Reinforcement of the esophageal hiatus using ligamentum teres during sleeve gastrectomy concerning gastroesophageal reflux disease

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Background
Gastroesophageal reflux disease (GERD) represents a disorder of the superior gastrointestinal tract that is defined by heartburn and regurgitation, which develops when reflux of the stomach contents causes troublesome symptoms and/or complications, according to the Evidence-Based Consensus of the Montreal Definition and Classification of Gastroesophageal Reflux Disease. Apart from heartburn and regurgitation, symptoms include dysphagia, chest pain, shortness of breath, cough, and hoarseness. GERD can be seen as one of sleeve gastrectomy's (SG) most important side effects and is still controversially discussed in the literature. Severe reflux does not only impact a patient's quality of life and forces them to permanently depend on proton pump inhibitors, it can actually lead to esophagitis, which can in turn cause Barrett's esophagus – a potential factor for the development of esophageal carcinoma.

Patients and methods
This is a prospective randomized study conducted on patients undergoing laparoscopic SG, and patients are randomly fit into one of the two groups A and B. The study was conducted on an estimated sample size of 60 patients (30 patients for each group). This study was conducted at the Bariatric Surgery Unit at Ain Shams University Hospitals starting from October 2019 to January 2021. Approval of the Ethics Committee and written informed consent from all participants was obtained.

Results
Our study results showed that group A which underwent SG only with no symptoms or signs of GERD preoperatively, the percentage of patients who developed GERD postoperatively through the 1st, 3rd, 6th, and 12th months of follow-up was 6.7, 16.7, 20, and 23.3%, respectively, and the percentage endoscopically for the development of GERD was 26.7 and 30% during the 6 and 12 months of follow-up. Also, our study results showed that in group B which underwent SG with ligamentum teres reinforcement of the hiatus, the percentage of patients who developed GERD postoperatively through the 1st, 3rd, 6th, and 12 months was 0, 0, 3.3, and 3.3%, respectively, and endoscopically was 3.3 and 6.7% during the 6 and 12 months of follow-up.

Conclusion
According to our study results, ligamentum teres reinforcement of the esophageal hiatus during SG showed a significant decrease in the development of GERD either symptomatically or endoscopically and is recommended as a preventive measure for the development of reflux postoperatively if done concomitantly with SG, which showed favorable results when compared with the ordinary technique; however, further, larger study groups and a long-term follow-up were needed.

Keywords:
esophageal hiatus, gastroesophageal reflux disease, ligamentum teres reinforcement

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Introduction

Gastroesophageal reflux disease (GERD) represents a disorder of the superior gastrointestinal tract, which is defined by heartburn and regurgitation, which develops when reflux of the stomach contents causes troublesome symptoms and/or complications, according to the Evidence-Based Consensus of the Montreal Definition and Classification of Gastroesophageal Reflux Disease. Apart from heartburn and regurgitation, symptoms include dysphagia, chest pain, shortness of breath, cough, and hoarseness [1].

Obesity represents one of the most important risk factors for GERD and, with a sharp increase in the number of obese patients globally, the incidence of GERD has significantly increased [2]. Obesity is defined as disproportionate body weight for height with an excessive accumulation of adipose tissue that is accompanied by chronic, systemic inflammation. In numbers, obesity is classified as a BMI of greater than 30 kg/m^2, and morbid obesity is classified as a BMI greater than 40 kg/m^2. Obesity has become one of the most threatening global public health problems and can be declared a pandemic of the 21st century [3,4].

The most commonly performed bariatric surgery worldwide is the laparoscopic sleeve gastrectomy (LSG). LSG proved to be efficient in weight loss and has gained popularity because of its advantages. It is a relatively simple procedure, which does not involve anatomical rearrangement or surgical anastomoses and has a shorter operative time. It also appears safer in the long term with a lower risk of marginal ulceration, internal hernias, or adverse nutritional consequences [5,6]. However, as LSG's popularity continues to increase, one major drawback is the potential development or worsening of GERD postoperatively [7].

GERD can be seen as one of SG's most important side effects and is still controversially discussed in the literature. Severe reflux does not only impact a patient's quality of life and forces them to permanently depend on proton pump inhibitors; it can actually lead to esophagitis, which can in turn cause Barrett's esophagus – a potential factor for the development of esophageal carcinoma [8].

Previous literature has described a technique for hiatal hernia and GERD using the ligamentum teres as a sling around the gastroesophageal junction (GEJ), given the term ligamentum teres cardiopexy [9,10]. It has also been described as a treatment option for patients with previous LSG who have developed GERD [11]. The authors used the same sling technique with slight modifications. Although this technique is reported to be not effective in the long term for the normal stomach [12,13], its purpose with LSG is to prevent GERD that is caused by intrathoracic migration of the gastric tube by pulling it caudally with the liver during inspiration, maintain the lower esophageal sphincter intra-abdominally, and lengthen the intra-abdominal esophagus.

Patients and methods

This is a prospective randomized study conducted on patients undergoing LSG and patients were randomly fit into one of the two groups: A and B. The study was conducted on an estimated sample size of 60 patients (30 patients for each group).

