

# Weight loss after endoscopic sleeve gastroplasty is independent of suture pattern: results from a randomized controlled trial



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## ABSTRACT

**Background and study aims** This was a single-blind, single-center, prospective randomized controlled trial aimed at comparing the efficacy of three different suture patterns for endoscopic sleeve gastroplasty using Endomina (E-ESG).

**Patients and methods** The suture patterns aimed to modify gastric accommodation by increasing the fundus distention ability (Group A), to reduce gastric volume (Group B) or to interrupt gastric emptying (Group C). Patients were randomized 1:1:1 and underwent clinical follow-up, gastric emptying scintigraphy, and satiety tests at baseline and 6 and 12 months post-procedure. The primary outcome was total body weight loss (TBWL) and excess weight loss (EWL) at 12 months post-procedure. Secondary outcomes included the impact of the suture patterns on gastric emptying and satiety.

**Results** Overall, 48 patients (40 [83.3%] female, aged 41.9±9.5 years, body mass index 33.8±2.7 kg/m<sup>2</sup>) were randomized (16 in each group). In the entire cohort, mean (95% confidence interval [CI]) TBWL and EWL at the end of the follow-up were 10.11% (7.1–13.12) and 42.56 (28.23–56.9), respectively. There was no difference among the three study groups in terms of TBWL (95%CI) (9.13% [2.16–16.11] vs. 11.29% [5.79–16.80] vs. 9.96% [4.58–15.35]; *P*=0.589) and EWL (95%CI) (34.54% [6.09–62.99] vs. 44.75% [23.63–65.88] vs. 46.94% [16.72–77.15]; *P*=0.888) at 12 months post-procedure. The three groups did not differ in terms of mean gastric emptying time or in terms of satiety tests at the end of the follow-up. No serious adverse events occurred.

**Conclusions** Three different suture patterns during E-ESG demonstrated comparable efficacy in terms of weight loss, with an overall EWL of >25% and TBWL of >10% at 12 months.

## Introduction

Obesity is a major health problem with a significant global burden. Surgery remains the only recognized treatment for obesity and obesity-associated complications [1]. Endoscopic bariatric and metabolic therapies have been developed to fill the gap between diet with lifestyle modification and surgery [2]. Among them, endoscopic sutured gastroplasty (ESG) has been associated with significant weight loss and an excellent safety profile [3].

ESG was initially described using the Overstitch system (Apollo Endosurgery, Austin Texas, United States). Overstitch has been the most frequently performed procedure for treating class I and II obesity with good results reported in post-marketing retrospective studies, while a systematic review and meta-analysis of eight (retrospective) studies concluded that ESG using the Overstitch system may lead to a 15.6% total body weight loss (TBWL) at 12 months post-procedure [4, 5]. The results of a randomized clinical trial (RCT) recently have been announced with a 49% EWL at 12 months, two times higher than lifestyle therapy alone in controls [6].

Another system used for ESG is the Endomina platform (Endo Tools Therapeutics S.A., Gosselies, Belgium), which has been shown to be effective in prospective studies, including a randomized cross-over trial, with excess weight loss (EWL) being significantly higher in the treatment group compared to the control group at 6 months post-procedure (38.6% vs. 13.4%;  $P < 0.001$ ) [7]. However, despite the efficacy of these systems, no exact mechanism through which ESG induces weight loss has been clearly identified. It has been hypothesized that reduced gastric volume, effects on gastric emptying, and/or fundus distensibility could be involved. In this context, we conducted a RCT to evaluate the effect of three different suture patterns during ESG using the Endomina System (E-ESG) on post-ESG weight loss.

## Patients and methods

### Study design

This investigator-initiated prospective, randomized study was conducted at Erasme University Hospital in Brussels, Belgium in compliance with the Helsinki Declaration. The hospital's Institutional Review Board approved the study protocol (ClinicalTrials.gov: NCT03843801). The devices were provided free of charge by Endo Tools Therapeutics S.A. All patients provided written informed consent and the study is reported according to CONSORT guidelines [8] (**Supplementary Table 1**).

### Participants

Individuals were assessed for eligibility during outpatient consultations at our dedicated multidisciplinary bariatric center. The inclusion criteria were as follows: age 18 to 65 years, obesity class I or II defined (body mass index [BMI] 30–40 kg/m<sup>2</sup>), ability to comply with all study requirements for the duration of the study as outlined in the protocol, ability to provide written informed consent and successful completion of the prespecified multidisciplinary workup including a consultation with a

gastroenterologist, a psychologist, a dietician, and an occupational therapist. In addition, each patient was discussed at the medical board meeting with the participation of bariatric surgeons before inclusion in the protocol. The exclusion criteria were: presence of an esophageal motility disorder, unstable angina, myocardial infarction within the past year, or heart disease classified within the New York Heart Association's Class III or IV functional capacity, uncontrolled hypertension during the last 3 months, severe renal, hepatic, or pulmonary disease, or active cancer, gastrointestinal stenosis or obstruction, pregnancy or breastfeeding or willing to become pregnant within study duration, history of any type of gastric surgery, impending gastric surgery 60 days post-intervention, history of weight changes ( $\pm 5\%$  of the total body weight [TBW]) or placement or removal of an intragastric balloon during the last 6 months, positive *Helicobacter pylori* status, and active participation in another clinical trial.

