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Postoperative dysphagia and short-term outcomes following laparoscopic floppy Nissen fundoplication combined with V-flap suturing

Haijun Du^{1†}, Hongyi Dong^{2†}, Ying Gao¹, Chuntao Liu³, Xing Du⁴ and Diangang Liu^{4*}

Abstract

Objective To compare postoperative dysphagia and anti-reflux efficacy between laparoscopic floppy Nissen fundoplication with V-flap suturing (LNF-V) and conventional laparoscopic Nissen fundoplication (LNF).

Methods This retrospective cohort study included patients with gastroesophageal reflux disease (GERD) who underwent LNF-V or LNF between January 2022 and January 2024 at the Department of General Surgery of Xuanwu Hospital, Xiong an Xuanwu Hospital, and Beijing Feng tai Hospital of Traditional Chinese Medicine. After applying inclusion and exclusion criteria, 173 patients were enrolled, including 113 in the LNF-V group and 60 in the LNF group. In the LNF-V procedure, following the standard 360° fundoplication, the wrap was further sutured to the left and right diaphragmatic crura to form a V-shaped configuration. Saeed dysphagia scores and Gerd-Q scores were assessed preoperatively and at 3, 6, and 12 months postoperatively. Operative time, intraoperative blood loss, hospital stay, and postoperative complications were also recorded.

Results There were no significant differences between the two groups in baseline characteristics including sex, age, BMI, symptom duration, lower esophageal sphincter (LES) pressure, and DeMeester score ($P > 0.05$). Intraoperative blood loss and hospital stay were also similar. The operative time was slightly longer in the LNF-V group than in the LNF group ($P < 0.001$). Regarding dysphagia, Saeed scores were significantly lower in the LNF-V group at 3 to 6 months postoperatively ($P < 0.001$), indicating better recovery of swallowing function; by 12 months, scores were comparable between the groups ($P = 0.785$). Gerd-Q scores at 3 months were significantly lower in the LNF-V group ($P = 0.008$), reflecting better reflux symptom control, while no significant differences were observed at 6 and 12 months ($P = 0.078$ and 0.541 , respectively).

Conclusion In this retrospective cohort, LNF-V was associated with a lower incidence of early postoperative dysphagia and showed superior short-term anti-reflux efficacy compared with conventional LNF. Prospective studies

[†]Haijun Du and Hongyi Dong are co-first author.

*Correspondence:
Diangang Liu
hal2008@hotmail.com

Full list of author information is available at the end of the article



are needed to confirm these findings. While the LNF-V procedure appears safe and feasible, its long-term durability requires further validation in prospective studies with extended follow-up.

Introduction

Gastroesophageal reflux disease (GERD) is a condition characterized by reflux-related symptoms and/or complications (such as esophagitis or Barrett's esophagus) resulting from the retrograde flow of gastric contents into the esophagus. The pathogenesis of GERD primarily involves lower esophageal sphincter (LES) hypotension, hiatal hernia, impaired esophageal clearance, and delayed gastric emptying. For patients with moderate-to-severe GERD—especially those who are long-term proton pump inhibitor (PPI) users with suboptimal symptom control—surgical intervention has been widely recognized as an effective treatment option. Fundoplication is the mainstay of anti-reflux surgery and achieves durable control of acid reflux by reinforcing LES pressure, extending the high-pressure zone, and reconstructing the angle of His, thereby providing durable control of GERD [1].

Since its first application in 1991, laparoscopic fundoplication has become one of the standard surgical treatments for GERD due to its advantages of minimal invasiveness, faster recovery, and shorter hospital stay. Among the various techniques, Nissen fundoplication, which involves a 360° wrap around the abdominal esophagus, is considered the most effective for reflux control and is the gold standard for treating moderate-to-severe GERD [2]. However, complete encirclement of the distal esophagus may impede bolus transit, leading to postoperative dysphagia, with reported incidence rates ranging from 10% to 25% at one year postoperatively [3–5]. The risk is particularly elevated when the wrap is excessively tight or long, or in patients with pre-existing esophageal motility disorders. In contrast, Toupet and Dor fundoplication, which are partial wrap techniques, are associated with lower incidences of dysphagia, bloating, and gas-related symptoms, making them more suitable for patients with esophageal motility abnormalities. Randomized controlled trials have demonstrated that posterior Toupet fundoplication achieves comparable reflux control with a lower risk of postoperative dysphagia compared with Nissen fundoplication. However, long-term follow-up suggests that early advantages in swallowing function may diminish over time, highlighting the need for continued innovation in fundoplication techniques [6]. Recent European series have reported that partial fundoplication may provide a lower risk of postoperative dysphagia without compromising reflux control [7]. Nevertheless, some studies have suggested that partial wraps may confer slightly inferior reflux suppression compared with the complete Nissen wrap, as reflected by higher

postoperative LES pressure after Nissen fundoplication [8].