This study was conducted at the Bariatric Surgery Unit at Ain Shams University Hospitals starting from October 2019 to January 2021. Approval of the Ethics Committee and written informed consent from all participants were obtained.

Individuals with morbid obesity eligible for SG as the bariatric surgery of choice had those criteria: Patients with BMI more than 35 kg/m^2 with comorbidities (diabetes or hypertension), patients with BMI more than 40 kg/m^2 without comorbidities, patients who are fit for anesthesia without complications (American Society of Anesthesiology 1 or 2), and patients without GERD.

While patients with one of those criteria were excluded from our study: patients for whom anesthesia is risky (American Society of Anesthesiology 3 or above), patients with known history of psychiatric illness, patients with a history of previous bariatric procedures, patients with a history of open abdominal surgeries, patient refusal, and patients diagnosed preoperatively with hiatus hernia or GERD or Barret's esophagus.

All patients included in the study were candidates for:

Clinical assessment: detailed medical, surgical, and family history; careful analysis of symptoms like heartburn, dysphagia, careful assessment of height, weight, and BMI; assessment of satisfaction level postoperatively; and general examination.

Investigations: routine laboratory investigations, pelviabdominal ultrasound, pulmonary function tests, echocardiography, ECG, and upper gastrointestinal tract endoscopy for the diagnosis of GERD preoperatively and postoperatively at 6 months and 1 year follow-up.

Patients were subjected to intervention by LSG only or SG with ligamentum teres reinforcement for esophageal hiatus.

In all, 60 patients who were candidates for SG with normal upper gastrointestinal tract endoscopy (no GERD) were divided into two groups:

Group A: 30 patients for SG only. Group B: 30 patients for SG with ligamentum teres reinforcement of the hiatus.

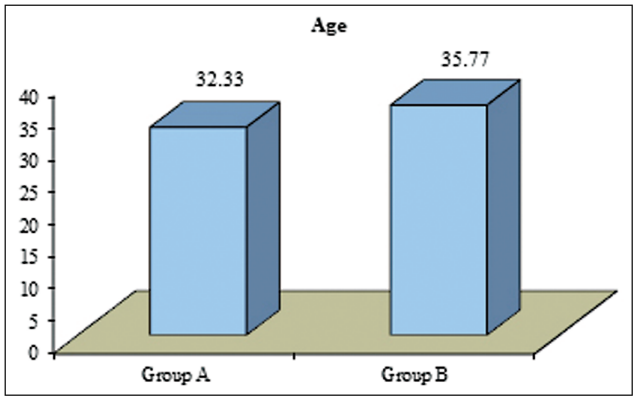
The patient lied in a supine position with both arms extended and legs separated in reverse Trendelenburg position secured with straps. The operator stood

between patient's legs with the assistant to the left of the patient and cameraman to the right. Access to the abdomen was safely granted by the transparent port technique (visi-port); then insufflation of the abdomen was done using CO_2 gas to an intra-abdominal pressure of 14 mmHg. Five ports were placed. The 'S-shaped' liver retractor was used to retract the liver. Dissection along the greater curvature of the stomach was done using a harmonic scalpel or ligasure energy device; then the 'GIA' endoscopic stapler was used for dividing the stomach after inserting a 36 Fr inside the stomach, where the stomach was divided longitudinally with the stapler starting 4–5 cm away from the pylorus up to the GEJ; then leak test was done for the sleeved stomach using methylene blue. The ligamentum teres reinforcement was then isolated beginning 2 cm from the umbilicus, continued up to the liver preserving its blood supply (Fig. 1), and wrapped around the GEJ by the pars flaccida technique, which was divided to get access for passing the ligamentum teres (falciform ligament) through it around the GEJ (Figs 2–4). Sutures anchored the ligament to itself, to the gastric staple line, to the left diaphragmatic crus, and to the gastric wall to prevent intrathoracic gastric migration and maintain the lower esophageal sphincter intra-abdominally (Figs 5–8). The excised part of the stomach was extracted outside the abdomen and then adequate hemostasis was done.

Statistical analysis

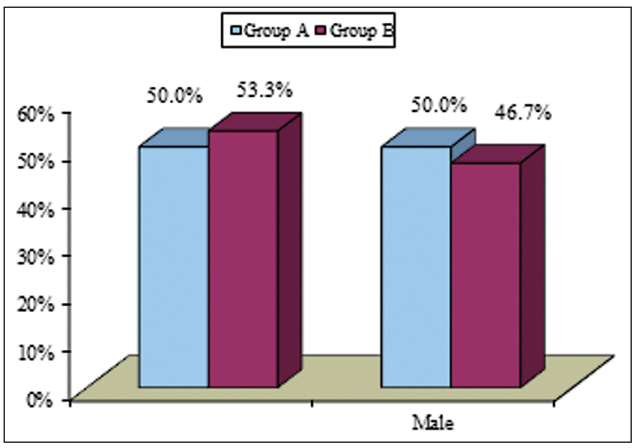
Data were collected, revised, coded, and entered to the Statistical Package for the Social Sciences (SPSS) (Released 2015. IBM SPSS Statistics for Windows, Version 23.0.; IBM Corporation, Armonk, New York, USA). The quantitative data were presented as mean, SDs, and ranges. Also, qualitative variables were presented as number and percentages. The comparison between groups regarding qualitative data was done using the χ^2 test. The comparison between two independent groups with quantitative data and parametric distribution was done by using independent t test. The confidence interval was set to 95% and the P value was considered significant at the level of less than 0.05.