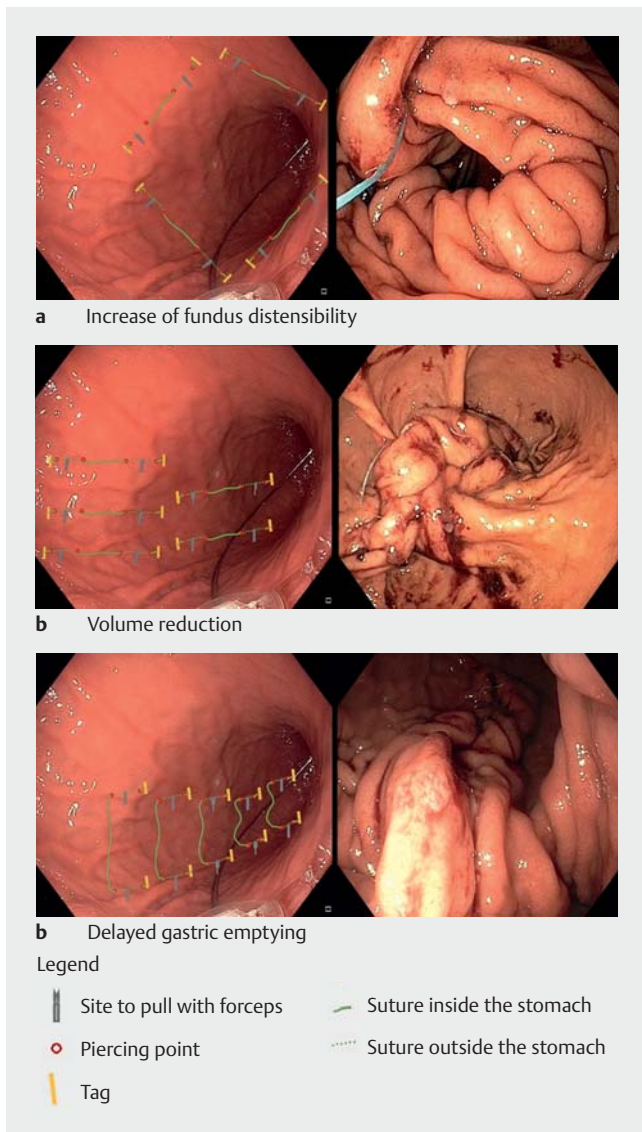
### Randomization and concealed allocation

We randomly assigned participants (1:1:1) by computer-generated randomization to undergo E-ESG with one of three different suture patterns (groups A, B, and C). Before starting the procedure, the site study coordinator opened the concealed envelope to reveal the group allocation to the endoscopist.

### Endoscopic procedure and study groups

The Endomina System is a triangulation platform that can be used with any flexible endoscope and a dedicated needle (TAPES, Endo Tools Therapeutics S.A., Gosselies, Belgium) to create gastrointestinal sutures and has been described in detail elsewhere [9].

The three evaluated suture patterns used for the purpose of this study are depicted in ► **Fig. 1**. The first pattern consisted of creating a pouch at the upper part of the body by placing intraluminal sutures mimicking a gastric band aiming to increase the distention ability of the fundus. After placing three to five sutures, food was expected to accumulate in the fundus, giving an early feeling of satiety. The second pattern aimed to drastically reduce the size of the stomach by placing five to seven longitudinal sutures on the anterior wall of the stomach, starting from the incisura and going up to the upper body of the stomach. Finally, the third pattern consisted of making bridges (dams) in the gastric body. Four to six sutures are placed antero-posteriorly along the greater curvature of the stomach to create an interruption of normal gastric emptying and provide a prolonged feeling of satiety (the pattern used in previously published RCT). All endoscopic procedures were performed under general anesthesia with endotracheal intubation and patients were hospitalized overnight per protocol for surveillance. All patients received proton pump inhibitors (40 mg once a day for 3 months) post-intervention. Patients were kept on a liquid diet for 3 days after the procedure, and then the food texture was gradually broadened during the second week using mashed food as a transition. Participants returned to solid food within 10 days.



► **Fig. 1** Graphic illustration and final endoscopic image of the three suture patterns and their respective endoscopic results post-procedure. **a** Pattern “band” aiming to increase distensibility of the fundus. **b** Gastric “volume reduction.” **c** Pattern “dams” aiming to slow down gastric emptying.

## Patient baseline and post-procedure evaluations

### Nutritional follow-up

A dietary evaluation was performed pre-procedure and then at 2 weeks and 1, 3, 6, 9, and 12 months post-procedure. Patients were prescribed a low-calorie, high-protein diet and lifestyle counseling based on Belgian Association for the Study of Obesity (BASO) 2020 and American Society of Metabolic and Bariatric Surgery (ASMBS) 2013 guidelines [10, 11]. Physical activity was promoted. Psychological support was added to follow-up on a case-by-case basis. Weight loss medication prescription was not allowed during the study period.

