

# Comparative evaluation of efficiency for gastroileostomy anastomosis in laparoscopic transit bipartition with sleeve gastrectomy between linear and circular staplers

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## Abstract

**Introduction:** The use of Transit Bipartition with Sleeve Gastrectomy (SG + TB) to treat obesity and type 2 diabetes related to it has been increasing, but there are many challenges related to the procedure. The anastomosis diameter of gastroileostomy (GI) performed using linear staplers is an important factor affecting the postoperative metabolic status.

**Aim:** We aimed to compare linear-stapled (LS) and circular-stapled (CS) GI in SG + TB in terms of early and late perioperative and postoperative status.

**Material and methods:** This retrospective study included 24 patients who had undergone SG + TB between January 2018 and June 2019 to treat obesity and/or type 2 diabetes. GI was performed using linear staplers in 13 (SG + TB-LS group) and circular staplers in 11 patients (SG + TB-CS group). Operative time, hospitalization duration, complications, body mass index, haemoglobin A1c, albumin, haemoglobin, etc. were compared between the 2 groups before and 12 months after the surgery.

**Results:** The operation time was shorter in the SG + TB-CS group than in the SG + TB-LS group. The surgical treatments were successful in both groups in terms of weight loss and diabetes remission. Although not statistically significant, malnutrition and anaemia were slightly higher in the SG+TB-LS group than in the SG + TB-CS group during the follow-up process.

**Conclusions:** Both anastomosis types were found to be safe for SG+TB, and the risks of postoperative complications were low and comparable in both groups. However, the diameter of the anastomosis should always be the gold standard in the CS technique, while it may be too wide or too narrow in the LS technique.

**Key words:** transit bipartition, metabolic surgery, bariatric surgery, type 2 diabetes, circular-stapled gastroileostomy, linear-stapled gastroileostomy.

## Introduction

Bariatric surgery is the most effective method to achieve permanent weight loss with minimum complications. The procedure further aids in the treatment of obesity-related diseases, especially

type 2 diabetes mellitus (T2DM). Therefore, bariatric surgery is also referred to as metabolic surgery [1–3]. Currently, the most widely used bariatric and metabolic surgery methods are sleeve gastrectomy (SG) and Roux-En-Y gastric bypass (RNYGB) [4, 5].

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The ideal procedure should be safe, effective, durable, reproducible, reversible, minimally invasive, and cost effective; however, such an approach is yet to be identified. Each year, a new device or procedure is introduced in the field of obesity surgery, thereby contributing to the rapidly developing world health market. Each method comes with its own advantages and disadvantages. Therefore, the search for the ideal method is still ongoing and will continue in the future [6].

SG + transit bipartition (SG + TB) is a relatively new technique that offers the advantages of both gastric bypass and SG [7]. To the best of our knowledge, linear staplers (LS) have always been used for the gastroileostomy (GI) anastomosis section of the technique.

## Aim

This study aims to compare patients who had undergone GI anastomosis with a circular stapler (CS) (SG + TB-CS group) and those who had undergone the procedure with a linear stapler LS (SG + TB-LS group).

## Material and methods

### Patients and study design

This was a retrospective study involving 38 patients diagnosed with obesity and T2DM, who had undergone SG + TB between January 2018 and April 2019 in the General Surgery department. The study was approved by the Local Institutional Ethics Committee (No. 14/194). This study was conducted in accordance with the Declaration of Helsinki and Good Clinical Practices.

Patients with missing information and no follow-up for 12 months and under 18 and over 65 of age were excluded from the study. Twenty-four patients were included in the study.

The patients were informed about the clinical study to be conducted, and consent was obtained from each of them. The findings of the first 13 patients operated using LS in GI section of the operation were compared with those of 11 patients operated using CS. Their identity information, age, sex, body mass index (BMI), comorbid diseases, and examination findings were recorded.