Figure 1



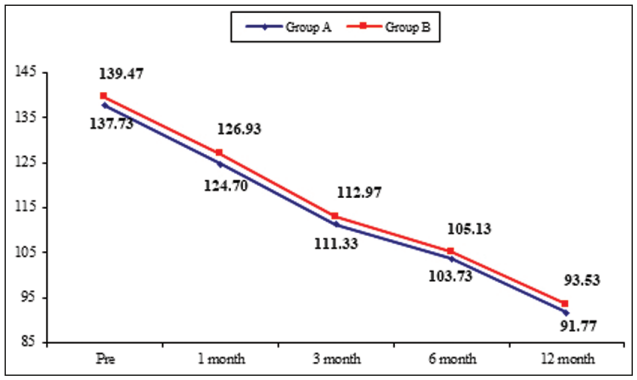
Ligamentum teres division.

Figure 2



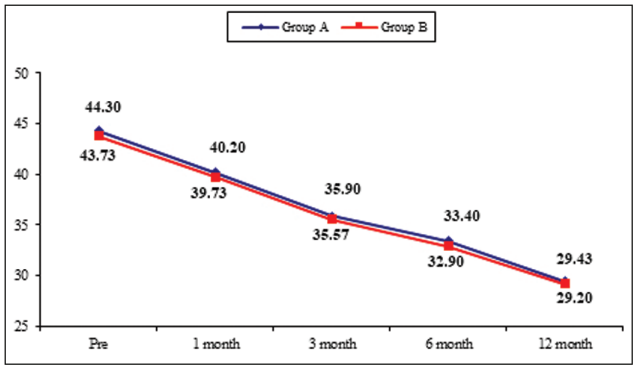
Pars flaccida division.

Figure 3



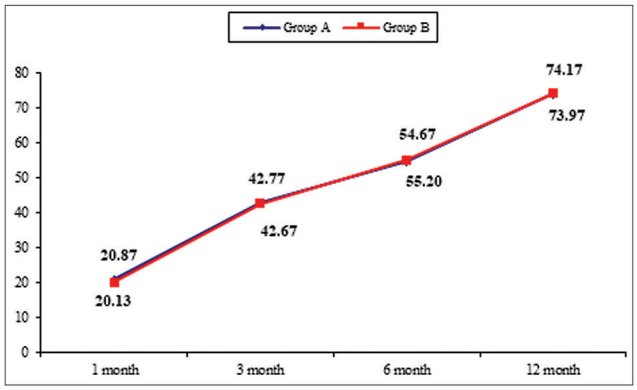
Passing the ligamentum teres through pars flaccida.

Figure 4



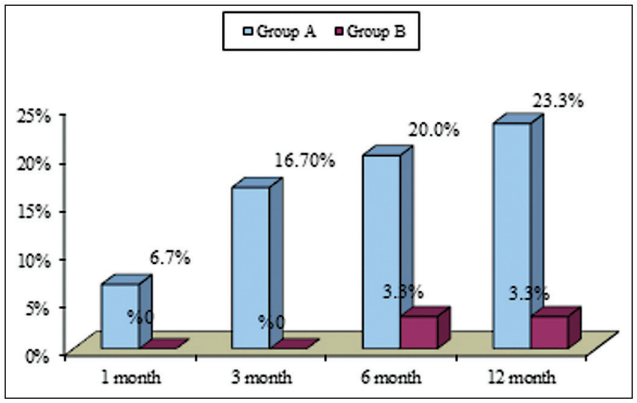
Wrapping the ligamentum teres around GEJ. GEJ, gastroesophageal junction.

Figure 5



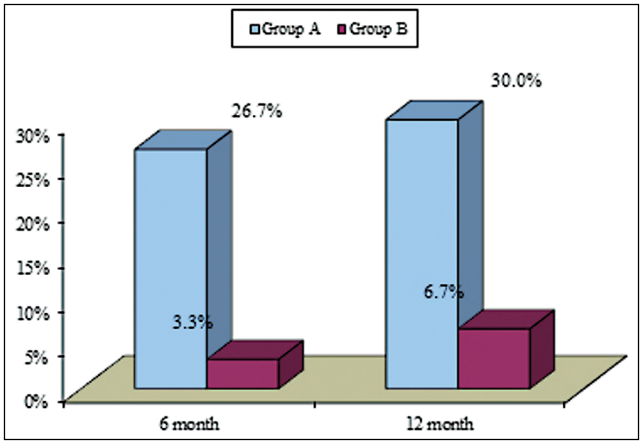
Suturing the ligamentum teres to itself.