### Satiety test

Patients underwent satiety tests at the baseline evaluation, and at 6 and 12 months post-procedure. The drinking satiety test (modified from a previously described version [12]) consisted of drinking, every 60 seconds, 30 mL of a protein-rich and high-calorie nutritional drink (Fortimel Energy [Nutricia] [1.5 kcal/mL, 5.9g P/100 mL, 18.4g CHO/100mL, 5.8g L/100 mL] and Resource Energy [Nestlé Health Science] [1.5 kcal/mL, 5.6g P/100 mL 21g CHO/100 mL, 5g L/100 mL]). Five symptoms (hunger, fullness, nausea, bloating, and pain) were assessed on a 10-point scale (0=no feeling, 10=maximal feeling) every 5 minutes. The test was stopped, and volume of intake was calculated when the patient reported fullness to be at a level of 10 or if one of the other symptoms became unbearable.

An upper gastrointestinal endoscopy was performed at 1, 6, and 12 months of follow-up to assess the integrity of the suture pattern and the number of sutures remaining intact.

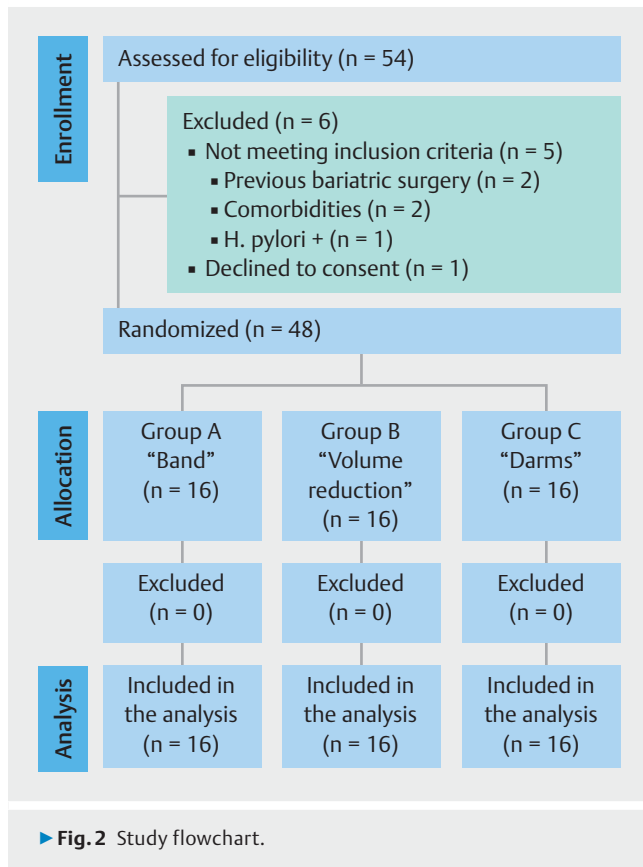
Gastric emptying scintigraphy was performed at baseline, and at 6 and 12 months post-procedure. The examination was performed according to the procedure laid down by the joint guideline of Society for nuclear medicine and the American Neurogastroenterology and Motility Society. Patients were scanned under a dual-head gamma camera set at a 99mTc window (140 keV ± 15%) in the supine position to visualize the whole stomach; simultaneous anterior and posterior radioactivity measurements were obtained. After ingesting the radiolabeled test meal, a static image of 60-second duration was done immediately post-meal, followed by static serial pictures at 30, 60, 120, and 180 minutes and a half emptying time was measured.

### Outcomes

Weight loss, expressed as TBWL and EWL, among the three groups at 12 months of follow-up was the primary outcome. Secondary outcomes included the impact of the different suture patterns on gastric emptying scintigraphy and satiety test, the impact of the remaining number of sutures at the end of the follow-up on weight loss and assessment of nausea, vomiting, and abdominal pain at 24 hours post-procedure using the 0–10 visual analog scale. As an exploratory outcome of our study, we evaluated potential correlations between the number of remaining sutures during the one year of the follow-up after the E-ESG. To do that, the number of sutures were counted during the follow-up gastroscopies (months 1, 6, and 12 post-procedural). Taking into account the fact that the three suture patterns necessitated a different number of sutures, any change in the number of remaining sutures was expressed as a percentage of the difference ( $\Delta$ ) between the number of the initially applied sutures and those remaining in place at each timepoint ( $[(\text{initial number of sutures} - \text{number of remaining sutures}) / \text{initial number of sutures}]$ ).

### Statistical analyses

Due the absence of existing studies which report the magnitude of effect of the type we aimed to investigate, we decided to proceed with a 1:1:1 randomization on a total of 48 patients (16 in each group). Descriptive statistics were computed for all study variables. Discrete variables were expressed as count



(percentage) and continuous variables as mean  $\pm$  standard deviation. Intention to treat is considered the principal approach for all analyses [13, 14]. For EWL and TBWL, the treatment effect has been assessed using linear mixed models with time as a repeated factor. Time, group, and interaction were considered fixed effects in the model. The model accounted for participant correlations over time and between groups. The fixed effects estimates are reported as means with 95% confidence intervals (CIs). To adjust for multiple comparisons, Bonferroni correction method was used. Multiple imputation was used to investigate the sensitivity of the results of the primary analysis with regard to the missing data. The mixed model was then refitted, and the obtained results were compared with those from the previous results. The association between variables was set by estimating the correlation between them. All statistical tests were two-tailed and  $P < 0.05$  was considered statistically significant. Data were analyzed using IBM SPSS Statistics for Windows v27 (Armonk, New York, United States) and R software (R Foundation for Statistical Computing, Vienna, Austria).