The surgical procedures, operation time, post-operative complications, and length of hospitaliza-

tion were documented from anaesthesia forms and hospital records. Additionally, BMI, haemoglobin A<sub>1c</sub> (HbA<sub>1c</sub>), albumin, haemoglobin, vitamin D, vitamin B<sub>12</sub>, folate, iron, and zinc were measured before the surgery and 12 months after it.

### Operative techniques

All patients were made to fast overnight before the operation. No bowel preparations were made, and premedication was not given. All patients were operated under general anaesthesia. One 2 g dose of cefazoline was given intravenously at induction. The patients were placed in the supine position, split-leg, with reverse Trendelenburg position. All patients received a flexion of the hips to help increase the surgical abdominal workspace [8]. At the beginning of the procedure the main surgeon stood between the legs. A video monitor was positioned at the level of the patient's head, and a 30° angle scope was used.

Pneumoperitoneum was provided using a Veress needle. The intra-abdominal pressure was maintained at 14 mm Hg. Two 12-mm trocars (one in the midline 3–5 cm above the umbilicus and the other in the upper left and right quadrants) and three 5-mm trocars (1 in the epigastrium for the liver retractor and 2 at each lateral flank) were positioned. A 10-mm camera trocar 15 cm below the xiphoid process, a 5-mm trocar epigastrium on the midline, a 12-mm trocar in the right upper quadrant, a 12-mm trocar in the left side camera trocar, and a 12-mm trocar in line with the left-side 12-mm trocar (left subcostal) were placed.

The SG + TB-LS group underwent a standard SG. First, the greater curvature was mobilized at the angle of His starting from 4–5 cm of the proximal pylorus using an advanced vessel sealing device. Second, 40 Fr orogastric tube guidance was stapled and cut with linear staplers (a black Tri-Staple; Covidien, 2 green 60 mm, and 2 or 3 blue Endopath Stapler and Cutter, 60 mm; Ethicon). Subsequently, the ileocecal valve was identified, and 100 cm of the ileum from the ileocecal valve was measured and marked with a clip. Thereafter, 250 cm of the proximal ileum from the ileocecal valve was dissected with the LS. The distal portion was anastomosed alongside the antrum using the LS with a blue cartridge (Echelon 60 Endopath Stapler, Ethicon, USA). The defect of the gastroileal anastomosis was closed with a 3-0 absorbable, 15-cm double V lock suture.

An intraoperative leak test was performed using air and blue dye to confirm a negative leak at the anastomosis. The proximal end of the dissected ileum, measuring 250 cm, was anastomosed alongside the previously marked 100-cm ileum using LS. The enterotomy defects were closed by a 3-0 absorbable 15-cm double V lock suture. The mesenteric defects were closed with a 3-0 nonabsorbable suture.

In the SG + TB-CS group, the greater curvature was initially mobilized at the angle of His starting from 4–5 cm of the proximal pylorus using an advanced vessel sealing device. Then, a vertical full thickness opening of approximately 3 cm was created from the middle of the large curvature of the stomach, prior to vertical resection of the stomach using an LS. Later, a full-thickness hole was made in the lateral edge of the antrum where the ileum would be anastomosed to the stomach. The leftmost lateral trocar hole was dilated. The anvil was tied to the tip with a 3-0 silk thread (a 25-mm Premium Plus CEEA; Covidien, USA) and inserted into the abdomen. Subsequently, a dissector was inserted through this hole to catch the rope at the end of the anvil and into the stomach through the large opening. The end of the anvil was removed from the antrum (Figure 1). The ileocecal valve was then identified, and 100 cm of the ileum from the ileocecal valve was measured and marked with a clip. Thereafter, an enterotomy was performed 250 cm from the ileocecal valve, and the Premium Plus CEEA was introduced over 5–6 cm of the jejunal loop via this opening in the distal direction. Then, the jejunum was perforated under slight traction with a spike, and the stapler was connected to the anvil. The anastomosis was completed by closing and firing the instrument (Figure 2).

