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**Original Research Article**

# Restoring the gate: laparoscopic Nissen fundoplication significantly elevates lower esophageal sphincter pressure and alleviates GERD symptoms

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## ABSTRACT

**Background:** Gastroesophageal reflux disease (GERD) is a highly prevalent condition with significant quality-of-life implications. Laparoscopic fundoplication is the established surgical standard of care, yet quantitative manometric data from Indian tertiary care centers remain sparse. To compare preoperative and postoperative lower esophageal sphincter (LES) pressure in patients undergoing laparoscopic Nissen fundoplication and to correlate manometric changes with symptomatic improvement.

**Methods:** An observational study of 45 adults who underwent laparoscopic Nissen fundoplication (January–December 2023) at a tertiary care center. High-resolution esophageal manometry (HRM) was performed within one month preoperatively and within three months postoperatively. Symptom severity was assessed using the validated GERD-Q questionnaire. Statistical analysis employed the Wilcoxon Signed-Rank Test ($p \leq 0.05$ considered significant).

**Results:** Mean LES pressure increased significantly from 10.80±1.78 mmHg preoperatively to 16.77±3.77 mmHg postoperatively (median: 10.11 → 15.80 mmHg, $p<0.05$). The GERD-Q score improved from 9.96±2.35 to 6.76±1.37 ($p<0.05$). Of 45 patients, 43 (95.6%) demonstrated LES pressure augmentation and 42 (93.3%) reported symptomatic improvement. The overall complication rate was 11.1%, all managed conservatively.

**Conclusions:** Laparoscopic Nissen fundoplication produces a statistically significant and clinically meaningful increase in LES resting pressure alongside significant symptomatic relief. These findings from an Indian tertiary care centre corroborate international data and support fundoplication as a safe, effective intervention for GERD refractory to medical therapy.

**Keywords:** Antireflux surgery, Esophageal manometry, GERD, GERD-Q score, LES pressure, Laparoscopic fundoplication, Lower esophageal sphincter

## INTRODUCTION

GERD is defined as the reflux of gastric contents into the esophagus, causing troublesome symptoms, mucosal injury or both.[1] It represents one of the most prevalent gastrointestinal disorders globally, with an estimated prevalence of 7.6% in India 6.7% in northern regions and 8.4% in southern parts based on the landmark multicentre study by the Indian Society of Gastroenterologists Task Force (ISG TF).[7] The cardinal symptoms are heartburn and acid regurgitation, though atypical manifestations including chronic cough, laryngitis and chest pain are increasingly recognised. The pathophysiology of GERD centres on dysfunction of the LES, a functionally critical high-pressure zone comprising four anatomic structures: the intrinsic distal esophageal musculature, the sling

fibers of the gastric cardia, the crura of the diaphragm and the intra-abdominal segment of the gastroesophageal junction.[20] A competent sphincter maintains 6–26 mmHg of resting pressure over at least 2 cm, with adequate intra-abdominal length.[2] Transient LES relaxations, reduced sphincter length and low basal pressure compounded by obesity, tobacco use and dietary factors collectively undermine this anti-reflux barrier.

While lifestyle modification and acid suppression with proton pump inhibitors (PPIs) form the cornerstone of GERD management, long-term PPI therapy carries recognised risks including Clostridium difficile-associated diarrhoea, osteoporosis and micronutrient malabsorption.[12] For patients with refractory symptoms, documented pathological reflux or Barrett's esophagus, surgical intervention is indicated.

LARS predominantly fundoplication has supplanted open surgery as the gold standard, with reported cure rates of 85%–93%.[13] Rudolf Nissen performed the first successful fundoplication in 1955–1956 and laparoscopic approaches have since demonstrated equivalent efficacy with reduced morbidity.[8]

Despite abundant global data, manometric evidence from Indian tertiary care settings is limited. HRM is not only essential for preoperative diagnosis and patient selection but is increasingly recognised as a prognostic tool that predicts surgical outcomes.[21] The present study was designed to quantify LES pressure changes before and after laparoscopic Nissen fundoplication (LNF), correlating manometric outcomes with clinician-assessed and patient-reported symptomatic improvement using the validated GERD-Q questionnaire.

## METHODS

### *Study design and setting*

This was an observational study conducted in the Department of General Surgery at Grant Medical College and Sir JJ Group of Hospitals, Mumbai, Maharashtra, India. Data were collected from the medical records of patients who underwent laparoscopic Nissen fundoplication between January 2023 and December 2023, with a minimum three-month post-operative follow-up.