Figure 6



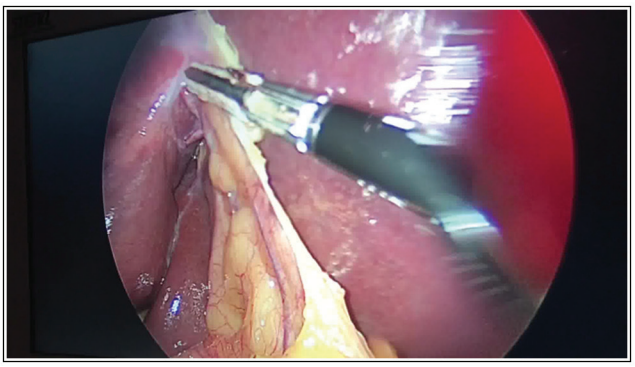
Suturing the ligamentum teres to the left crus.

Figure 7



Suturing the ligamentum teres to the gastric wall.

Figure 8



SG with reinforced GEJ using ligamentum teres. GEJ, gastroesophageal junction; SG, sleeve gastrectomy.

Table 1 Correlation between age and sex in the two study groups

	Group A	Group B	Test value	*P* value	Significance
	N=30	*N*=30			
Age					
Mean±SD	32.33±6.20	35.77±7.27	−1.968•	0.054	NS
Range	23–45	23–48			
Sex [*n* (%)]					
Female	15 (50.0)	16 (53.3)	0.067*	0.796	NS
Male	15 (50.0)	14 (46.7)			

*χ^2 test.
•Independent *t* test.
P value more than 0.05: nonsignificant (NS); *P* value less than 0.05: significant (S); *P* value less than 0.01: highly significant (HS).

Results

Table 1 shows a comparison between age and sex of the two groups, and results between them where nonsignificant, where group A shows a mean age of 32.33 ranging from 23 to 45 year olds, while group B shows a mean age of 35.77 ranging from 23 to 48 year olds. Concerning sex, group A was about 50% males to 50% females, while group B was 53.3% females to 46.7% males (Figs 9, 10).

Table 2 shows a comparison in weight per kilogram and follow-up of the two groups for weight through 1, 3, 6, and 12 months, where preoperatively group A has a weight ranging from 118 to 158 kg with a mean±SD of 137.73±12.05 kg, while group B weight ranged from 110 to 160 kg with a mean±SD of 139.47±10.46 kg. During follow-up, group A has a range of 108–144, 99–128, 93–117, and 82–105 kg, respectively, while in group B it was 102–143, 94–125, 89–118, and

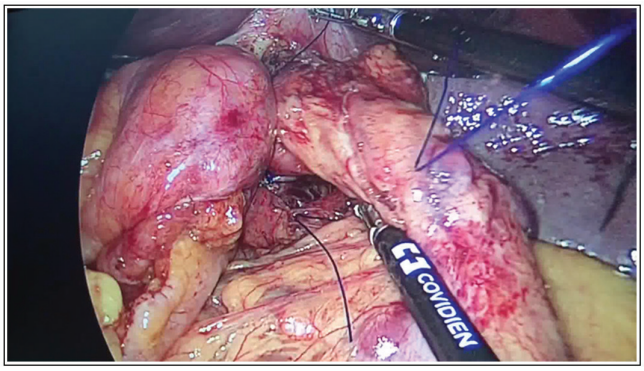
82–102 kg, respectively, with no significance in weight reduction in comparison between the two different techniques (Fig. 11).

Table 3 shows a comparison in BMI preoperatively and follow-up of the two groups for BMI through 1, 3, 6, and 12 months, where preoperatively group A has a BMI ranging from 36 to 55 with a mean±SD of 44.30 ± 4.43, while in group BMI ranged from 35 to 50 with a mean±SD of 43.73 ± 3.63. During follow-up, group A has a BMI range of 34–49, 32–41, 30–38, and 26–32, respectively, while in group B it was 33–45, 31–39, 29–36, and 27–31, respectively, with no signficance in BMI reduction in comparison between the two different techniques (Fig. 12).

Table 4 shows a comparison in excess weight loss% follow-up of the two groups through 1, 3, 6, and 12 months; group A has a range of 16–24, 40–45, 52–58, and 70–77%, respectively, while in group B it was 18–22, 40–46, 53–58, and 70–78%, respectively, with no significance in excess weight loss% in comparison between the two different techniques (Fig. 13).

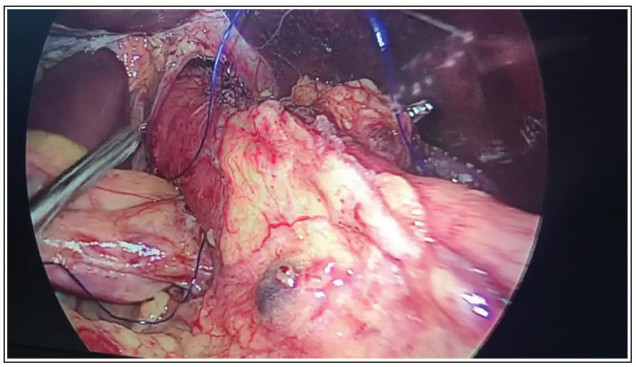
Table 5 shows a comparison concerning developing symptoms of reflux between the two groups through 1,

Figure 9



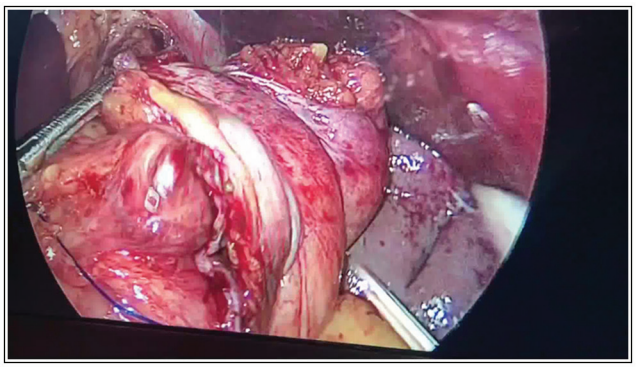
Correlation in age in the two study groups.