## Results

### Patients

We randomly allocated 48 patients (mean age  $41.9 \pm 9.5$  years; 40 female [83.3%], BMI  $33.8 \pm 2.7$  kg/m<sup>2</sup>) to the three index study arms from April 2019 to November 2019. ► **Fig. 2** shows the study flowchart. Baseline BMI was similar for the three groups ( $34.65 \pm 2.55$ ,  $33.8 \pm 2.69$ , and  $33.34 \pm 2.51$  for groups

A, B, and C, respectively). The detailed baseline demographic, anthropometric, and laboratory parameters of the enrolled patients per group are shown in ► **Table 1**.

### Procedure details

Overall, the mean duration of the procedure was  $60.67 \pm 19.04$  minutes. Procedural time in Group B ( $72.94 \pm 19.58$ ) tended to be longer compared to Group A ( $55.13 \pm 16.49$ ) and C ( $53.94 \pm 15.45$ ), but this difference did not reach the level of statistical significance ( $P = 0.06$ ). As expected per study design, fewer sutures were used in Group A ( $3.88 \pm 0.62$ ) and C ( $4.5 \pm 0.73$ ) compared to Group B ( $5.5 \pm 0.89$ ;  $P < 0.001$ ). No severe adverse events related to the E-ESG were reported during the study period.

### Primary outcome

► **Fig. 3a** depicts the TBWL (95%CI) and EWL (95%CI) per suture pattern group during the 12 months of the study. After 12 months of follow-up, the mean TBWL in all groups was 10.11% (7.1–13.12), over the recommended 5%, compared to baseline weight [2]; however, no statistical difference among the different groups was detected. TBWL was 9.13% (2.15–16.11) in Group A, 11.29% (5.79–16.80) in Group B, and 9.96% (4.58–15.35) in Group C ( $P = 0.589$ ). At the end of the follow-up (12 months), the mean EWL exceeded the recommended 25% (42.56% (28.23–56.9) compared to the baseline weight in the entire cohort ► **Fig. 3b**). Once again, there were no statistically significant differences among the three groups [34.54% (6.09–62.99) vs. 44.75% (23.63–65.88) vs. 46.94% (16.72–77.15) for groups A, B, and C, respectively;  $P = 0.888$ ]. ► **Table 2** shows the per group TBWL and EWL for the different study time points. The lack of difference between the three groups was confirmed during the multiple imputation analysis (**Supplementary Table 2**); TBWL (95%CI) was 10.43% (6.01–14.85) in Group A, 11.5% (7.79–15.20) in Group B, and 9.97% (5.71–14.23) in Group C ( $P = 0.497$ ) and EWL (95% CI) was 37.40% (19.70–55.11) vs. 47.76% (30.25–65.27) vs. 45.61% (22.51–68.70) for groups A, B, and C ( $P = 0.970$ ), respectively, at the end of the 12-month follow-up.

### Secondary outcomes

#### Gastric emptying scintigraphy

At the end of the follow-up, 25 patients performed the control gastric emptying scintigraphy (6, 8, and 11 for groups A, B, and C, respectively). At baseline, the half emptying time was 57.5 min (43.64–71.36) for Group A (n = 16), 59.64 min (46.91–72.37) for Group B (n = 16), and 68.07 min (59.86–76.27) for Group C (n = 16) with no differences between the three groups. There was no statistically significant difference regarding the half emptying time either per group compared to baseline or among the three different suture patterns at the end of follow-up (54.00 min [32.86–75.14], 68.38 min [48.25–88.50], and 69.45 min [55.05–83.86]) for groups A, B, and C, respectively;  $P = 0.577$ . ► **Table 3** presents the results of gastric emptying scintigraphy for the three different time points (baseline, month 6, month 12).

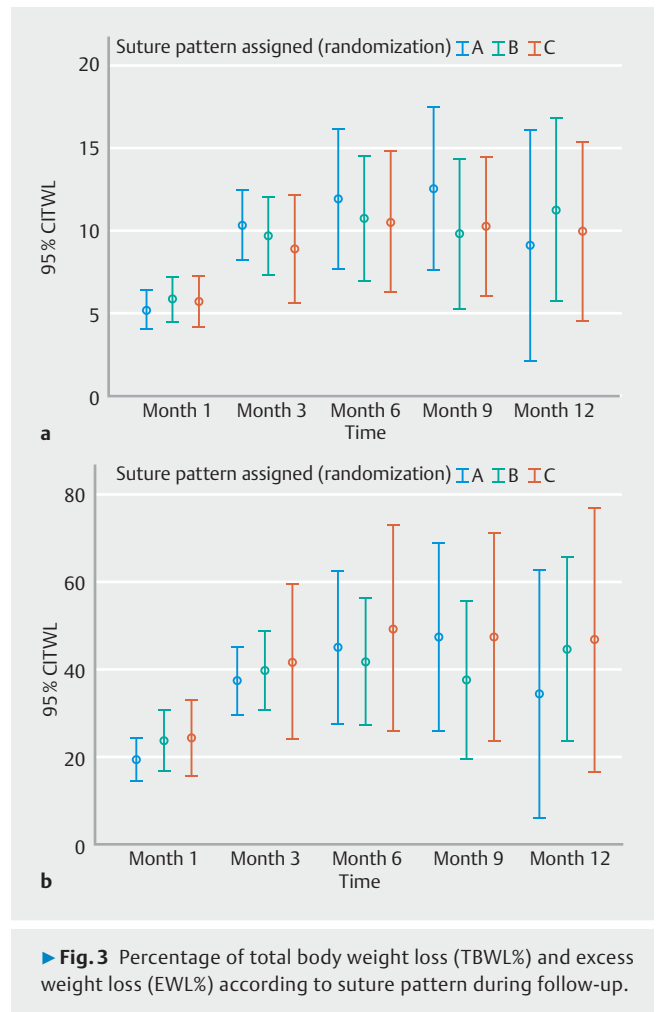
**► Table 1** Baseline demographic, anthropometric, and laboratory parameters of enrolled patients.