Ethical clearance was obtained from the Institutional Ethics Committee (IEC) and patient data were de-identified prior to analysis.

### *Inclusion criteria*

Patients were included if they underwent laparoscopic fundoplication during the study period, had documented pre- and postoperative LES pressure measurements via high-resolution manometry, had at least three months of post-surgical follow-up data and were ≥18 years of age.

### *Exclusion criteria*

Patients were excluded for incomplete perioperative data or missing manometry concomitant or secondary surgical procedures; severe esophageal hypomotility or aperistalsis; significant comorbidities likely to independently influence LES pressure (morbid obesity, loco-regional malignancies, chronic alcoholism with end-organ dysfunction) or pregnancy.

### *Data collection*

Preoperative data included HRM-derived LES pressure (within one month prior to surgery), demographics (age, sex, BMI), GERD-specific symptom severity via the GERD-Q questionnaire 53 (scored 0–18), upper GI endoscopy findings and comorbidity profile. Postoperative data included repeat HRM (within three months post-surgery) and GERD-Q scores documented at follow-up visits.

### *Statistical analysis*

Data were tabulated in Microsoft Excel and analysed using IBM SPSS Statistics, Version 25. The Kolmogorov–Smirnov and Shapiro–Wilk tests were applied to assess normality. Since LES pressure and GERD-Q score data did not follow a normal distribution, the Wilcoxon Signed-Rank Test was used to compare paired pre- and postoperative values. A p-value $\leq 0.05$ was considered statistically significant. Results are expressed as mean±standard deviation (SD), median and range. References were cited using the Vancouver system.

## RESULTS

### *Demographic and baseline characteristics*

A total of 45 patients fulfilling the selection criteria were included. The mean age was 42.27±7.14 years (range 28–60 years), with the 41–50-year age group constituting the majority (55.6%). The cohort comprised 28 males (62.2%) and 17 females (37.8%), yielding a male-to-female ratio of approximately 1.6:1. The mean BMI was 26.81±3.52 kg/m2; no patient was morbidly obese or underweight. 82.2% of patients had no comorbidities; the remainder had well-controlled diabetes mellitus, hypertension or ischaemic heart disease (Table 1).

### *Clinical presentation and endoscopic findings*

Heartburn was the predominant presenting complaint in 24 patients (53.3%), followed by regurgitation (17.8%), dysphagia (15.6%), bloating (8.9%) and atypical symptoms including dry cough and sore throat (one each, 2.2%). Upper GI endoscopy classified 33 patients (73.3%) as having non-erosive reflux disease (NERD) and 12 (26.7%) as having erosive esophagitis. All 45

patients underwent laparoscopic Nissen fundoplication (Table 2).