Figure 10



Correlation in sex in the two study groups.

Figure 11



Correlation between weights (kg) preoperatively and during follow up in the two study groups.

Table 2 Correlation between weight (kg) preoperatively and postoperatively in the two study groups

Weight (kg)	Group A	Group B	Test value	*P* value	Significance
	N=30	*N*=30			
Pre					
Mean±SD	137.73 ± 12.05	139.47 ± 10.46	−0.595	0.554	NS
Range	118–158	110–160			
1 month					
Mean±SD	124.70 ± 10.01	126.93 ± 8.75	−0.920	0.361	NS
Range	108–144	102–143			
3 months					
Mean±SD	111.33 ± 7.92	112.97 ± 6.47	−0.874	0.386	NS
Range	99–128	94–125			
6 months					
Mean±SD	103.73 ± 6.96	105.13 ± 5.66	−0.855	0.396	NS
Range	93–117	89–118			
12 months					
Mean±SD	91.77 ± 5.81	93.53 ± 4.28	−1.341	0.185	NS
Range	82–105	82–102			

Independent *t* test.
P value more than 0.05: nonsignificant (NS); *P* value less than 0.05: significant (S); *P* value less than 0.01: highly significant (HS).

Table 3 Correlation between BMI preoperatively and during follow-up in the two study groups

BMI	Group A	Group B	Test value	*P* value	Significance
	N=30	*N*=30			
Pre					
Mean±SD	44.30±4.43	43.73±3.63	0.542	0.590	NS
Range	36–55	35–50			
1 month					
Mean±SD	40.20±3.50	39.73±2.83	0.568	0.572	NS
Range	34–49	33–45			
3 months					
Mean±SD	35.90±2.41	35.57±2.08	0.573	0.569	NS
Range	32–41	31–39			
6 months					
Mean±SD	33.40±2.04	32.90±1.67	1.038	0.304	NS
Range	30–38	29–36			
12 months					
Mean±SD	29.43±1.22	29.20±1.10	0.778	0.439	NS
Range	26–32	27–31			

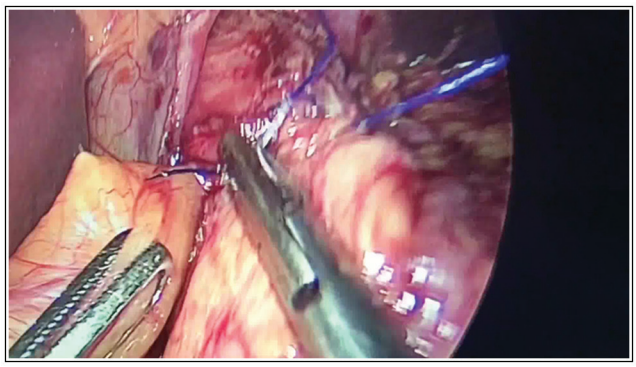
Independent *t* test.
P value more than 0.05: nonsignificant (NS); *P* value less than 0.05: significant (S); *P* value less than 0.01: highly significant (HS).

Table 4 Correlation between excess weight loss (%) postoperatively during follow-up in the two study groups

Excess weight loss (%)	Group A	Group B	Test value	*P* value	Significance
	N=30	*N*=30			
1 month					
Mean±SD	20.87±2.03	20.13±1.25	1.684	0.098	NS
Range	16–24	18–22			
3 months					
Mean±SD	42.77±1.83	42.67±2.01	0.202	0.841	NS
Range	40–45	40–46			
6 months					
Mean±SD	54.67±1.35	55.20±1.27	−1.577	0.120	NS
Range	52–58	53–58			
12 months					
Mean±SD	73.97±2.08	74.17±2.35	−0.349	0.728	NS
Range	70–77	70–78			

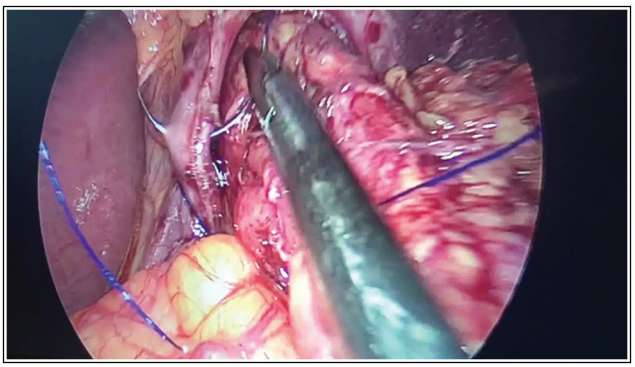
Independent *t* test.
P value more than 0.05: nonsignificant (NS); *P* value less than 0.05: significant (S); *P* value less than 0.01: highly significant (HS).