	Group A	Group B	Group C
Sex, n (%)			
▪ Female	14 (87.5)	13 (81.3)	13 (81.3)
▪ Male	2 (12.5)	3 (18.7)	3 (18.7)
Smoking status, n (%)			
▪ Never	8 (50)	13 (81.3)	12 (75)
▪ Past	2 (12.5)	1 (6.2)	2 (12.5)
▪ Active	6 (37.5)	2 (12.5)	2 (12.5)
Alcohol, n (%)			
▪ Never	8 (50)	12 (75)	10 (62.5)
▪ Past	0 (0)	1 (6.2)	0 (0)
▪ Active	8 (50)	3 (18.8)	6 (37.5)
Age (years), mean (SD)	42.81 (7.95)	36.75 (6.78)	44.25 (11.2)
Weight (kg), mean (SD)	93.81 (10.24)	91.79 (7.84)	90.23 (11.67)
Height (cm), mean (SD)	165 (7)	165 (7)	164 (8)
BMI (kg/m <sup>2</sup> ), mean (SD)	34.65 (2.55)	33.8 (2.69)	33.34 (2.51)
Fat Mass	40.9 (4.76)	39.23 (6.3)	41.04 (19.84)
Glucose (mg/dL), mean (SD)	97.6 (14.9)	92.46 (12)	94.31 (9.68)
Total cholesterol (mg/dL), mean (SD)	185.69 (50.03)	172.64 (44.34)	212.25 (48.95)
HDL cholesterol (mg/dL), mean (SD)	51.54 (12.19)	57.07 (16.28)	57.44 (12.75)
Triglycerides (mg/dL), mean (SD)	146.93 (105.92)	96.64 (41.36)	127.06 (71.66)
AST	19.4 (11.59)	20.13 (5.63)	19.13 (6.28)
ALT	22.07 (13.37)	19.93 (7.18)	22.63 (12.8)
gGT	24.07 (16.42)	20.53 (13.48)	24.06 (16.12)
ALP	76.67 (28.24)	79.25 (10.72)	46 (21.31)

BMI, body mass index; AST, aspartate transaminase; ALT, alanine amino-transferase; ALP, alkaline phosphatase; gGT, gamma glutamyl transferase; HDL, high density lipoprotein.

### Drinking satiety test

At baseline, the mean ingested volume was 375.63 mL in Group A (n=16), 444.38 mL in Group B (n=16), and 513.13 mL in Group C (n=16). Overall, 12 months after the E-ESG, the inges-



**► Fig. 3** Percentage of total body weight loss (TBWL%) and excess weight loss (EWL%) according to suture pattern during follow-up.

ted volume to reach the test's endpoint dropped in all groups [268.57 mL in Group A (n=7), 231.43 mL in Group B (n=7), and 401 mL in Group C (n=10)]. No statistically significant difference was evident between the three groups ( $P=0.875$ ).

**► Table 4** shows the results of the drinking satiety test for the three different time points (baseline and months 6 and 12). The feeling of satiety using a 0–10 visual scale was 8 (5–9), 7 (7–8), and 8 (5–8) for groups A, B, and C, respectively and was less intense in all three groups (4.5 [1–8], 6 [2–8], and 6.5 [2.5–8.5]) for groups A, B, and C, respectively) at the end of follow-up. There was no difference among the three groups regarding the satiety test at the end of follow-up ( $P=0.933$ ).

### Correlation between the percentage of sutures remaining in place with TBWL and EWL

The mean difference in number of sutures between those initially applied and those remaining in place 1 year later was 30.21% (7.27–53.15) for Group A, 17.99% (3.46–32.52) for Group B, and 17.42% (6.99–27.86) for Group C ( $P=0.001$ ).

When taking into account the observations from all follow-up endoscopies, a statistically significant positive correlation between the number of remaining sutures and TBWL was observed (correlation coefficient [95%CI] 0.37 [0.18–0.53],  $P<$

► **Table 2** Total body weight loss and excess weight loss over time.