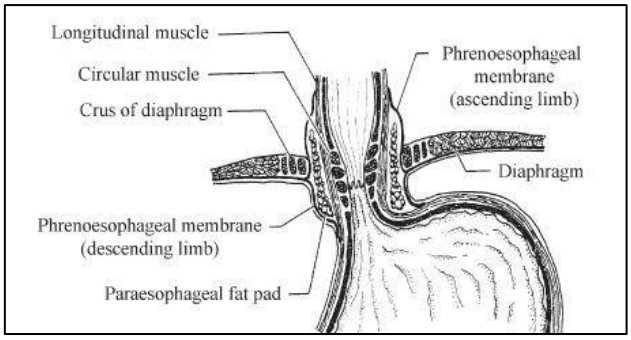


**Figure 1: Anatomy of the lower esophageal sphincter.**

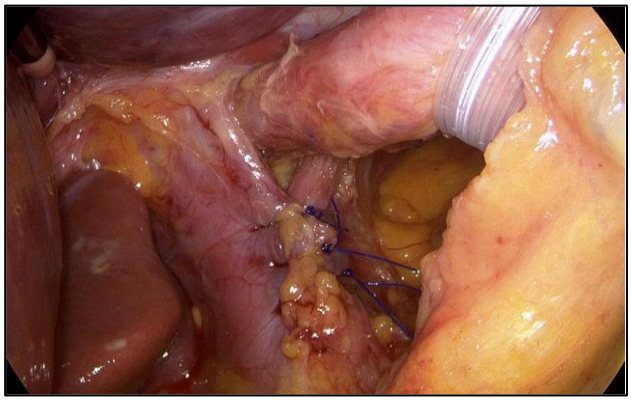

**Figure 2: Crural closure in LARS.**

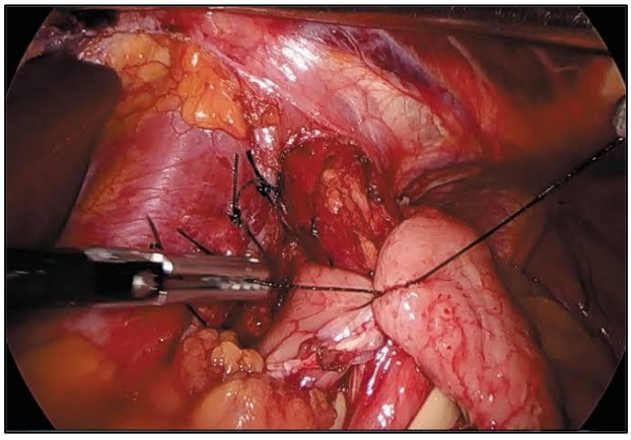

**Figure 3: Suturing of fundic wrap in LNF.**

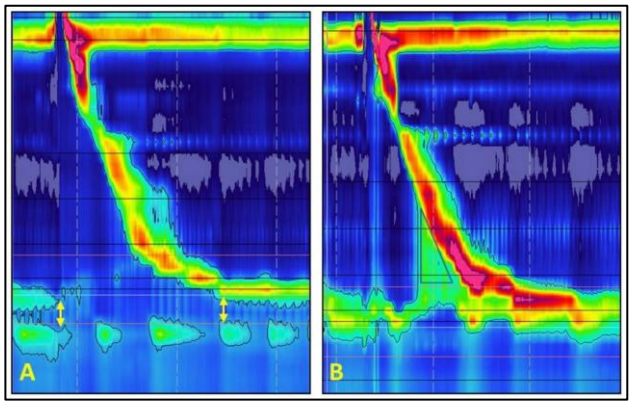


**Figure 4 (A, B): High resolution manometry pictures pre and postoperatively.**

***Postoperative complications***

Forty patients (88.9%) experienced no postoperative complications. Five patients (11.1%) developed non-serious complications: dyspepsia/bloating in 3 patients (6.7%), new-onset dysphagia in 1 patient (2.2%) and surgical site infection (SSI) in 1 patient (2.2%). All complications resolved with conservative management. No patient required reoperation during the follow-up period.

***Symptomatic improvement-GERD-Q score***

The mean GERD-Q score improved from 9.96±2.35 preoperatively to 6.76±1.37 postoperatively. The data did not follow a normal distribution (Shapiro–Wilk $p<0.05$); hence the Wilcoxon Signed-Rank Test was applied. Of 45 patients, 42 (93.3%) demonstrated score reduction, 1 (2.2%) showed an increase and 2 (4.4%) showed no change. The difference was highly significant ($p<0.001$, standardised test statistic=−5.679, Table 3).

***Lower esophageal sphincter pressure changes***

The mean LES pressure increased significantly from 10.80±1.78 mmHg preoperatively to 16.77±3.77 mmHg postoperatively (median: 10.11→15.80 mmHg; range: 8–15→10–26 mmHg). Of 45 patients, 43 (95.6%) demonstrated an increase in LES pressure, while 2 patients (4.4%) experienced a reduction. The result was highly significant ($p<0.001$, standardised test statistic=5.762, Table 4).

**Table 1: Baseline demographic and clinical characteristics (n=45).**

| Variables | Category/statistic | N/Value | Percent/range |
|---|---|---|---|
| **Age (in years)** | **Mean±SD** | **42.27±7.14** | **28–60** |
| | 18–30 | 3 | 6.7 |
| | 31–40 | 15 | 33.3 |
| | 41–50 | 25 | 55.6 |
| | 51–60 | 2 | 4.4 |
| **Sex** | Male | 28 | 62.2 |
| | Female | 17 | 37.8 |

Continued.

| Variables | Category/statistic | N/Value | Percent/range |
|---|---|---|---|
| **BMI (kg/m²)** | Mean±SD | 26.81±3.52 | 19–32 |
| **Comorbidities** | None | 37 | 82.2 |
| | DM only | 2 | 4.4 |
| | HTN only | 2 | 4.4 |
| | DM+HTN | 2 | 4.4 |
| | DM+IHD | 1 | 2.2 |
| | HTN+IHD | 1 | 2.2 |