Most cases of postoperative dysphagia are transient, typically caused by local edema or hematoma at the surgical site, and gradually resolve within 6 to 8 weeks postoperatively [9]. However, persistent dysphagia can occur in 3% to 10% of cases and may be related to an overly tight wrap, esophageal motility dysfunction, or altered anatomical relationships [3]. Management strategies include lifestyle modifications such as small frequent meals, soft diets, and prolonged chewing. For patients with severe or persistent symptoms, endoscopic dilation may be considered, and surgical revision is rarely required. To further improve surgical outcomes and reduce postoperative complications, several modified forms of Nissen fundoplication have been introduced. One such technique is the floppy Nissen fundoplication, which limits the wrap length to 1.5–2 cm and applies moderate tension during gastric fundus suturing. Studies have shown that this approach significantly lowers the incidence of postoperative dysphagia, with some reporting a reduction from 28% with the conventional technique to less than 10% [10].

To better balance reflux control and reduce the risk of dysphagia, we developed a novel modification: laparoscopic floppy Nissen fundoplication combined with V-flap suturing (LNF-V). This technique structurally adjusts the configuration of the fundic wrap by suturing it to both diaphragmatic crura in a V-shaped manner, thereby optimizing the tension distribution on the anterior esophageal wall and decreasing the likelihood of postoperative dysphagia. This study aims to retrospectively compare this modified procedure with conventional laparoscopic Nissen fundoplication (LNF) in terms of reflux control and dysphagia incidence.

Method

Study Population

This retrospective cohort study included patients who underwent laparoscopic Nissen fundoplication between January 2022 and January 2024 at three centers: Xuanwu Hospital of Capital Medical University, Xiong'an Xuanwu Hospital, and Beijing Feng tai Hospital of Traditional Chinese Medicine. A total of 173 patients were enrolled, including 113 patients in the LNF-V group and 60 in the conventional LNF group. The enrollment flowchart is shown in Fig. 1. Clinical data were collected using preoperative and postoperative questionnaires administered by trained staff and reviewed by database administrators through electronic medical records. Patients were