	TBWL (%), mean (95%CI)			P value	EWL, % (95%CI)			P value
	Group A (n=16)	Group B (n=16)	Group C (n=16)		Group A (n=16)	Group B (n=16)	Group C (n=16)	
Month 1	(n=15) 5.24 (4.04–6.44)	(n=15) 5.89 (4.50–7.28)	(n=14) 5.74 (4.20–7.29)	0.589*	(n=15) <sup>1</sup> 9.46 (14.58–24.34)	(n=15) 23.89 (16.92–30.86)	(n=14) 24.55 (15.81–33.29)	0.888*
Month 3	(n=13) 10.35 (8.21–12.48)	(n=13) 9.70 (7.33–12.07)	(n=15) 8.92 (5.67–12.16)		(n=13) 37.54 (29.77–45.32)	(n=13) 39.93 (30.97–48.89)	(n=15) 41.91 (24.12–59.69)	
Month 6	(n=11) 11.93 (7.67–16.19)	(n=13) 10.75 (6.96–14.55)	(n=14) 10.57 (6.27–14.86)		(n=11) 45.15 (27.68–62.62)	(n=13) 41.96 (27.37–56.56)	(n=14) 49.60 (26.12–73.08)	
Month 9	(n=11) 12.55 (7.62–17.48)	(n=13) 9.81 (5.28–14.35)	(n=15) 10.28 (6.08–14.49)		(n=11) 47.55 (26.11–68.98)	(n=11) 37.75 (19.78–55.72)	(n=15) 47.60 (23.90–71.31)	
Month 12	(n=11) 9.13 (2.15–16.11)	(n=13) 11.29 (5.79–16.80)	(n=15) 9.96 (4.58–15.35)		(n=11) 34.54 (6.09–62.99)	(n=13) 44.75 (23.63–65.88)	(n=15) 46.94 (16.72–77.15)	

TBWL, total body weight loss; EWL, excess weight loss; n: available data in that time; data are analyzed as ITT using mixed models.

\* Comparison among the three groups at month 12.

► **Table 3** Results of gastric emptying scintigraphy over time.

Half time emptying (min), mean (95% CI)							
	Group A	P value	Group B	P value	Group C	P value	P value
Baseline	(n=16) 57.50 (43.64–71.36)	0.999 <sup>1</sup>	(n=16) 59.64 (46.91–72.37)	0.945 <sup>1</sup>	(n=16) 68.07 (59.86–76.27)	0.999 <sup>1</sup>	0.577 <sup>2</sup>
Month 6	(n=8) 57.50 (40.48–74.52)		(n=9) 65.56 (45.29–85.82)		(n=8) 61.25 (45.51–76.99)		
Month 12	(n=6) 54.00 (32.86–75.14)		(n=8) 68.38 (48.25–88.50)		(n=11) 69.45 (55.05–83.86)		

n, available data in that time; data are analyzed as ITT using mixed models.

CI, confidence interval; ITT, intention to treat.

<sup>1</sup> Per group comparison between baseline and month 12.

<sup>2</sup> Time-group interaction for the three groups at month 12.

0.001). When looking separately at the three suture patterns, this correlation remained statistically significant for groups B and C (coefficient [95%CI] 0.55 [0.23–0.76],  $P=0.001$  and 0.51 [0.19–0.73],  $P=0.002$ , respectively), but not for Group A (coefficient [95%CI] 0.14 [–0.24–0.48],  $P=0.480$ ). Similar observations were made regarding EWL both for the entire cohort (correlation coefficient ([95%CI] 0.33 [0.14–0.50],  $P=0.001$ ), as well as per randomization group (correlation coefficient [95%CI] 0.11 [–0.27–0.46],  $P=0.568$  for Group A, 0.54 [0.22–0.75],  $P=0.001$  for Group B, and 0.43 [0.09–0.68],  $P=0.011$  for Group C).

## Adverse events

► **Table 5** shows evaluation of nausea, vomiting, and abdominal pain (cramps) at 24 hours post-procedure using the 0–10 visual analog scale. There was no difference among the three groups for all of these symptoms. Even though abdominal cramps were numerically less intense in Group C (mean score  $3.63 \pm 2.53$ ) compared to Group A ( $4.40 \pm 2.59$ ) and Group B ( $4.25 \pm 2.67$ ), this difference did not reach statistical significance ( $P=0.617$ ).

► **Table 4** Results of drinking satiety test over time.

Volume to reach endpoint <sup>1</sup> (mL), mean (95%CI)							
	Group A	P value	Group B	P value	Group C	P value	P value
Baseline	(n = 16) 375.63 (299.69–451.56)	0.330 <sup>2</sup>	(n = 16) 444.38 (303.41–585.34)	0.077 <sup>2</sup>	(n = 16) 513.13 (368.10–658.15)	0.214 <sup>2</sup>	0.875 <sup>3</sup>
Month 6	(n = 8) 221.25 (138.68–303.82)		(n = 9) 253.33 (135.69–370.98)		(n = 10) 297.00 (160.72–433.28)		
Month 12	(n = 7) 268.57 (130.11–407.03)		(n = 7) 231.43 (162.13–300.73)		(n = 10) 401.00 (34.78–767.22)		

n, available data in that time; data are analyzed as ITT using mixed model.

CI, confidence interval; ITT, intention to treat.