The remaining small bowel loop with the previously created opening was transected at 1 cm proximal to the GI using a linear stapler with a 60-mm white cartridge (Ethicon, USA). Thus, the ileal segment was anastomosed to the gastric antrum (Figure 2). An intraoperative leak test was performed. Then, as in the TB-LS group, standard vertical SG was performed (Figure 3). The loop of the biliopancreatic limb was anastomosed to the marked location 100 cm away from the ileocecal valve side-to-side using a 60-mm white cartridge. The blind end of the biliopancreatic limb was resected with a white linear cartridge, and the resected bowel segment was removed from the abdomen. The enterotomy defect was closed with a 3-0 absorbable 15-cm double V

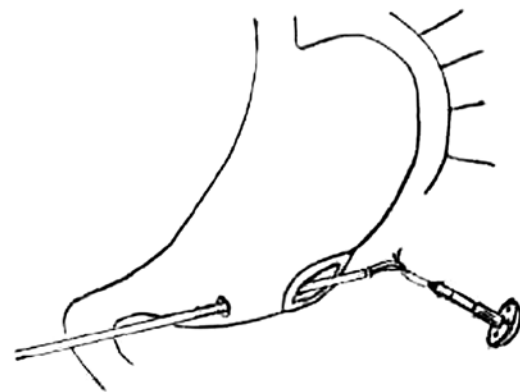


Figure 1. Placing the anvil into the antrum



Figure 2. Connecting the circular stapler to the anvil

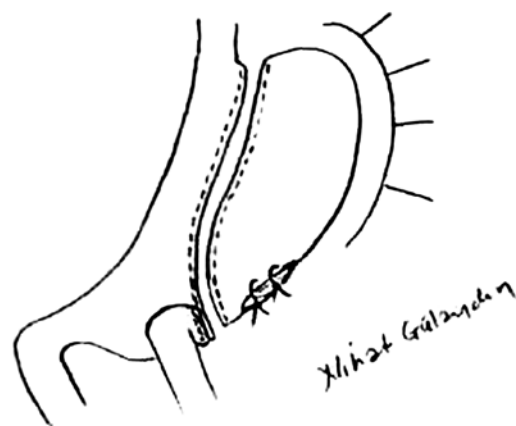


Figure 3. Completed gastroileostomy anastomosis and vertical sleeve gastrectomy

lock suture. The mesenteric defects were closed with a 3-0 nonabsorbable suture.

### Statistical analysis

The categorical variables were defined using frequency and percentage. Mean, standard deviation, median, minimum, and maximum values were given for the continuous variables. Either  $\chi^2$  analysis or Fisher's exact test was used to compare the categorical variables. Mann-Whitney *U* test was utilized for the independent case groups. Wilcoxon test was employed to analyse the results before the surgery and 12 months after it.  $P < 0.05$  was considered statistically significant.

### Results

The GI anastomosis was performed with LS in the first 21 patients and with CS in the next 17 patients. Seven patients from the SG + TB-LS group and 6 patients from the SG + TB-CS group were excluded from the study owing to missing data. Thus,

**Table I.** Demographic findings of patients in the 2 groups

Parameter	SG + TB-LS (n = 13)	SG + TB-CS (n = 11)
Age [years]	46.85 ±9.67 (32–64)	45.75 ±8.55 (30–60)
Female	9 (69.2)	7 (63.6)
Male	4 (30.8)	4 (36.4)
BMI [kg/m <sup>2</sup> ]	42.08 ±3.62	40.55 ±2.42

Data are presented as n (%) or mean ± standard deviation (minimum–maximum). SG + TB-LS – sleeve gastrectomy + transit bipartition with a linear-stapled gastroileostomy, SG + TB-CS – sleeve gastrectomy + transit bipartition with a circular-stapled gastrojejunostomy, BMI – body mass index.