Figure 12



Correlation between BMI preoperatively and during follow-up in the two study groups.

Figure 13



Correlation between excess weight loss (%) postoperatively and during follow-up in the two study groups.

3, 6, and 12 months, respectively. Group A shows two, five, six, and seven patients developing reflux symptoms through 1, 3, 6, and 12 months with a percentage of 6.7, 16.7, 20, and 23.3%, respectively, while in group B shows zero, zero, one, and one patients developed reflux with a percentage of 0, 0, 3.3, and 3.3%, respectively. The results were not significant during the 1st month postoperatively but were significant through

Table 5 Correlation between symptoms of reflux postoperatively during follow-up in the two study groups

Symptoms of reflux	Group A [*n* (%)]	Group B [*n* (%)]	Test value	*P* value	Significance
1 month					
Negative	28 (93.3)	30 (100.0)	2.069	0.150	NS
Positive	2 (6.7)	0			
3 months					
Negative	25 (83.3)	30 (100.0)	5.455	0.020	S
Positive	5 (16.7)	0			
6 months					
Negative	24 (80.0)	29 (96.7)	4.043	0.044	S
Positive	6 (20.0)	1 (3.3)			
12 months					
Negative	23 (76.7)	29 (96.7)	5.192	0.023	S
Positive	7 (23.3)	1 (3.3)			

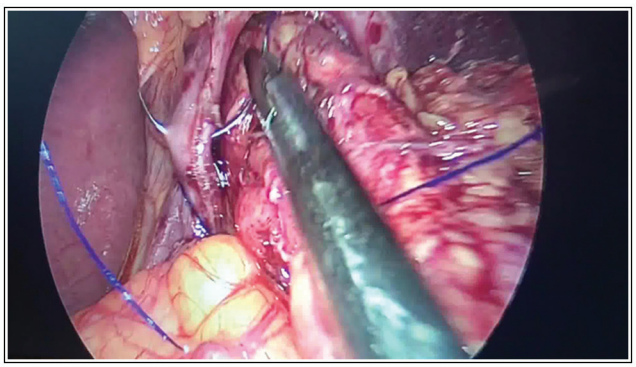
χ^2 test.
P value more than 0.05: nonsignificant (NS); *P* value less than 0.05: significant (S); *P* value less than 0.01: highly significant (HS).

Table 6 Correlation of evident reflux endoscopically postoperatively during follow-up in the two study groups

Endoscope	Group A [*n* (%)]	Group B [*n* (%)]	Test value	*P* value	Significance
6 months					
Negative	22 (73.3)	29 (96.7)	6.405	0.011	S
Positive	8 (26.7)	1 (3.3)			
12 months					
Negative	21 (70.0)	28 (93.3)	5.455	0.020	S
Positive	9 (30.0)	2 (6.7)			

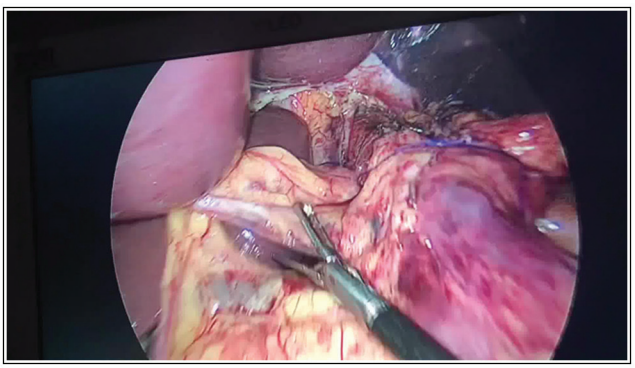
χ^2 test.
P value more than 0.05: nonsignificant (NS); *P* value less than 0.05: significant (S); *P* value less than 0.01: highly significant (HS).

Figure 14



Correlation between symptoms of reflux postoperatively and during follow-up in the two study groups.

Figure 15



Correlation of evident reflux endoscopically postoperatively during follow-up in the two study groups.

the 3rd, 6th, and 12th month adding an advantage to the ligamentum teres reinforcement of the esophageal hiatus technique (Fig. 14).

Table 6 shows a comparison in follow-up by endoscopy in 6 and 12 months between the two groups where group A shows eight and nine patients with signs of reflux, respectively, while group B shows one and two patients with signs of reflux, respectively. Follow-up by endoscopy shows a significant difference between both study groups as 26.7 and 30% of patients developed signs of reflux in group A, respectively, while it was 3.3 and 6.7% of patients only who developed signs of reflux using the falciform reinforcement of the esophageal hiatus technique (Fig. 15).

