Importantly, there was a 1.3% serious adverse event rate, demonstrating ESG to be highly effective and safe. There was also significant improvement in comorbidities including hypertension, diabetes, and hypertriglyceridemia at 1 year. At 3- and 5-year follow-up, patients who underwent ESG had an average TWL of 14.9% and 15.9%, respectively.<sup>22</sup> In another study of 1,000 patients with an average BMI of 33.3 kg/m<sup>2</sup> who underwent ESG, individuals demonstrated a TWL of 15.0% and 14.8% at 12 and 18 months, respectively.<sup>23</sup> Notably, all patients in this study who had pre-procedure hypertension or dyslipidemia had complete resolution of their comorbidities. Among patients with diabetes, 76.5% had complete resolution and were off all antidiabetic medications at 2-year follow-up.

In addition to its use as an independent therapy, endoscopic suturing has been combined with other weight-loss interventions like pharmacotherapy. A multicenter retrospective propensity-matched study in 2021 examined combination liraglutide therapy 4 months post-ESG.<sup>24</sup> In this study, patients in the ESG-plus-liraglutide group achieved significantly more weight loss compared with the ESG-alone group at 12 months (TWL 24.72% vs 20.51%). Patients receiving ESG-plus-liraglutide were also noted to achieve a greater reduction in percent body fat (10.54% vs 7.85%). These results suggest that ESG may be combined with more novel pharmacotherapy to promote synergistic weight-loss results, similar to that of bariatric surgery, without patients having to undergo the knife. Further studies involving more novel GLP-1 and GLP-1/GIP receptor agonists are underway.

## GASTRIC PPLICATION

Another technique, called gastric plication, is approved for tissue apposition although it is not FDA approved for obesity or weight management. This technique is similar to endoscopic suturing but uses interrupted anchors as opposed to running polypropylene suture material. Primary obesity surgery endoluminal (POSE), a minimally invasive endoscopic procedure, reduces the size of the gastric lumen and utilizes the Incisionless Operating Platform system (UGSI Medical) consisting of an overtube with 4 working channels to plicate the gastric fundus and distal gastric body. The first use of POSE in humans showed

a 15.5% TWL at 6 months.<sup>25</sup> A subsequent randomized sham-controlled trial confirmed a significantly greater 12 month TWL with POSE compared to the lifestyle group.<sup>26</sup> Several other studies have shown similar TWL ranging from 15% to 27% at 12 months with a similar side effect profile to suturing.<sup>25-29</sup> Despite these impressive results, POSE is not commonly performed and limited to expert centers at this time.

Another device, the Endomina system (Endo Tools Therapeutics) is an EBMT used for endoscopic gastric plication. Initially used primarily in Europe, it has now received approval for tissue apposition (no obesity indication) as of 2022. The Endomina system uses an over-the-scope triangulation platform to create plications along the greater curvature of the stomach to restrict gastric volume. A randomized clinical trial showed that the Endomina system resulted in a 12-month mean EWL of 45.1% and TWL of 11.8%, outperforming the control group with lifestyle modification.<sup>30</sup> Another multicenter observational study found Endomina to be highly effective with a 15.3% TWL at 12 months.<sup>31</sup>

## SUMMARY OF ENDOSCOPIC SLEEVE GASTROPLASTY

In summary, ESG using a suturing or plication method is effective in achieving a 15% to 25% TWL with a low adverse event rate of < 2%. It is by far the most widely used EBMT in the US, with suturing being the most commonly employed technique at present. Different from the surgical sleeve gastrectomy, no tissue or portion of the stomach is surgically removed during endoscopic suturing or plication, eliminating the risk of malabsorption or need for vitamin/mineral supplementation. ESG results in delayed gastric emptying with early satiety and subsequent weight loss. Compared to laparoscopic sleeve gastrectomy, ESG is associated with non-inferior weight loss and improvement in comorbid conditions and also has significantly lower rates of gastroesophageal reflux disease.<sup>4,32</sup> Additionally, statistically significant reductions in HbA1c, blood pressure, waist circumference, and triglyceride levels have been reported.<sup>21</sup>

## ENDOSCOPIC GASTRIC BYPASS AND SLEEVE GASTRECTOMY REVISION

Although bariatric surgery has been proven to be the most effective weight loss option for individuals with class III obesity, up to 20% of patients may not achieve > 50% EWL within 1 year of surgery, and an additional 20% of patients who do achieve this may experience significant weight regain.<sup>11</sup> For patients with weight regain after bariatric surgery or non-responders, typically RYGB but also sleeve gastrectomy, use of argon plasma coagulation, endoscopic suturing, and endoscopic plication are very

effective treatment modalities.<sup>7</sup> These non-primary EBMTs are associated with an 8% to 12% TWL and very low rate of serious adverse events (< 2%). While endoscopic suturing has an FDA-approved obesity indication similar to primary therapies, gastric plication is FDA approved only for tissue apposition. Even so, weight-loss outcomes and side effect profiles for both techniques are similar.