**Table II.** Comparisons of peri- and postoperative parameters between the two study groups

Parameter	SG + TB-LS (n = 13)	SG + TB-CS (n = 11)	P-value
Operative time [min]	195.22 ±35.44	167.27 ±23.49	0.006
	195– (170–260)	160– (140–205)	
Hospitalization [days]	3.38 ±1.26	3.09 ±1.04	0.628
	3– (2–6)	3– (2–5)	
Total complications	2 (15.38)	1.(9.09)	0.764

Data are presented as n (%) or mean ± standard deviation (minimum–maximum). SG + TB-LS – sleeve gastrectomy + transit bipartition with a linear-stapled gastroileostomy, SG + TB-CS – sleeve gastrectomy + transit bipartition with a circular-stapled gastrojejunostomy, Mann-Whitney *U* test.

the remaining 24 patients were included (SG + TB-LS (n = 13), SG + TB-CS (n = 11)).

The mean age of the patients was 46.13 ±9.96 years. Sixteen patients were women, and 8 were men. The preoperative mean BMI of the patients was 41.38 ±3.16. The demographic findings and BMI values of the patients were comparable between the 2 groups (Table I).

The operative time was significantly longer in the SG + TB-LS group than in the SG + TB-CS group ( $p < 0.006$ ). The mean length of hospitalization and the rate of postoperative complications were similar in the 2 groups. In the SG + TB-LS group, 2 extraluminal haemorrhages were observed, while 1 patient in the SG + TB-CS group developed intraluminal bleeding, but there was no statistically significant difference between the groups. None of the patients had any anastomosis leakage, and mortality was not observed (Table II).

The intragroup and intergroup comparisons were made according to the mean BMI, HbA<sub>1c</sub>, albumin, and haemoglobin levels. In both groups, the mean BMI was significantly reduced at 12 months after the surgery ( $p < 0.001$  for SG + TB-LS and  $p < 0.003$  for SG + TB-CS) (Table II). The percentage weight loss, percentage excess weight loss, percentage excess body index loss rates are 32.4%, 65.5%, and 67.3% for the SG + TB-LS group and 31.2%, 64.4%, and 66.1% for the SG + TB-CS group, and there was no statistical difference between the 2 groups ( $p = 0.312$ ,  $p = 0.423$ ,  $p = 0.298$ ).

The preoperative levels of HbA<sub>1c</sub> were > 6 g/dl in 69.3% (n = 9) of the patients in the SG + TB-LS group, while the postoperative levels were > 6 g/dl in 30.77% (n = 4) of the patients. This decrease in the rate was statistically significant ( $p = 0.001$ ). It was observed that 72.3% (n = 8) of the patients in the SG + TB-CS group had preoperative levels of HbA<sub>1c</sub> > 6 g/dl, while 45.5% (n = 5) of them had higher postoperative higher levels, and the difference was statistically significant ( $p = 0.005$ ) (Table III).

All patients in the SG + TB-LS group (n = 13) had preoperative albumin levels > 3.5 g/dl, while patients who had high levels postoperatively decreased to 76.92% ( $p = 0.01$ ). In the SG + TB-CS group, the percentage decreased from 100% to 90.91% without any significance ( $p = 0.920$ ) (Table III).

All patients in the SG + TB-LS group (n = 13) had preoperative haemoglobin levels > 10 g/dl, while the percentage having high levels postoperatively