**Table 2: Chief presenting complaints and endoscopic findings.**

| Parameters | N | (%) |
|---|---|---|
| **Heartburn** | 24 | 53.3 |
| **Regurgitation** | 8 | 17.8 |
| **Dysphagia** | 7 | 15.6 |
| **Bloating** | 4 | 8.9 |
| **Dry cough** | 1 | 2.2 |
| **Sore throat** | 1 | 2.2 |
| **Endoscopy finding** | | |
| Non-erosive reflux disease | 33 | 73.3 |
| Erosive Esophagitis | 12 | 26.7 |

**Table 3: Descriptive statistics and Wilcoxon test results-GERD-Q score.**

| Parameters | Preoperative | Postoperative | Change | P value |
|---|---|---|---|---|
| **Mean±SD** | 9.96±2.35 | 6.76±1.37 | −3.20 | <0.001* |
| **Median** | 9.42 | 6.70 | −2.72 | — |
| **Minimum** | 6 | 4 | — | — |
| **Maximum** | 17 | 10 | — | — |
| **Patients improved** | — | 42 / 45 (93.3%) | — | — |

* Wilcoxon Signed-Rank Test; SD: Standard Deviation.

**Table 4: Descriptive statistics and Wilcoxon test results-LES pressure.**

| Parameters | Preoperative (mmHg) | Postoperative (mmHg) | Change | P value |
|---|---|---|---|---|
| **Mean±SD** | 10.80±1.78 | 16.77±3.77 | + 5.97 | < 0.001* |
| **Median** | 10.11 | 15.80 | + 5.69 | — |
| **Minimum** | 8 | 10 | — | — |
| **Maximum** | 15 | 26 | — | — |
| **Patients with increased LES pressure** | — | 43/45 (95.6%) | — | — |

* Wilcoxon Signed-Rank Test; SD: Standard Deviation.

**Table 5: Cross-study comparison of pre- and postoperative LES pressure.**

| Study (in year) | n | Mean age (in years) | Preop LES pressure | Postop LES pressure | P value |
|---|---|---|---|---|---|
| **Boris et al[24], 2024** | 95 | 60 | 21.7 mmHg | 28.9 mmHg | 0.038 |
| **Sales et al[25], 2024** | 14 | 42.7 | 8.1 mmHg | 18.1 mmHg | 0.002 |
| **Bjekeset et al[29], 1980** | 12 | 62 | 5.4 cm$H_2O$ | 11.8 cm$H_2O$ | <0.01 |
| **Euler et al[30], 1977** | 9 | Paediatric | 11.3 mmHg | 22.3 mmHg | <0.001 |
| **Bowes et al[31], 1975** | 26 | — | 12.6 cm$H_2O$ | 16.5 cm$H_2O$ | — |
| **Present study, 2024** | 45 | 42.27 | 10.11 mmHg (med.) | 15.80 mmHg (med.) | <0.05 |

## DISCUSSION

This manometric study provides robust, single-centre evidence from an Indian tertiary care context that LNF significantly augments LES resting pressure and concurrently reduces GERD symptom burden within three months of surgery. The statistically significant LES pressure gain (10.80→16.77 mmHg mean, p<0.001) aligns mechanistically with the established principle that fundoplication restores the anatomical and functional competence of the gastroesophageal junction.

***Demographic profile***

The mean age of 42.27 years in our cohort is consistent with the 42.7-year mean reported by Sales et al and comparable to the 36.1-year mean in the series by Hamdy et al.[25,28] The male preponderance (62.2%) aligns with global patterns wherein male sex is an independent risk factor for GERD complications. Our mean BMI of 26.81 kg/m2 parallels the 27.2–27.8 kg/m2 range reported by Castelijns et al and Sales et al, suggesting our cohort represents a representative overweight GERD population, consistent with the well-established visceral obesity–GERD relationship.[3,25,27]

***Lower esophageal sphincter pressure augmentation***

The mechanism by which fundoplication elevates LES pressure is multifactorial. Wrapping the gastric fundus circumferentially around the distal esophagus increases both the intrinsic high-pressure zone and the intra-abdominal LES length, while crural closure reconstitutes the diaphragmatic pinch mechanism.[21] Manometric studies correlate GERD severity with lower mean LES pressure, shorter intra-abdominal LES length and shorter overall sphincter length all of which are corrected surgically.[11]

Comparing the data with published series (Table 5), the postoperative median of 15.80 mmHg falls within the reported international range. Boris et al,24 observed a mean rise from 21.7 to 28.9 mmHg ($p=0.038$) in 95 patients, while Sales et al,25 reported an increase from 8.1 to 18.1 mmHg ($p=0.002$) in a smaller cohort with lower baseline pressures resembling ours. The seminal study by Euler et al documented a near-doubling of LES pressure from 11.3 to 22.3 mmHg ($p<0.001$) and Bjekeset et al similarly reported statistically significant augmentation.[29,30] Across all comparable studies, LNF consistently elevates LES pressure irrespective of technique nuances or measurement timing.