### ARGON PLASMA COAGULATION

Argon plasma coagulation (APC) is a noncontact electrocoagulation method used to create a thermal coagulation of the superficial mucosa. This coagulation is aimed at the gastrojejunostomy in patients with RYGB to effectively scar down the anastomosis, reducing the size of the outlet, in an effort to improve early satiety and weight loss.<sup>33</sup> Notably, this treatment is not possible in patients with a history of sleeve gastrectomy due to lack of a gastrojejunal anastomosis but is effective for those with a history of RYGB. For patients with recurrent weight gain after RYGB, treatment has been shown to reduce the diameter of the gastric pouch outlet.<sup>34,35</sup> In a randomized sham-controlled trial comparing APC versus lifestyle interventions, APC was associated with significantly greater TWL along with reductions in glycated hemoglobin (HbA1c) and triglycerides.<sup>36</sup> A previous multicenter retrospective study found a 6% to 10% TWL at 12 months with an adverse event rate of 4.8%.<sup>37</sup> Although multiple other studies have shown similar results, compared with suturing or plication techniques, the results with APC may be more short-term (ie, less durable) and may require retreatment.<sup>34,35</sup>

### TRANSORAL OUTLET REDUCTION

Among patients with a history of RYGB and weight regain post-surgery, an endoscopic suturing technique called transoral outlet reduction (TORe) involves reducing the size of the gastrojejunal anastomosis, which may become dilated and cause weight regain due to lack of appropriate satiety. Similar to the ESG, the OverStitch endoscopic suturing system (Boston Scientific) is FDA approved for adults with obesity and weight regain after patients have undergone RYGB. This procedure involves APC in addition to endoscopic suturing to reduce the outlet size in patients with a dilated and incompetent gastrojejunal anastomosis. This revision of the gastrojejunal anastomosis and gastric pouch is completed using a minimally invasive approach to place multiple running and interrupted stitches using absorbable and nonabsorbable suture materials. Following the procedure, the revised gastric pouch and preexisting surgical Roux-en-Y anatomy provides a durable weight-loss response and is considered less invasive and with fewer complications compared to a surgical revision.

The RESTORe (Randomized evaluation of endoscopic suturing transorally for anastomotic outlet reduction) trial was a pivotal multicenter, randomized, sham-controlled study that demonstrated TORe to be effective and associated with significantly greater TWL at 6 month follow-up compared to patients with lifestyle interventions alone.<sup>38</sup> This study also demonstrated that weight loss or stabilization of weight was achieved in 96% of patients in the treatment arm and showed significant improvement in obesity-associated comorbid conditions including hypertension. Additional full-thickness endoscopic suturing for gastric bypass revision (ie, TORe) has shown TWL of 8.4% at 12 months with durable results at 3 years.<sup>39-44</sup> Subsequent 5-year literature found that patients who underwent TORe had a TWL of 8.5% and 8.8% at 1 and 5 years, respectively.<sup>42</sup> The diameter of the gastrojejunal anastomosis also decreased significantly from an average of 23.4 mm preprocedure to a postprocedure size of 8.4 mm, with no serious adverse events.

In a meta-analysis including > 1,500 patients, TORe was associated with a TWL of 9.0% and 9.5% at 3 and 12 months, respectively.<sup>45</sup> Unpublished data from our own group has shown significantly improved weight loss when endoscopic suturing has been combined with novel GLP-1 or GLP-1/GIP receptor agonists, achieving 12% to 25% TWL at 6-12 months. When comparing an endoscopic versus surgical revision approach, a study by Dolan et al. found non-significant differences in weight loss at 5 years.<sup>46</sup> More importantly, this study demonstrated the safety of the endoscopic approach and a significantly lower rate of adverse events for endoscopy versus surgery (6.5% vs 29%).