**Table III.** Comparisons of the laboratory findings of the two study groups before and 12 months after the surgery

Parameter	SG + TB-LS (n = 13)			SG + TB-CS (n = 11)			P-value
	Preoperative	Postoperative	P-value	Preoperative	Postoperative	P-value	
BMI [kg/m <sup>2</sup> ]	42.08 ±3.62	26.23 ±3.0	0.001	40.55 ±2.42	27.55 ±2.42	0.003	0.375
HbA <sub>1c</sub> > 6	9 (69.3)	4 (30.77)	0.001	8 (72.3)	5 (45.45)	0.005	0.839
Albumin > 3.5	13 (100)	10 (76.92)	0.01	11 (100)	10 (90.91)	0.920	0.280
Hemoglobin > 10 g/dl	13 (100)	10 (76.92)	0.01	11 (100)	11 (100)	1.00	0.794
Vitamin B <sub>12</sub> > 200 ng/l	10 (76.92)	11 (84.61)	0.650	9 (81.81)	10 (90.91)	0.890	0.490
Vitamin D > 20 ng/ml	2 (15.38)	8 (61.53)	0.0001	1 (7.69)	7 (63.63)	0.0001	0.470
Folate > 4 µg/l	13 (100)	12 (92.30)	0.820	11 (100)	11 (100)	1.00	0.560
Iron > 60 µg/dl	13 (100)	9 (69.23)	0.002	11 (100)	9 (81.81)	0.720	0.250
Zinc > 10 µmol/l	13 (100)	10 (76.92)	0.01	11 (100)	10 (90.91)	0.920	0.390

Data are presented as n (%) or mean ± standard deviation (minimum–maximum). SG + TB-LS – sleeve gastrectomy + transit bipartition with a linear-stapled gastrojejunostomy, SG + TB-CS – sleeve gastrectomy + transit bipartition with a circular-stapled gastrojejunostomy, BMI – body mass index.

significantly decreased to 76.92% ( $p = 0.01$ ). All patients in the SG + TB-CS group ( $n = 11$ ) had haemoglobin levels > 10 g/dl both preoperatively and postoperatively (Table III).

Intergroup comparison of the postoperative levels between the 2 groups showed that the percentages of HbA<sub>1c</sub> > 6 g/dl, albumin > 3.5 g/dl, and haemoglobin > 10 g/dl were 30.77% ( $n = 4$ ), 76.92% ( $n = 10$ ), and 76.92% ( $n = 10$ ) in the SG + TB-LS group and 45.45% ( $n = 5$ ), 90.91% ( $n = 10$ ), and 100% ( $n = 11$ ) in the SG + TB-CS group, respectively. The differences between the groups were not statistically significant ( $p > 0.05$ ) (Table III).

## Discussion

The SG + TB technique was first developed by Santoro *et al.*, and after the publication of the results of 1020 patients in 2012, surgeons in the field of obesity and metabolic surgery became very interested in it [7, 8]. This technique serves as an important alternative to ileal interposition surgery, which has greater metabolic effect but is more aggressive [9]. In the present study, we compared the use of LS and CS GI in SG + TB in terms of early and late perioperative and postoperative status. Both anastomosis types for SG + TB were found to be safe, and the risks of postoperative complications were low and comparable. However, the diameter of the anastomosis should always be the gold standard in the CS technique, while it may be too wide or too narrow in the LS technique.

The new method (SG + TB) focuses on 2 issues. The first is a restrictive surgery method alone, which reduces the high pressure that occurs in the new gastric tube connected to SG. On the other hand, the second issue exposes the stomach and duodenum with endoscopy, which are disabled after absorption-disruptive operations such as biliopancreatic diversion with duodenal switch (BPD-DS), ileal interposition, and RNYGB [7, 10, 11]. In this way, it is possible to perform endoscopic retrograde cholangiopancreatography (ERCP), which is a very important examination if there is a need to control the bleeding that may occur in these parts with the endoscopic method and to obtain biopsy samples from the lesions suspected of malignancy. SG + TB surgery consists of 2 anastomoses, which, applied later as a single anastomosis in the form of a loop, became even easier [12].

The extent of nutrient absorption decrease achieved after SG + TB surgery depends on the pyloric canal and GI anastomosis created in the antrum. Although Santoro suggested that one-third of the nutrients entering the stomach pass through the pyloric channel and two-thirds through the newly formed GI anastomosis in this surgical technique, this may vary because, unlike the pyloric channel, GI anastomosis created in the antrum does not have a real sphincter mechanism [7]. Therefore, solid or semi-solid foods entering the stomach always prefer the path of least resistance. Consequently, the rate of nutrients passing through the pylorus canal and GI anastomosis may be higher or lower than that

suggested. This amount seems to be directly proportional to the GI diameter.

