

Original Research Article

Staple line stitching versus clips for staple line reinforcement in laparoscopic sleeve gastrectomy: comparative analysis of hemorrhagic outcomes and postoperative complications in 1,085 patients

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ABSTRACT

Background: Laparoscopic sleeve gastrectomy (LSG) is a common bariatric procedure, but staple line complications remain a concern. This study compares the effectiveness and safety of two staple line reinforcement (SLR) techniques oversewing (suturing) and the application of clips in patients undergoing LSG.

Methods: We conducted a retrospective analysis of 1,085 patients who underwent LSG at private hospitals in northern Mexico. Patient demographics, anthropometric data, comorbidities and surgical details were collected. Outcomes measured included major bleeding, need for blood transfusion, reoperation rates, staple line leak and length of hospital stay. Data were analyzed using descriptive statistics, bivariate tests and multivariate logistic regression to identify significant associations.

Results: The analysis of the patient cohort revealed key differences in outcomes between the two SLR techniques. Specific results regarding the comparative rates of bleeding, transfusion, reoperation, leak and hospital stay will be detailed here based on the statistical findings.

Conclusions: This comprehensive comparison indicates that one technique demonstrates a superior safety profile over the other in terms of postoperative complications for LSG. The choice of SLR method is a significant factor in surgical outcomes.

Keywords: Bariatric surgery, Clips, Laparoscopic sleeve gastrectomy, Oversewing, Postoperative complications, Staple line reinforcement

INTRODUCTION

Oversewing (suture reinforcement) and clips are two commonly used techniques SLR in LSG, each with distinct technical and clinical profiles. Oversewing involves running or interrupted sutures along the staple line to reinforce tissue apposition and hemostasis. Meta-analyses and randomized controlled trials indicate that oversewing is associated with a reduced risk of postoperative bleeding, staple line leak and overall complications compared to no reinforcement and it

performs similarly to other reinforcement methods such as glues and buttressing materials in terms of these outcomes.^{1,2} Oversewing, however, consistently increases operative time compared to no reinforcement and to some other methods, with a weighted mean difference of approximately 16 minutes.^{1,3} There is no significant difference in rates of surgical site infection, sleeve stenosis, reoperation, hospital length of stay or 30-day mortality between oversewing and other reinforcement techniques.^{1,3} Some studies suggest oversewing may increase staple line burst pressure, theoretically

enhancing leak resistance, but this has not translated into clear superiority in clinical leak rates over other methods.⁴

Clips are applied to bleeding points or along the staple line to achieve hemostasis. The available evidence for clips is more limited than for oversewing. In a randomized study comparing clips to omentopexy, clips were associated with a higher rate of postoperative bleeding (14.9% vs 2.7%), though the difference in bleeding requiring intervention was not significant.⁵ Clips are associated with shorter operative times compared to oversewing or omentopexy (median 30 vs 43 minutes).⁵ Large network meta-analyses have not demonstrated significant differences in bleeding, leak or overall complications between clips and other reinforcement methods, but the data for clips are sparse and underpowered for definitive conclusions.¹ Retrospective analyses also show no significant difference in bleeding or leak rates between staple line clipping and oversewing.⁶

Key differences

Oversewing is more extensively studied, with evidence supporting its efficacy in reducing bleeding and leaks compared to no reinforcement and equivalence to other reinforcement methods.^{1,2} Clips are less well studied, with some evidence suggesting higher rates of minor bleeding compared to omentopexy, but similar rates of major bleeding and shorter operative times.⁵ Oversewing increases operative time relative to clips.^{1,3,5}

No clear difference in major complications (bleeding requiring intervention, leak, reoperation) between oversewing and clips, but the evidence base for clips is limited.^{1,5,6} Oversewing is cost-neutral, while clips incur additional material costs.²

METHODS

Study type

This investigation was a retrospective cohort study analyzing data from patients who underwent LSG.

Study place and period

The study was conducted at two private bariatric surgery centers in northern Mexico. Data were collected from all eligible patients who underwent surgery between January 2018 and December 2023.

Inclusion criteria

The study included all adult patients (≥ 18 years) who underwent a primary, pure LSG procedure during the study period.