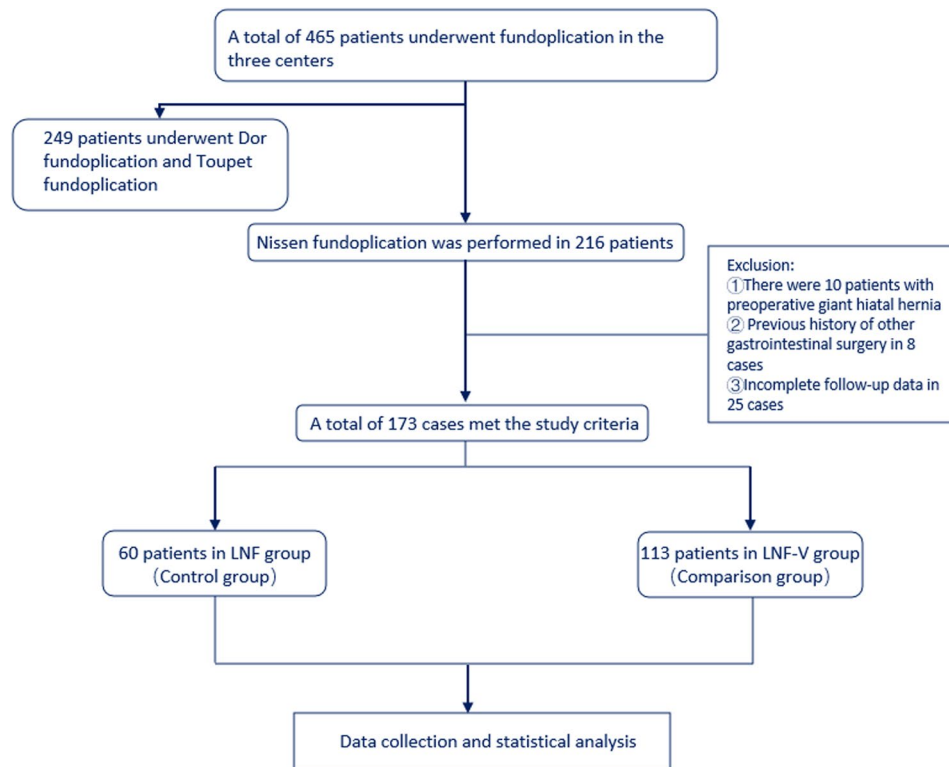


Fig. 1 Flowchart of Patient Selection and Group Allocation for LNF vs. LNF-V Comparison Study

included if they underwent conventional LNF (control group) or LNF-V (intervention group), and met at least one of the following inclusion criteria: ① Objective evidence of GERD with inadequate response to medical therapy. ② Established diagnosis of GERD and unwillingness to continue long-term PPI therapy. ③ GERD with complications such as Barrett esophagus or reflux esophagitis. Exclusion criteria were as follows: ① Esophageal manometry showing esophageal motility disorders preoperatively. ② Presence of large hiatal hernia (Hill gastroesophageal flap valve grade > 2). ③ History of previous gastric or esophageal surgery. ④ Incomplete follow-up data. Informed consent was obtained from all patients before surgery. Written informed consent for surgery and the use of anonymized clinical data for research was obtained from all patients at the time of their operation. For this retrospective analysis, the requirement for additional study-specific consent was waived by the Ethics Committee of Xuanwu Hospital, Capital Medical University (Reference No. 2024-P2-097-02).

Variables

Clinical data collected for all enrolled patients included demographics and baseline characteristics such as sex, age, body mass index (BMI), duration of reflux symptoms, preoperative use of acid-suppressive medications, mean resting pressure of the LES, and DeMeester score. Perioperative indicators included operative time,

intraoperative blood loss, time to first postoperative flatus, and length of hospital stay. Postoperative complications recorded included dysphagia, bloating, diarrhea, constipation, and belching. The primary outcome measures were Saeed dysphagia score at 1, 3, 6 and 12 months Postoperatively and Gerd-Q score at 3, 6 and 12 months Postoperatively. The Gerd-Q questionnaire consists of six items that assess heartburn, regurgitation, sleep disturbance, and use of additional medication (each scored from 0 to 3, based on frequency over the past 7 days), as well as upper abdominal pain and nausea (scored inversely from 3 to 0). The total score ranges from 0 to 18, with a score ≥ 8 suggesting probable GERD. Postoperative dysphagia was assessed using the Saeed scale, which ranges from 0 (complete inability to swallow) to 5 (normal swallowing). A score of ≤ 2 was defined as the presence of dysphagia. All patients were followed up at 1, 3, 6, and 12 months postoperatively via telephone, outpatient visits, or other means. The final follow-up was completed by December 2024.

Surgical procedure

All procedures were performed by the same surgical team. Under general anesthesia, patients were placed in the supine position with reverse Trendelenburg tilt. A standard five-port laparoscopic technique was used to establish access. The hepato-gastric and gastrosplenic ligaments were dissected to fully expose the gastric