In the literature, GI anastomoses have been performed using LS in most of the studies, and there are no data on the use of CS [7, 8, 12, 13]. Although different brands of LS were used in previous studies, a length of 60 mm was mostly preferred. The diameter of the anastomosis created with a 60-mm LS can be 50 mm after closing the opening, and sometimes it can even be narrower than this. However, with the use of CS, the diameter of the anastomosis will always be in standard sizes, depending on the size used.

We preferred a CS anastomosis diameter of 25 mm because in RNYGB surgeries the stenosis rate of patients who had undergone a gastro enterostomy with a 21-mm CS was higher than that of patients with a 25-mm CS [14].

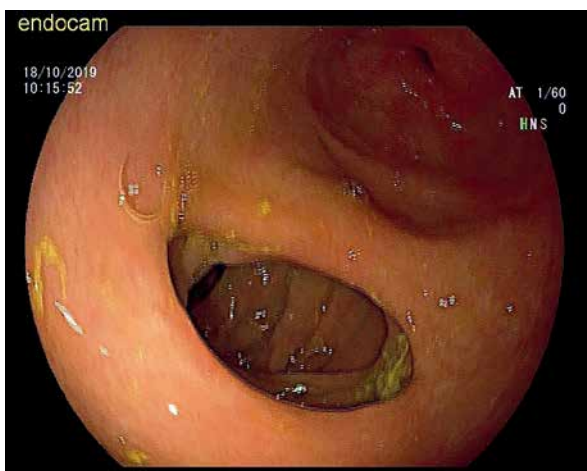
Regardless of whether anastomoses are made with LS or CS, their endoscopic appearance becomes circular after a while (Photos 1 and 2). Therefore, the area of the anastomoses made is directly proportional to the radii (circle area =  $\pi \times r^2$ ;  $\pi = 3.14$ ,  $r =$  the radius of the circle). The area of an anastomosis with a 25-mm CS is approximately  $3.14 \times (1.25 \text{ cm})^2 = 5.31 \text{ cm}^2$ . The anastomosis area made with a 60-mm LS is approximately  $3.14 \times (2.5 \text{ cm})^2 = 19.62 \text{ cm}^2$ , assuming that the anastomosis diameter is 50 mm. According to these results, the area of an anastomosis with a diameter of 50 mm is about 4 times greater than that of an anastomosis with a diameter of 25 mm ( $19.62 \text{ cm}^2/5.31 \text{ cm}^2 = 3.69$ ). Therefore, even millimetric changes in anastomosis

diameters significantly affect the area of anastomosis. Although this aspect is not important in RNYGB or mini-gastric bypass surgeries in which the pylorus ring is disabled, it may affect the postoperative outcome in SG + TB operations in which the pyloric ring is active. A wide anastomosis can allow the passage of all nutrients and lead to serious problems such as malnutrition or sarcopaenia, depending on the length of the small intestine that is disabled after the pylorus [15, 16].

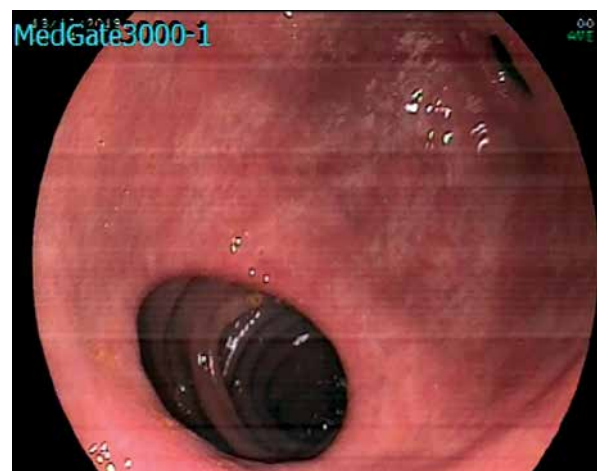
In addition, anastomosis diameters may increase spontaneously over time. While this may lead to weight gain, for example after RNYGB surgery, it may also lead to malnutrition, serious vitamin and mineral deficiencies, and even complications such as liver cirrhosis over time following SG + TB operations [17, 18].