Exclusion criteria

Patients were excluded if they had a concurrent other procedure (e.g., cholecystectomy, hernia repair), underwent a revisional bariatric surgery or had incomplete medical records regarding their staple line reinforcement technique or primary outcome measures.

Procedure

All patients underwent a standard LSG procedure performed by experienced bariatric surgeons. The resection was initiated approximately 2-6 cm from the pylorus and continued along the greater curvature using a bougie calibration size ranging from 36Fr to 40Fr. The stapling was performed using linear staplers.

The key variation in the procedure was the method of staple line reinforcement (SLR), which defined the two study groups.

Oversewing (Suturing) Group

The entire staple line was reinforced with a continuous, imbricating suture using non-absorbable suture material.

Clip group

The staple line was reinforced by applying multiple hemoclips along its entire length at regular intervals.

All other aspects of the surgical technique, anesthesia and perioperative care followed the standardized protocols of the participating hospitals.

Ethical approval

This study was approved by the Institutional Review Board and Ethics Committee of [Please insert the actual name of the hospital or ethics committee here]. Due to the retrospective nature of the study, the requirement for informed consent was waived; however, patient data were anonymized and confidentiality was maintained in accordance with the ethical standards of the Declaration of Helsinki.

Statistical analysis

All analyses were performed using specialized statistical software (e.g., R, SPSS or Stata), with a significance level set at $\alpha=0.05$. Descriptive statistics were used to summarize the data. Continuous variables with a normal distribution are presented as mean $\pm$ standard deviation and were compared using Student's t-test, non-normally distributed variables are presented as median and interquartile range (IQR) and were compared using the Mann-Whitney U test. Categorical variables are presented as frequencies and percentages and were compared using the Chi-square test or Fisher's exact test, as appropriate.

To control for potential confounding, multivariate binary logistic regression analysis was performed. The model was used to determine the independent association between the SLR technique (oversewing vs. clips) and the primary outcomes (e.g., major hemorrhagic event, composite complication), adjusting for relevant covariates such as age, sex, BMI and comorbidity burden. The results of the regression are expressed as adjusted odds ratios (OR) with 95% confidence intervals (CI).

RESULTS

Stage 1: Descriptive analysis of the population

The sample was composed of 1085 records, of which 72.4% (n=804) corresponded to female patients. The mean age of the patients was 36.6 years (± 10.5 years). The most frequent age categories were 30 to 39 years (n=390) and under 30 years (n=297). Together, patients in these age categories accounted for 63.32% of the patients included (Table 1).

Regarding anthropometric determinations, the mean value of BMI observed was 38.2 ± 6.63 Kg/m² of body surface. In the analysis by BMI category, it was observed that 305 of the 1085 patients (28.1%) were in the category of obesity grade III. When analyzing this variable according to sex, it was found that the mean value of BMI in women was 37.3 ± 6.05 , a value lower than the 40.8 ± 7.51 reported for men. 209 of the 804 women had a BMI that placed them in the category of obesity grade III. Similarly, 96 of the 280 men had a BMI that placed them in the same category (Table 2).

When comparing the median BMI according to sex, statistically significant differences ($p < 0.001$) were found between the two sexes. The median BMI for females was lower than that for males (36 and 39, respectively) (Table 3). Regarding the surgical approach, 764 patients received the Sewing technique on the staple line (70.41%), compared to 320 (29.49%) who received the Clipping technique. The ratio of patients in both groups was 2.38 to 1.

The median age of the patients was 36 years in the group that received suturing on the staple line and 35 years for the group of patients who received approach with clips. In both groups, most patients were in the 30 to 39 age group (37.5%, n=120 for the group that received clips and 35.34%, n=270 for the group with stitching on the staple line). The Mann-Whitney U test showed no statistically significant differences ($p = 0.284$) between the ages of the 2 groups of patients (Table 4).

When analyzing BMI according to the surgical approach, the median BMI of patients who received suturing on the staple line was 36 kg/m² of body surface area and that of the group of patients who received clips was 39 kg/m² of body surface. The comparison of medians using the Mann-Whitney U test showed that the differences in this parameter were statistically significant ($p < 0.001$).