Table 7 shows a correlation summary between the two study groups preoperatively and postoperatively concerning the age and sex of the two groups, the results between them were nonsignificant, while in weight per kilogram and follow-up of the two groups for weight through 1, 3, 6, and 12 months, where preoperatively group A has a weight ranging from 118 to 158 kg with a mean±SD of 137.73 ± 12.05 kg, while group B weight ranged from 110 to 160 kg with a mean±SD of 139.47 ± 10.46 kg. During

Table 7 Correlation summary between the two study groups preoperatively and postoperatively

	Group A	Group B	Test value	*P* value	Significance
	N=30	*N*=30			
Age (years)					
Mean±SD	32.33±6.20	35.77±7.27	−1.968•	0.054	NS
Range	23–45	23–48			
Sex [*n* (%)]					
Female	15 (50.0)	16 (53.3)	0.067*	0.796	NS
Male	15 (50.0)	14 (46.7)			
Weight (kg) pre					
Mean±SD	137.73±12.05	139.47±10.46	−0.595•	0.554	NS
Range	118–158	110–160			
Weight (kg) 1 month					
Mean±SD	124.70±10.01	126.93±8.75	−0.920•	0.361	NS
Range	108–144	102–143			
Weight (kg) 3 months					
Mean±SD	111.33±7.92	112.97±6.47	−0.874•	0.386	NS
Range	99–128	94–125			
Weight (kg) 6 months					
Mean±SD	103.73±6.96	105.13±5.66	−0.855•	0.396	NS
Range	93–117	89–118			
Weight (kg) 12 months					
Mean±SD	91.77±5.81	93.53±4.28	−1.341•	0.185	NS
Range	82–105	82–102			
BMI (kg/m^2) pre					
Mean±SD	44.30±4.43	43.73±3.63	0.542•	0.590	NS
Range	36–55	35–50			
BMI (kg/m^2) 1 month					
Mean±SD	40.20±3.50	39.73±2.83	0.568•	0.572	NS
Range	34–49	33–45			
BMI (kg/m^2) 3 months					
Mean±SD	35.90±2.41	35.57±2.08	0.573•	0.569	NS
Range	32–41	31–39			
BMI (kg/m^2) 6 months					
Mean±SD	33.40±2.04	32.90±1.67	1.038•	0.304	NS
Range	30–38	29–36			
BMI (kg/m^2) 12 months					
Mean±SD	29.43±1.22	29.20±1.10	0.778•	0.439	NS
Range	26–32	27–31			
Excess weight (%) 1 month					
Mean±SD	20.87±2.03	20.13±1.25	1.684•	0.098	NS
Range	16–24	18–22			
Excess weight (%) 3 months					
Mean±SD	42.77±1.83	42.67±2.01	0.202•	0.841	NS
Range	40–45	40–46			
Excess weight (%) 6 months					
Mean±SD	54.67±1.35	55.20±1.27	−1.577•	0.120	NS
Range	52–58	53–58			
Excess weight (%) 12 months					
Mean±SD	73.97±2.08	74.17±2.35	−0.349•	0.728	NS
Range	70–77	70–78			
Symptoms of reflux at 1 month [*n* (%)]					
Negative	28 (93.3)	30 (100.0)	2.069*	0.150	NS
Positive	2 (6.7)	0			
Symptoms of reflux at 3 months [*n* (%)]					
Negative	25 (83.3)	30 (100.0)	5.455*	0.020	S
Positive	5 (16.7)	0			
Symptoms of reflux at 6 months [*n* (%)]					
Negative	24 (80.0)	29 (96.7)	4.043*	0.044	S
Positive	6 (20.0)	1 (3.3)			

(*Continued*)

Table 7 (*Continued*)

	Group A	Group B	Test value	*P* value	Significance
	N=30	*N*=30			
Symptoms of reflux at 12 months [*n* (%)]					
Negative	23 (76.7)	29 (96.7)	5.192*	0.023	S
Positive	7 (23.3)	1 (3.3)			
Endoscope at 6 months [*n* (%)]					
Negative	22 (73.3)	29 (96.7)	6.405*	0.011	S
Positive	8 (26.7)	1 (3.3)			
Endoscope at 12 months [*n* (%)]					
Negative	21 (70.0)	28 (93.3)	5.455*	0.020	S
Positive	9 (30.0)	2 (6.7)			

*χ^2 test.
•Independent *t* test.
P value more than 0.05: nonsignificant (NS); *P* value less than 0.05: significant (S); *P* value less than 0.01: highly significant (HS).s

follow-up, group A has a range of 108–144, 99–128, 93–117, and 82–105 kg, respectively, while in group B it was 102–143, 94–125, 89–118, and 82–102 kg, respectively, with no significance in weight reduction in comparison between the two different techniques. Also concerning BMI preoperatively and follow-up of the two groups for BMI through 1, 3, 6, and 12 months, where preoperatively group A has a BMI ranging from 36 to 55 with a mean±SD of 44.30 ± 4.43 while in group BMI ranged from 35 to 50 with a mean±SD of 43.73 ± 3.63. During follow-up, group A has a BMI range of 34–49, 32–41, 30–38, and 26–32, respectively, while in group B it was 33–45, 31–39, 29–36, and 27–31 respectively, with no signficance in BMI reduction in comparison between the two different techniques, while comparing excess weight loss% follow-up of the two groups through 1, 3, 6, and 12 months, group A has a range of 16–24, 40–45, 52–58, and 70–77%, respectively, while in group B it was 18–22, 40–46, 53–58, and 70–78%, respectively, with also no significance in excess weight loss% in comparison between the two different techniques. The table also compares developing symptoms of reflux between the two groups through 1, 3, 6, and 12 months, respectively. Group A shows two, five, six, and seven patients developing reflux symptoms through 1, 3, 6, and 12 months with a percentage of 6.7, 16.7, 20, and 23.3%, respectively, while group B shows zero, zero, one, and one patients developed reflux with a percentage of 0, 0, 3.3, and 3.3%, respectively. The results were not significant during the 1st month postoperatively but were significant through the 3rd, 6th, and 12th month adding an advantage to the ligamentum teres reinforcement of the esophageal hiatus technique. Lastly, the table shows a comparison in follow-up by endoscopy in 6, 12 months between the two groups, where group A shows eight and nine patients with signs of reflux, respectively, while group B shows one and two patients with signs of reflux, respectively. Follow up by endoscopy shows a significant difference between both study groups as it was 26.7 and 30% of patients who developed signs of reflux in group A, respectively, while 3.3 and 6.7% of patients only developed signs of reflux using the ligamentum teres reinforcement of the esophageal hiatus technique.