<sup>1</sup> Hunger, fullness, nausea, bloating, and pain according to protocol.

<sup>2</sup> Per group comparison between baseline and month 12.

<sup>3</sup> Time-group interaction for the three groups at month 12.

► **Table 5** Adverse events assessed at 24 hours post-procedure using a 0–10 visual analogue scale.

	Group A	Group B	Group C	P value
Nausea, mean (SD)	1.27 (1.87)	2.25 (2.84)	1.88 (2.31)	0.690
Vomiting, mean (SD)	1.27 (3.03)	1.94 (3.36)	0.94 (2.57)	0.483
Cramps, mean (SD)	4.40 (2.59)	4.25 (2.67)	3.63 (2.53)	0.617

SD, standard deviation.

## Discussion

Endoscopic sleeve gastroplasty using Endomina (E-ESG) previously has been demonstrated to be effective for weight loss when compared to only lifestyle interventions [15]. In the present randomized study, none of the three different suture patterns tested proved to be superior compared to the others. Still, all three of them led to a  $\geq 10\%$  TBWL and  $\geq 25\%$  EWL at the end of the 12-month follow-up, achieving the target for an endoscopic bariatric treatment to be considered efficacious [2].

Currently, different techniques for performing an endoscopic sleeve gastroplasty are available, with all of them showing promising results for the treatment of obesity. However, the exact mechanism through which the goal of weight loss is achieved remains unclear. Volume reduction leads to earlier postprandial satiety and lower calorie intake, and a decrease in the rate of gastric emptying has also been proposed to be important.

Although various studies in the literature have tested different suture patterns for ESG, almost exclusively using the Overstitch system [16, 17], the major aim of these studies was not to reveal potential pathophysiologic mechanisms regarding beneficial effects of ESG, but rather, to evaluate different patterns in terms of feasibility, ease of application, and cost-effectiveness.

Espinet-Coll et al. [18] performed a retrospective study examining three different suture patterns; a transverse bilinear

design starting from the anterior wall then moving to the greater curvature, to the posterior wall, and then repeated vice versa, a longitudinal pattern with two rows of parallel sutures along the gastric body, and a transverse monolinear pattern starting from the anterior wall then moving to the greater curvature and finishing at the posterior wall. All three patterns were performed using the first generation of the Overstitch and reflect the evolution of the technique at a single center. All three designs aimed to achieve a “classic” endoscopic gastroplasty by suturing the gastric body and reducing the gastric volume.

In contrast, we aimed to create three different gastroplasty types: increased fundus distensibility, decreased volume, and delayed gastric emptying. This study demonstrated that patients in all three groups achieved sufficient weight loss with no differences in the number of the sutures or stitches applied. However, in both studies, no difference was detected between the evaluated patterns regarding weight loss, meaning that regardless of the suture pattern used, a similar weight loss was achieved.

Although gastric emptying recently has been associated with the sensation of appetite in obese patients [19], our results do not confirm this observation. Interestingly, our study did not demonstrate any difference in gastric emptying. The gastric emptying scintigraphy time did not differ among the three groups at the end of follow-up. In comparison, there was

no statistically significant difference in scintigraphy between baseline and the end of follow-up for all three groups. On the other hand, the feeling of satiety was achieved more quickly at the end of follow-up compared to baseline for groups A and B, but not for Group C. It is also worth mentioning that the volume needed to be ingested to achieve satiety did not differ among the three groups at the end of follow-up. A trend to a lower required volume was detected in Group B between baseline and the end of follow-up. While acknowledging that our study was not powered to detect these differences, we should consider that endoscopic gastroplasty may contribute weight loss in a multifactorial way, beyond volume reduction and delayed gastric emptying.

From a technical point of view, the ease of performing each of the suture patterns was not assessed in this study. However, all endoscopists reported Group A to be the most challenging to achieve. This is confirmed because the mean procedural time was similar for all three groups, while Group A was the one with the smallest number of sutures used. Moreover, Group A was associated with a higher percentage of displaced sutures at the end of follow-up, probably due to higher tension between the sutures applied in the different parts of the gastric wall in this pattern trying to mimic a gastric band. Even if dislodgement of some of the initially placed sutures did not lead to loss of efficacy, as shown in our exploratory analysis, we would tend to avoid pattern A because it was technically more cumbersome.

This is the first RCT evaluating different suture patterns in patients undergoing ESG. Despite great interest in this topic [5], existing evidence derives either from simple cohort studies or from retrospective studies evaluating a single center's experience with different suture patterns throughout the years [16]. While RCTs on ESG are scarce, this is the second RCT evaluating the efficacy of Endomina for obesity, confirming the previously published results, showing that E-ESG can lead to a significant weight loss among obese patients [15]. Another advantage of our study is that all patients underwent a detailed pre-intervention structured bariatric workup guided by a multidisciplinary team. Beyond the standard workup, all participants underwent gastric scintigraphy and a satiety test, allowing us to assess the potential impact of our intervention in terms of gastric emptying and gastric volume.