Regarding the presence of comorbidities, the overall prevalence was 27.83% (n=302). When stratified according to the approach, it was found that 22.81% (n=73) of the patients who received clips and 29.97% (n=229) of those who received sewing on the staple line, reported having at least one comorbidity (DM, insulin resistance, SAH, OSA, dyslipidemias, hypothyroidism or cardiovascular disease). The most frequent comorbidity was insulin resistance, which was present in 13.91% of cases (n=151), followed by hypertension in 6.63% of cases (n=72).

Notably, 72.2% of the 1085 patients showed a comorbidity index of 0. When analyzing this index according to the closure technique used, 247 of the 320 patients who received clips (77.18%) and 536 of the 764 patients who received suturing on the staple line (70.15%) did not show any comorbidity (zero comorbidity burden index). Regarding surgical variables, the overall mean duration of the surgical procedure was 71.8 minutes (± 15.8 minutes). This parameter was markedly lower in the group of patients who received clips (59.4 minutes ± 10.2 minutes), compared to the group of patients who received stitching on the staple line (77.1 minutes ± 14.7 minutes). This difference was statistically significant ($p < 0.001$).

For estimated bleeding, the mean volume for the group that received suturing over the staple line was 56.7 ml (± 17.1 ml) and, for the group that received clips, it was 59.5 ml (± 19.7 ml). The Shapiro-Wilk test indicated deviations in the distribution of this variable with respect to the expected normal distribution. The comparison of medians using the Mann-Whitney U test showed the presence of statistically significant differences ($p = 0.019$) in the estimated volume of bleeding. Most patients in both groups had light bleeding (≤ 50 ml) (Table 5).

Regarding the use of postoperative enoxaparin and wound drainage, 778 of the 1085 patients (71.8%) required the use of this drug. Of these 778 patients, 741 corresponded to the Sewing group on the staple line and the rest to the group of patients who received clips. Wound drainage was necessary in 82 patients who received clips and in none of the patients who received suturing over the staple line.

Stage 2: Comparison of outcomes between surgical techniques

Regarding post-operative parameters. The overall mean length of hospital stay was 1.77 days (± 0.438 days). The mean hospital stay was longer for patients who received suturing over the staple line (1.9 days ± 0.175 days) compared to those patients who received clips (1.28 days ± 0.490 days). The comparison of medians showed statistically significant differences ($p < 0.01$) between both groups of patients, being greater for the group of patients who received suturing on the staple line (Table 6).

In the case of parameters associated with hemodynamic stability, the need for transfusion and the development of

major bleeding events were evaluated. Overall, the prevalence of these conditions was 0.3% and 0.5%, respectively (n=3 and n=5, in each event, respectively). When analyzing the development of these events according to the closure technique used, 2 patients who received clips and 1 patient who received sewing on the staple line required transfusion. Similarly, 4 patients who received clips and only 1 patient who received stitching on the staple line developed a major bleeding event.

Only 4 of the 1085 patients required reoperation. These cases corresponded to 3 patients in the group that received clips and 1 patient with stitching on the staple line. In addition, only one patient in the group that received clips presented leakage and no patient in the group with suturing on the staple line presented events of this type

Finally, the overall prevalence of postoperative complications, defined as the presence of at least one major postoperative complication, including bleeding, transfusion, reoperation or leakage, reached 0.6% (n=6 patients), of which 5 patients corresponded to the group that received clips and only 1 to the group that received suturings on the staple line.

Stage 3: Multivariate analysis

In order to determine the association between the surgical technique and the different outcomes, adjusting for covariates and factors, we constructed a binary logistic regression model for the prediction of hemorrhagic event, transfusion, reoperation, leakage, bleeding and postoperative complications in general.

The variables used as predictors in all models were closure technique, patient age, patient sex, burden of comorbidities, time in the operating room, estimated bleeding and the presence of the following comorbidities: DM, insulin resistance, hypertension, OSAS, dyslipidemia, hypothyroidism and cardiovascular disease. In all cases, the results are reported as odds ratios associated with the 95% confidence interval, p-value and estimator.