***Symptomatic outcomes***

The GERD-Q instrument, validated across multiple clinical settings, demonstrated a clinically meaningful mean improvement of 3.20 points (9.96→6.76; $p<0.001$). A GERD-Q score ≥8 indicates likely GERD warranting treatment; our postoperative mean of 6.76 suggests the majority of patients crossed below the clinical action threshold.[23] While direct numeric comparison across studies is limited by heterogeneous outcome instruments GERD-HRQL in Boris et al heartburn and regurgitation scores in Sales et al the directional consistency is compelling: all series report statistically significant symptom reduction following LNF.[24,25] The one patient who showed an increase in GERD-Q score warrants clinical attention. Post-fundoplication symptoms including gas-bloat syndrome, dysphagia and wrap herniation are well-characterised sequelae requiring endoscopic and manometric re-evaluation.[19] Fortunately, no re-operation was required in this cohort.

***Safety profile***

The overall complication rate of 11.1% compares favourably with published literature. Zehetner et al reported a total morbidity rate of 19.5% at five-year follow-up after laparoscopic Toupet fundoplication.[16] In our series, the most frequent complication was dyspepsia/bloating (6.7%), consistent with the known side-effect profile of Nissen fundoplication attributed to increased outflow resistance.[24] Dysphagia occurred in one patient (2.2%), lower than the 5% endoscopic dilatation rate reported by Zehetner et al.[16] The isolated SSI case resolved with wound care. No intraoperative adverse events were recorded.

***Nissen vs. Toupet fundoplication***

All patients in this cohort underwent LNF (360° wrap). The SAGES guidelines advocate shared decision-making between complete and partial fundoplication, noting that while complete fundoplication may offer superior reflux control, partial (Toupet) fundoplication is associated with lower rates of postoperative dysphagia and gas-bloat syndrome.[10,15] A recent network meta-analysis of 29 RCTs by Andreou et al found Toupet fundoplication equivalent to Nissen in reflux control, morbidity and reoperation rates, with reduced dysphagia. Wetscher et al demonstrated that both procedures significantly increased LES resting pressure, though the augmentation was more pronounced after LNF.[15,17] The uniformity of LNF in our study precludes inter-procedure comparison but ensures data homogeneity.

***Role of manometry in surgical planning***

High-resolution manometry with esophageal pressure topography is indispensable in the preoperative workup for LARS.[5] It identifies patients with esophageal dysmotility who may fare poorly after complete fundoplication, detects achalasia or pseudo-achalasia and provides baseline LES data for outcome benchmarking.[21] Ayazi et al articulate the emerging prognostic utility of manometry in predicting durable symptom control.[21] The study corroborates this by demonstrating that postoperative manometric improvement closely parallels patient-reported symptomatic outcomes, reinforcing HRM as both a selection and surveillance tool in antireflux surgery.

***Limitations***

Several limitations merit acknowledgement. The sample size of 45 patients, while adequate for preliminary analysis, limits generalisability. Postoperative manometry was performed within three months, precluding assessment of long-term pressure maintenance a concern particularly regarding partial fundoplication durability.[18]

Ambulatory 24 hours pH monitoring, the gold standard for reflux quantification, was not available for all patients.[4] Additionally, the study is restricted to a single centre and a single surgical technique (LNF), limiting external validity. Prospective multi-centre studies with extended follow-up are required to address these gaps.

## CONCLUSION

Laparoscopic Nissen fundoplication produces a statistically significant and clinically meaningful increase in lower esophageal sphincter resting pressure from a median of 10.11 mmHg to 15.80 mmHg alongside significant reduction in GERD-Q symptom scores within three months of surgery. These manometric and symptomatic gains were observed in 95.6% and 93.3% of patients, respectively, with a low and manageable complication rate of 11.1%. Our findings from a tertiary care Indian centre are consistent with international benchmarks and affirm that laparoscopic fundoplication is safe and efficacious for patients with medically refractory GERD. Larger prospective studies with longer follow-up and 24 hours pH-impedance monitoring are recommended to comprehensively evaluate the durability of LES pressure augmentation and its correlation with long-term quality of life.

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