Discussion

Comparing our study results concerning group A which underwent SG only with no symptoms or signs of GERD preoperatively, the percentage of patients who developed GERD postoperatively through 1st, 3rd, 6th, and 12th months of follow-up was 6.7, 16.7, 20, and 23.3%, respectively, and the percentage endoscopically for the development of GERD was 26.7 and 30% during the 6th and 12th months of follow-up, while according to Felsenreich *et al*. [14] a total of 53 patients underwent SG in the three participating Austrian bariatric centers between January 2003 and December 2005. Forty-one patients received SG as a first bariatric procedure and 12 patients were excluded from the study. Within the 10-year follow-up period, a total of 16 (37%) patients were converted to RYGB, 10 (23%) due to weight regain, and six (14%) due to reflux as the main symptom. One (2%) patient out of the 41 was converted for acute leakage. Symptomatic reflux was found in 38% of the nonconverted patients, as defined and recognized by clinically interviewing patients about their symptoms, such as heartburn, regurgitation, an acidic taste in the mouth, pain with swallowing or a sore throat after eating, coughing, increased salivation, or chest pain.

The largest series so far (with 4832 patients) has been presented by DuPree *et al*. [15], who observed new-onset GERD in 8.6% of non-GERD patients preoperatively after 3 years. They therefore determined reflux as a contraindication to SG.

Also, a postoperative increase in GERD was found in 21% of the patients of Kular *et al*. [16] after SG. Reflux was no contraindication here; they did, however, encourage their patients suffering from reflux preoperatively to undergo one anastomosis gastric bypass instead.

Boza *et al*. [17] found the highest incidence of new-onset GERD with 26.7% at a 5-year follow-up of SG performed with 60 Fr bougie calibrations.

Himpens *et al*. [18] observed reflux at 6 years postoperatively in 23% of the patients, while only 3.6% had suffered from GERD preoperatively.

According to Castagneto-Gissey *et al*. [19] between October 2017 and August 2018, a total of 21 patients affected by morbid obesity with a mean BMI of $41.2 \pm 0.9\,kg/m^2$ and eligible for SG were prospectively enrolled in their study. Patients underwent preoperative high-resolution manometry, 24-h pH monitoring, and GERD symptom evaluation by means of the GERD-HRQL questionnaire. Reported use of proton pump inhibitors or other antacid medications was recorded. A total of 19 patients, 15 (78.9%) female and four (21.1%) male, of mean age 41.6 ± 2.8 years and BMI of $41.2 \pm 0.9\,kg/m^2$, completed this study. BMI change was $14.4 \pm 0.9\,kg/m^2$ ($P<0.001$), with a %total weight loss of $34.8 \pm 1.7\%$. No postoperative major and minor complications or mortality were registered during this study. The number of participants taking proton pump inhibitors increased significantly ($P=0.02$) from 10.5% at baseline to 42.1% 1 year after SG. Endoscopic findings showed significant changes after SG, with an increase in the number of cases of cardiac incontinence (26.3–73.7%, $P=0.001$), erosive esophagitis (10.5–42.1%, $P=0.01$), Z-line upward migration more than 2 cm (31.6–84.2%, $P<0.0001$), and biliary gastric stagnation (5.3–47.4%, $P<0.0001$), and appearance of esophageal mucosal tongues (5.3–42.1%, $P=0.002$).

Also, when comparing patients in our study group B who underwent SG with ligamentum teres reinforcement of the hiatus, the percentage of patients who developed GERD postoperatively through the 1st, 3rd, 6th, and 12 months was 0, 0, 3.3, and 3.3%, respectively, and endoscopically was 3.3 and 6.7% during the 6th and 12 months of follow-up, while according to Huang *et al*. [20] a prospective study was held for GERD prevention for patients undergoing LSG using ligamentum teres cardiopexy in 18 patients, where 11 of them underwent concomitant crural repair and the results showed that 100% of patients were asymptomatic in a follow-up period of 6 months duration.

Conclusion

According to our study results, ligamentum teres reinforcement of the esophageal hiatus during SG shows a significant decrease in the development of GERD either symptomatically or endoscopically and is recommended as a preventive measure for the development of reflux postoperatively if done concomitantly with SG, which showed favorable results when compared with the ordinary technique.

Limitations of the study

Limited number of patients and a longer time follow-up were needed.

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Conflicts of interest

No conflict of interest.

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