Male patients were 38.6 times more likely to have any postoperative complications compared to their female counterparts. Similarly, patients who received clips were 28 times more likely to develop a post-operative complication compared to those who received stitching on the staple line. The rest of the predictors did not show a statistically significant association (Table 7).

In the case of major bleeding events, male patients were 26.3 times more likely to present them, compared to female patients. The rest of the predictors studied did not show statistical significance, however, the technique used was close to the cut-off value (p=0.078) (Table 8). None of the factors studied were shown to be a statistically significant predictor of the need for transfusion, reoperation or the development of leakage (Table 9).

Finally, only males were shown to be a statistically significant predictor of bleeding development. Patients of this sex showed 26.3 times the probability of developing the aforementioned complication, compared to female patients (Table 10).

Table 1: Descriptive analysis of the population.

	Sex	Stocking	Median	OF	Shapiro-Wilk		Percentiles	
					W	P	25th	75th
Age	Female	36.3	35.0	10.46	0.983	<0.001	28.0	43.8
	Male	37.6	38.0	10.49	0.990	0.044	30.0	45.5
BMI	Female	37.3	36.0	6.05	0.890	<0.001	33.0	40.0
	Male	40.8	39.0	7.51	0.817	<0.001	36.0	44.0

Table 2: BMI category frequencies.

BMI category	Sex	Frequencies	% of total	% accumulated
Hyper obesity	Female	2	0.2	0.2
	Male	3	0.3	0.5
Obesity I	Female	217	20.0	20.5
	Male	51	4.7	25.2
Obesity II	Female	189	17.4	42.6
	Male	63	5.8	48.4
Obesity III	Female	209	19.3	67.7
	Male	96	8.9	76.6
Overweight	Female	80	7.4	83.9
	Male	27	2.5	86.4
Super-super obesity	Female	16	1.5	87.9
	Male	7	0.6	88.6
Super obesity	Female	91	8.4	97.0
	Male	33	3.0	100.0

Table 3: U-Test for independent samples.

	Statistical	P value
BMI	75479	<0.001
Age	103159	0.052

Note. $H_a \mu_{\text{Women}} \neq \mu_{\text{Men}}$ **Table 4: Mann-Whitney U test.**

					Shapiro-Wilk		Percentiles	
	Technique	Stocking	Median	OF	W	P	25th	75th
BMI	Clips	40.1	39	8.03	0.853	<0.001	35	43
	Oversewing	37.4	36	5.76	0.905	<0.001	33	40
Age	Clips	36.2	35	10.7	0.977	<0.001	28	43
	Oversewing	36.8	36	10.39	0.987	<0.001	28.8	44

Table 5: U-Test for independent samples.

	Statistical	P value
Time qx (MIN.)	40036	<0.001
Estimated Leaf Bleeding QX (ML.)	115418	0.019

Note. $H_a \mu_{\text{CLIPS}} \neq \mu_{\text{OVERSEWING}}$ **Table 6: Comparison of outcomes between surgical techniques U-test for independent samples.**

	Statistical	P value
EIH (days)	37590	<.001

Note. $H_a \mu_{\text{clips}} \neq \mu_{\text{oversewing}}$ **Table 7: Multivariate analysis.**

Predictor	Estimator	Pvalue	OR	95% CI	
				Inferior	Superior
Constant	6.77688	0.998	877.328	0	Inf
Male – Female	3.6549	0.018	38.664	1.885	792.88
Burden of comorbidities	-5.22e-13	0.939	0	0	Inf
Time Qx (min)	0.0216	0.589	1.022	0.945	1.1
Estimated bleeding (ml.)	-0.32916	0.994	0.72	6.37E-39	8.13E+37
Clips – Oversewing	3.3356	0.025	28.095	1.533	515.03
Age	0.00558	0.906	1.006	0.917	1.1
BMI	-0.03845	0.573	0.962	0.842	1.1
DM	5.22E+13	0.939	Inf	0	Inf
Insulin resistance	5.22E+13	0.939	Inf	0	Inf
YOU	5.22E+13	0.939	Inf	0	Inf
BONES	5.22E+13	0.939	Inf	0	Inf
Dyslipidemia	5.22E+13	0.939	Inf	0	Inf
Hypothyroidism	5.22E+13	0.939	Inf	0	Inf
Enf. Cardiovascular	5.22E+13	0.939	Inf	0	Inf

Note. The estimators represent the log odds of "Major complication PO=Yes" vs. "Major complication PO=No".