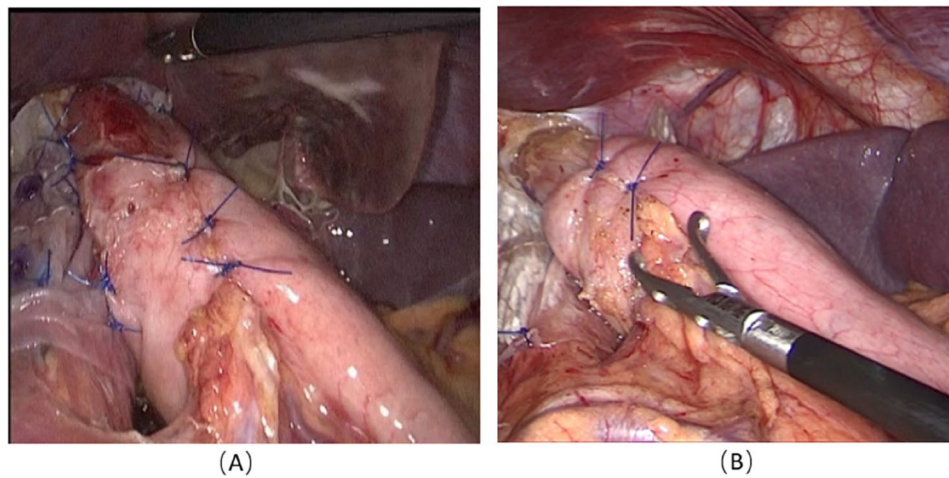


Fig. 2 Schematic Illustration of Laparoscopic Nissen Fundoplication. (A) Laparoscopic floppy Nissen fundoplication with V-flap suturing. (B) Conventional laparoscopic Nissen fundoplication

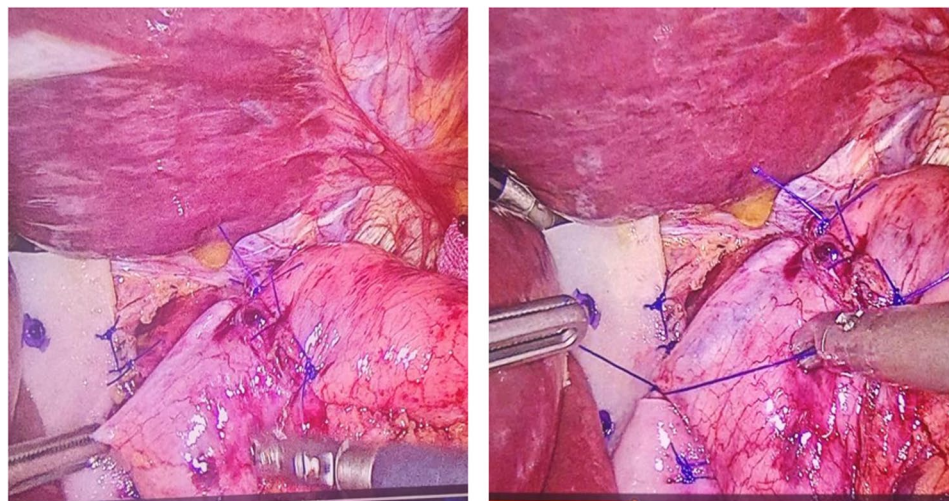


Fig. 3 Detailed Illustration of Right-Sided Gastric Fundus Fixation to the Diaphragm After Laparoscopic Nissen Fundoplication: The right fold of the wrap is sutured to the right crus of the diaphragm, typically at a point approximately 1 cm above the junction of the left and right crura. Care should be taken to avoid placing the suture too high. Prior to suturing, it is essential to ensure that the right half of the V-shaped wrap does not exert compressive pressure on the right lateral wall of the esophagus. The left side of the V-shaped wrap may be fixed slightly higher as appropriate

fundus and cardia. The phreno-esophageal membrane was opened, and the distal esophagus was mobilized anterior to the abdominal aorta to a length of at least 6 cm. The left and right diaphragmatic crura were also fully exposed.

The diaphragmatic crura were first approximated using a continuous suture with 2–0 absorbable barbed suture for tension reduction, followed by interrupted reinforcement sutures with non-absorbable material to achieve a snug but non-constrictive hiatus around the esophagus. In patients with coexisting hiatal hernia, an absorbable mesh was applied and fixed in place using absorbable tacks. The gastric fundus was then wrapped 360° around the distal esophagus from both anterior and posterior sides, secured with three interrupted sutures, with the

wrap length controlled at approximately 2 cm, completing construction of the anti-reflux valve (see Fig. 2). In the LNF-V group, after the standard floppy Nissen fundoplication, the anterior flap of the gastric fundus was further elevated and sutured in a “V” configuration (Fig. 2): one stitch on each side (left and right) and one superiorly, anchoring to the corresponding diaphragmatic crura. The left-sided suture was placed to reinforce the angle of His, while the right-sided suture was placed approximately 1 cm above the junction of the right diaphragmatic crus to avoid excessive tension or compression of the esophageal wall (Fig. 3). Prior to suturing, care was taken to ensure that the right half of the V-shaped flap did not exert undue pressure on the right esophageal wall. This additional step created a V-shaped anchoring