In studies conducted in humans, small intestine lengths were found to be highly variable (350–1049 cm). It has been suggested that the intestine is longer in tall and male individuals, and this situation is associated with being overweight [19]. The correct proportional relationship between intestinal length and obesity may explain why some patients lose less weight while others lose more, leading to malnutrition, even though the intestinal length and anastomosis diameter bypassed are the same as in obesity surgery methods.

In the SG + TB technique, the length of the common canal of small intestine is 100 cm, and that of the GI anastomosis is 150 cm. The small intestine length from the Trietz ligament to the common small intestine canal is always variable. This segment, which may be very long in some individuals and very



**Photo 1.** Gastroileostomy anastomosis with linear stapler



**Photo 2.** Gastroileostomy anastomosis with circular stapler



short in others, may lead to malnutrition because the food does not pass through the pyloric canal due to a very large GI anastomosis.

Malnutrition related to macronutrients or micronutrients can be observed in obesity patients both in the preoperative and postoperative periods [20, 21]. Low levels of albumin and haemoglobin are important parameters for macro-malnutrition and have been reported to be seen in > 20% of the patients, especially after biliopancreatic diversion. In our study, no preoperative albumin level was < 3.5 g/dl and no preoperative haemoglobin level was < 10 g/dl. In the SG + TB-LS group, both postoperative albumin and haemoglobin levels were found to decrease significantly, while in the SG + TB-CS group, 1 patient had low albumin level and none of the patients had low haemoglobin level. However, the difference was not statistically significant, which may be due to the standard diameter of the anastomosis with CS.

In the preoperative period, vitamin D levels were found to be significantly low in both groups of patients. Twelve months after the surgery, the vitamin D level increased significantly in both groups, whereas vitamin B<sub>12</sub> and folate levels did not change. Nonetheless, there was a statistically significant decrease in the iron and zinc levels. We suggest that the significant increase in the level of vitamin D in both groups 12 months after the operation may be due to replacement therapy, which was started before the surgery and was continued postoperatively. This difference was not compatible with similar studies in the literature [22, 23].

Accordingly, vitamin B<sub>12</sub> and multivitamin replacements, which were prescribed in the sublingual form, explain why vitamin B<sub>12</sub> and folate levels did not reduce after the surgery. The fall in these minerals after surgery despite taking iron and zinc supplements may be due to the decreased absorption rate and the patients' inability to tolerate such mineral supplements [24, 25]. There was no statistically significant difference between the 2 groups in terms of changes in vitamin and mineral levels at 12 months after the operation.

The mean BMI in both the SG + TB-LS and SG + TB-CS groups decreased significantly after the surgery, and the outcomes were consistent with those of similar studies [7, 25]. Based on the mean HbA<sub>1c</sub> level, the remission rates from T2DM showed a statistically significant change before and after surgery, but there was no significant difference between the

groups. The remission rates for T2DM were found to be lower in our study when compared with similar studies in the literature [7, 25]. In the group in which anastomosis was performed with LS, the risk of malnutrition may increase due to the expansion of the anastomosis area over time.

The length of hospitalization and complication rates were similar between the 2 groups, but the operation time was significantly shorter in the group using CS than in the group using LS. This difference may be due to the experience of the surgeons in performing routine gastrojejunostomy anastomosis mostly by using CS during RNYGB operations. Similar results have been reported also in other studies [26].

## Conclusions

Based on the findings of the study, it can be concluded that performing GI anastomosis using CS in the SG + TB technique significantly reduces the operation time. In addition, the standard anastomosis diameter created in all patients with CS may reduce the risk of malnutrition related to anastomosis diameter. Although these results imply that the use of CS is more advantageous than LS in the SG + TB technique, the findings should be corroborated by further studies involving larger populations.

## Conflict of interest

The authors declare no conflict of interest.

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