Our work is not without limitations. Most importantly, this study was not powered to detect any difference regarding secondary outcomes (impact of suture patterns on gastric emptying and gastric volume). Thus, even in the absence of statistical significance, these results should be interpreted cautiously. Beyond that, the unprecedented COVID-19 pandemic inevitably affected our academic projects because participants hesitated to visit the hospital for non-urgent issues or planned follow-up appointments were canceled during the first pandemic wave.

Consequently, and despite all our efforts, in terms of the primary outcome (EWL and TBWL) nine patients were lost during follow-up and were not evaluated at month 12. To overcome this drawback, we performed an imputation analysis, taking into account the available data for every patient until the last follow-up, confirming our per-protocol analysis results. Finally,

this study did not aim to evaluate changes in patient comorbidities (hypertension, diabetes) before and after treatment application. However, we acknowledge that this could be part of the design of a future study, which would also be warranted to elucidate potential pathophysiological mechanisms contributing to weight loss following endoscopic gastroplasty.

## Conclusions

To conclude, our study showed that different suture patterns effectively achieved significant weight loss among obese patients. On the other hand, the differences regarding gastric scintigraphy results and volume needed to achieve satiety were non-significant among the three different patterns at the end of follow-up.

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## Competing interests

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## Clinical trial

ClinicalTrials.gov  
NCT03843801  
TRIAL REGISTRATION: Single center randomized controlled trial at <https://www.clinicaltrials.gov/>

## References

- [1] Sjöström L, Narbro K, Sjöström CD et al. Effects of bariatric surgery on mortality in Swedish obese subjects. *N Engl J Med* 2007; 357: 741–752
- [2] Abu Dayyeh BK, Kumar N. ASGE Bariatric Endoscopy Task Force and ASGE Technology Committee. et al. ASGE Bariatric Endoscopy Task Force systematic review and meta-analysis assessing the ASGE PIVI thresholds for adopting endoscopic bariatric therapies. *Gastrointest Endosc* 2015; 82: 425–438
- [3] Sullivan S, Edmundowicz SA, Thompson CC. Endoscopic bariatric and metabolic therapies: new and emerging technologies. *Gastroenterology* 2017; 152: 1791–1801
- [4] Hedjoudje A, Dayyeh BA, Cheskin LJ et al. Efficacy and safety of endoscopic sleeve gastroplasty: a systematic review and meta-analysis. *Clin Gastroenterol Hepatol* 2020; 18: 1043–1053
- [5] 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: 3021–3029
- [6] 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; 28: doi:10.1016/S0140-6736(22)01280-6



- [7] Huberty V, Machytka E, Boškoski I et al. Endoscopic gastric reduction with an endoluminal suturing device: a multicenter prospective trial with 1-year follow-up. *Endoscopy* 2018; 50: 1156–1162
- [8] Schulz KF, Altman DG, Moher D et al. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. *PLoS Med* 2010; 7: e1000251
- [9] Huberty V, Ibrahim M, Hiernaux M et al. Safety and feasibility of an endoluminal-suturing device for endoscopic gastric reduction. *Gastrointest Endosc* 2017; 85: 833–837
- [10] BASO consensus 2020. Available from (Accessed 2021 Dec 12): [https://belgium.easo.org/wp-content/uploads/2020/02/BASO\\_consensus\\_2020\\_French\\_main.pdf](https://belgium.easo.org/wp-content/uploads/2020/02/BASO_consensus_2020_French_main.pdf)
- [11] Mechanick JL, Youdim A, Jones DB et al. Clinical practice guidelines for the perioperative nutritional, metabolic, and nonsurgical support of the bariatric surgery patient – 2013 update: cosponsored by American Association of Clinical Endocrinologists, the Obesity Society, and American Society for Metabolic & Bariatric Surgery. *Surg Obes Relat Dis* 2013; 9: 159–191
- [12] Tack J, Piessevaux H, Coulie B et al. Role of impaired gastric accommodation to a meal in functional dyspepsia. *Gastroenterology* 1998; 115: 1346–1352
- [13] Xi W, Pennell M, Andridge R et al. Comparison of intent-to-treat analysis strategies for pre-post studies with loss to follow-up. *Contemp Clin Trials Commun* 2018; 11: 20–29
- [14] Twisk JW, Rijnhart JJ, Hoekstra T et al. Intention-to-treat analysis when only a baseline value is available. *Contemp Clin Trials Commun* 2020; 20: 100684
- [15] Huberty V, Boskoski I, Bove V et al. Endoscopic sutured gastroplasty in addition to lifestyle modification: short-term efficacy in a controlled randomised trial. *Gut* 2020; doi:10.1136/gutjnl-2020-322026
- [16] Singh S, Hourneaux de Moura DT, Khan A et al. Safety and efficacy of endoscopic sleeve gastroplasty worldwide for treatment of obesity: a systematic review and meta-analysis. *Surg Obes Relat Dis* 2020; 16: 340–351
- [17] Currie AC, Glaysheer MA, Blencowe NS et al. Systematic review of innovation reporting in endoscopic sleeve gastroplasty. *Obes Surg* 2021; 31: 2962–2978
- [18] Espinet-Coll E, Nebreda-Durán J, Galvao-Neto M et al. Suture pattern does not influence outcomes of endoscopic sleeve gastroplasty in obese patients. *Endosc Int Open* 2020; 8: E1349–E1358
- [19] 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: 37–43