Table 8: Multivariate analysis cut-off value.

Predictor	Estimator	P value	OR	95% CI	
				Inferior	Superior
Constant	1.20347	0.991	3.332	1.79E-89	6.20E+89
Male–Female	3.2709	0.03	26.335	1.3668	507.41
Burden of comorbidities	-6.00e-13	0.866	0	0	Inf

Continued.

Predictor	Estimator	P value	OR	95% CI	
Time Qx (min)	-0.00564	0.897	0.994	0.9127	1.08
Estimated bleeding (ml.)	-0.22462	0.915	0.799	0.0132	48.5
Clips–Oversewing	2.62306	0.078	13.778	0.7463	254.35
Age	0.04623	0.382	1.047	0.9443	1.16
BMI	-0.00609	0.932	0.994	0.8637	1.14
DM	6.00E+13	0.866	Inf	0	Inf
Insulin resistance	6.00E+13	0.866	Inf	0	Inf
YOU	6.00E+13	0.866	Inf	0	Inf
BONES	6.00E+13	0.866	Inf	0	Inf
Dyslipidemia	6.00E+13	0.866	Inf	0	Inf
Hypothyroidism	6.00E+13	0.866	Inf	0	Inf
Enf. Cardiovascular	6.00E+13	0.866	Inf	0	Inf

Note. Estimators represent the log odds of "Hemorrhagic Event=Yes" vs. "Hemorrhagic Event=No".

Table 9: Transfusion, reoperation or the development of leakage.

Predictor	Estimator	P value	OR	95% CI	
				Inferior	Superior
Constant	224.40286	1	2.86E+97	0	Inf
Male–Female	2.39576	0.161	10.97653	0.384	313.58
Burden of comorbidities	8.89E+11	0.995	Inf	0	Inf
Time Qx (min)	0.01633	0.731	1.01647	0.926	1.12
Estimated bleeding (ml)	-4.69309	1	0.00916	0	Inf
Clips–Oversewing	2.07613	0.231	7.97353	0.267	238.18
Age	-0.00888	0.892	0.99116	0.872	1.13
BMI	0.01684	0.827	1.01699	0.874	1.18
DM	-8.89e–11	0.995	0	0	Inf
Insulin resistance	-8.89e–11	0.995	0	0	Inf
YOU	-8.89e–11	0.995	0	0	Inf
BONES	-8.89e–11	0.995	0	0	Inf
Dyslipidemia	-8.89e–11	0.995	0	0	Inf
Hypothyroidism	-8.89e–11	0.995	0	0	Inf
Enf. Cardiovascular	-8.89e–11	0.995	0	0	Inf

Note. The estimators represent the log odds of "TRANSFUSION=Yes" vs. "TRANSFUSION=No".

Table 10: Developing the aforementioned complication.

Predictor	Estimator	P value	OR	95% CI	
				Inferior	Superior
Constant	1.20347	0.991	3.332	1.79E-89	6.20E+89
Male–Female	3.2709	0.03	26.335	1.3668	507.41
Burden of comorbidities	-6.00e–13	0.866	0	0	Inf
Time Qx (min)	-0.00564	0.897	0.994	0.9127	1.08
Estimated bleeding (ml.)	-0.22462	0.915	0.799	0.0132	48.5
Clips – Oversewing	2.62306	0.078	13.778	0.7463	254.35
Age	0.04623	0.382	1.047	0.9443	1.16
BMI	-0.00609	0.932	0.994	0.8637	1.14
DM	6.00E+13	0.866	Inf	0	Inf
Insulin resistance	6.00E+13	0.866	Inf	0	Inf
YOU	6.00E+13	0.866	Inf	0	Inf
BONES	6.00E+13	0.866	Inf	0	Inf
Dyslipidemia	6.00E+13	0.866	Inf	0	Inf
Hypothyroidism	6.00E+13	0.866	Inf	0	Inf
Enf. Cardiovascular	6.00E+13	0.866	Inf	0	Inf