### GASTRIC BYPASS REVISION USING PLICATION TECHNIQUE

Similar to endoscopic suturing, gastric plication may also be utilized as an effective revisional EBMT. Data using both the Incisionless Operating Platform System (UGSI Medical) and Endomina system (Endo Tools Therapeutics) has shown promising results, with both having received FDA approval for tissue apposition (not a specific obesity indication).<sup>47</sup> The initial study of revisional plication procedure for weight regain demonstrated a 65% decrease in gastrojejunal anastomosis diameter and 36% reduction in pouch size.<sup>48</sup> In a prospective study of 116 patients with weight regain after RYGB, endoscopic revision plication resulted in an EWL of 18% at 6 months.<sup>49</sup> Two additional studies of plication among patients with weight regain after RYGB showed a TWL of 7.8% and EWL of 23.1% at 12 months.<sup>50,51</sup>

## ENDOSCOPIC SLEEVE GASTRECTOMY REVISION

Endoscopic suturing and plication has also been performed to reduce the size of the stomach for patients with recurrent weight gain after surgical sleeve gastrectomy.<sup>52</sup> For revision of a surgical sleeve gastrectomy, both endoscopic suturing and plication techniques may be used. Though the data is limited compared to patients with weight regain after RYGB, one single-center retrospective study compared patients who underwent endoscopic sleeve revision versus surgical sleeve revision or conversion to RYGB and found that weight loss with endoscopic sleeve revision was equivalent to surgical revision at 12 months (9.8% vs 9.8%) though with a significantly shorter hospital stay.<sup>53</sup>

## SUMMARY OF ENDOSCOPIC REVISION FOR WEIGHT REGAIN AFTER BARIATRIC SURGERY

Endoscopic suturing, APC, and endoscopic plication may all be utilized as effective and safe EBMTs for the treatment of weight regain after RYGB. For patients with weight recurrent after surgical sleeve gastrectomy, endoscopic suturing or plication are viable alternatives with similar weight loss and reduced morbidity compared to surgical revision. While APC may be the least durable of the treatment strategies, each can be combined with pharmacotherapy to achieve even greater weight-loss results compared with endoscopic treatments alone. Ultimately, these revisional EBMTs may achieve 8% to 12% TWL with a < 2% rate of serious adverse events.

## NOVEL ENDOSCOPIC TREATMENT OPTIONS

While the above treatments have FDA approval for obesity or tissue apposition, there are a variety of other endoscopic therapies in the pipeline.<sup>54</sup> One such treatment, duodenal mucosal resurfacing, is a non-FDA approved EBMT that uses thermal or non-thermal ablation of the superficial layer of duodenal mucosa to improve insulin sensitivity and facilitate weight loss. Several studies have demonstrated an improvement in glycemic control and insulin sensitivity, with HbA1c reduction of approximately 1.2% and about 2.5 kg of weight loss.<sup>55-57</sup>

Other investigational therapies include an endoluminal bypass liner called RESET (Morphic Medical), formally known as EndoBarrier (GI Dynamics). Formerly CE marked in Europe, this device is a 60-cm fluoropolymer duodenal-jejunal bypass liner placed with endoscopic and fluoroscopic guidance and designed to decrease the absorption of food from the proximal duodenum. Several studies have shown this bypass liner to improve glycemic control, although concerns about the risk of hepatic abscesses have limited more widespread adoption.<sup>58-60</sup>

## CONCLUSION

Numerous EBMTs are available for the treatment of obesity, with effective options for the treatment of both treatment-naïve patients as well as those with a history of bariatric surgery. These procedures offer more durable weight-loss results and glycemic control compared with lifestyle changes and pharmacotherapy alone while also mitigating the risks associated with more invasive surgeries. These therapies add to the number of potential treatment options and may even be combined with pharmacotherapy to achieve synergist weight-loss results.


## KEY POINTS


- Endoscopic bariatric and metabolic therapies (EBMTs) are ultra-minimally invasive treatment options for obesity.
- These endoscopic therapies may be used for treatment-naïve patients with no history of bariatric surgery or as a therapy for weight recurrence after bariatric surgery.
- Endoscopic treatment options approved by the US Food and Drug Administration (FDA) include intragastric balloon, endoscopic suturing, and endoscopic plication, with additional novel therapies like duodenal mucosal resurfacing and endoluminal bypass liner that are not yet FDA approved.
- EBMTs can also be combined with glucagon-like peptide 1 (GLP-1) and GLP-1/glucose-dependent insulinotropic polypeptide receptor agonists to achieve weight-loss results similar to bariatric surgery.
- EBMTs provide a highly effective and safe tool to reduce the prevalence of obesity and the risk of obesity-associated comorbid conditions.

## COMPETING INTERESTS

Thomas R. McCarty is a consultant for Medtronic/Covidien and Endoquest Robotics. Ronan P. Allencherril has no competing interests to declare.

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