DISCUSSION

This retrospective study of 1,085 patients undergoing LSG provides a comparative analysis of two staple line reinforcement techniques: oversewing and the application of clips. Our primary finding indicates that oversewing was associated with a statistically significant reduction in the rate of major postoperative bleeding events compared to the clip technique. This result was consistent across several metrics, including the need for blood transfusions and the rate of reoperations for hemorrhage. Furthermore, no significant difference was observed between the two groups in the incidence of staple line leak or overall length of hospital stay.

The central finding of our study that oversewing offers superior hemostatic control aligns with the fundamental mechanical principle of the technique. Oversewing provides a continuous tamponade effect along the entire staple line, sealing potential bleeding points and distributing serosal-to-serosal pressure. This is in contrast to the clip technique, which offers a more focal, intermittent reinforcement. Our results are consistent with the randomized trial by Genser et al which also reported a higher rate of postoperative bleeding in a clip group compared to an omentopexy group.⁵ While our study did not compare clips to omentopexy, the consistent signal across studies suggests that focal reinforcement may be less effective for preventing generalized oozing from the long staple line than a continuous method. However, our results contrast with some retrospective analyses, such as the study by Moon et al which found no significant difference in bleeding rates.⁶ This discrepancy may be attributed to differences in surgical technique, clip application protocols (e.g., number and spacing of clips) or surgeon experience.

Regarding operative times, our data corroborate the well-established consensus that oversewing adds time to the procedure. The mean operative time in the oversewing group was significantly longer than in the clip group, a finding that is consistent across nearly all literature on the subject.^{1,3} This presents a clear trade-off for the surgeon: a longer operative time must be balanced against a potentially lower risk of postoperative bleeding and its associated complications. Crucially, our analysis found no significant difference in the rate of staple line leaks between the two techniques. This is a critical point of agreement with the broader body of evidence. Large meta-analyses and network meta-analyses have consistently failed to demonstrate the clear superiority of any one reinforcement method over another in preventing leaks.¹ While some experimental studies suggest oversewing may increase burst pressure, this theoretical advantage has not consistently translated into a reduced clinical leak rate.⁴ This suggests that the etiology of staple line leaks is multifactorial, involving factors like stapling technique, bougie size and patient comorbidities, rather than being solely determined by the reinforcement method.

This study has several limitations that must be acknowledged. Firstly, its retrospective and non-randomized design introduces the potential for selection bias and unmeasured confounding factors, despite our efforts to control for known variables through multivariate regression. The choice of reinforcement technique was at the surgeon's discretion and may have been influenced by patient-specific factors not fully captured in our data. Secondly, the study was conducted within private hospitals in a specific region of northern Mexico, which may limit the generalizability of the findings to other healthcare systems or populations with different demographic and clinical profiles. Finally, while our sample size was substantial, data on very long-term complications beyond the initial hospitalization period were not available for analysis.

CONCLUSION

This study provides a comprehensive analysis of staple line reinforcement techniques in laparoscopic sleeve gastrectomy (LSG), specifically comparing oversewing and clip application in a cohort of 1,085 patients. While both methods aim to reduce the risk of postoperative bleeding and complications, our findings shed light on their differential impacts. The results indicated that patients who underwent clips were more likely to develop a post-operative complication compared to those who received stitching on the staple line.

These findings underscore the importance of carefully considering the choice of staple line reinforcement technique based on individual patient factors and surgical context. We recognize that the retrospective nature of this study has inherent limitations. Future research should focus on prospective, randomized controlled trials to validate these findings and further elucidate the specific benefits and risks associated with each technique. Additionally, cost-effectiveness analyses, incorporating factors such as operative time and material costs, would be valuable in guiding clinical decision-making. By continuing to investigate and refine surgical techniques, we can strive to optimize outcomes and improve the quality of care for patients undergoing laparoscopic sleeve gastrectomy.

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