Table 1 Baseline characteristics of patients in the LNF-V and LNF groups

Variables	LNF-V group	LNF group	$\chi^2/t/Z$	<i>P</i>
Gender			0.592	0.445
Male	59(52.2%)	35(58.3%)		
Female	54(47.8%)	26(43.3%)		
Age	53.0 (45.0,60.0)	53.5(38.0,61.0)	-0.305	0.761
BMI	24.0±3.86	24.4±3.45	0.713	0.477
Duration of symptoms (month)	36.0 (12.0,72.0)	36.0 (22.5,69.0)	-0.887	0.380
Hiatal hernia	90 (80.0%)	49 (81.7%)	0.101	0.75
Erosive esophagitis	73 (64.6%)	39 (65.0%)	0.003	0.958
Los Angeles grade A	44 (38.9%)	24 (40%)		
Los Angeles grade B	26 (23.0)	13 (21.7%)		
Los Angeles grade C	2 (1.8%)	1 (1.7%)		
Los Angeles grade D	1(0.9%)	1 (1.7%)		
Barrett esophagus	5 (4.4%)	5 (8.3%)	1.099	0.294
Mean respiratory pressure of LES	9.42±3.24	9.46±3.30	-0.072	0.942
DeMeester score	18.46±4.31	18.31±4.14	0.222	0.824
Saeed score	4.92±0.27	4.95±0.22	0.727	0.468
Gerd-Q score	11.22±2.20	10.90±2.01	0.941	0.348

structure, referred to as the V-flap suturing technique (see Fig. 2). This modified design aimed to reduce anterior compression on the esophagus, thereby preserving the anti-reflux effect while minimizing the risk of postoperative dysphagia.

Statistical analysis

Statistical analyses were performed using SPSS version 29.0 (IBM Corp, Armonk, NY, USA). The normality of all continuous variables was assessed using the Shapiro–Wilk test. Variables with a normal distribution were expressed as mean±standard deviation (Mean±SD) and compared between groups using the independent samples t-test. Variables not conforming to a normal distribution were presented as median (interquartile range, IQR) and compared using the Mann–Whitney U test. Categorical variables were expressed as frequencies (percentages) and compared using the chi-square test or Fisher’s exact test, where appropriate (i.e., when expected counts were <5). All statistical tests were two-tailed, and a *P*-value <0.05 was considered statistically significant. No imputation was performed for missing data, and sensitivity analyses were not conducted due to the minimal rate of missingness. No formal power calculation was performed because this was a retrospective study with a fixed cohort size.

Table 2 Operative data and procedural details of patients

Variables	LNF-V group	LNF group	$\chi^2/t/Z$	<i>P</i>
Operation time (min)	137 (89,164)	100 (90,114)	4.184	<0.001
Intraoperative blood loss (ml)	15 (11,20)	15 (10,20)	0.157	0.875
Postoperative time to first flatus(h)	37 (31,44)	24 (24,36)	4.665	<0.001
Hospital stay (d)	7 (7,8)	7 (7,8)	-0.184	0.854

Results

The baseline characteristics of patients in the LNF-V and LNF groups showed no significant differences in gender (male: 52.2% vs. 58.3%, *P*=0.445), age [median 53.0 years (45.0, 60.0) vs. 53.5 years (38.0, 61.0), *P*=0.761], body mass index (24.0±3.86 vs. 24.4±3.45, *P*=0.477), or symptom duration [36.0 months (12.0, 72.0) vs. 36.0 months (22.5, 69.0), *P*=0.380]. Furthermore, the incidence of hiatal hernia (80.0% vs. 81.7%, *P*=0.750), erosive esophagitis (64.6% vs. 65.0%, *P*=0.958), and Barrett esophagus (4.4% vs. 8.3%, *P*=0.294) were comparable between groups, with similar grade distributions. There were also no significant differences in LES mean respiratory pressure (9.42±3.24 vs. 9.46±3.30, *P*=0.942), DeMeester score (18.46±4.31 vs. 18.31±4.14, *P*=0.824), Saeed score (4.92±0.27 vs. 4.95±0.22, *P*=0.468), and Gerd-Q score (11.22±2.20 vs. 10.90±2.01, *P*=0.348). Taken together, detailed statistical comparisons confirmed that baseline demographics and clinical parameters were well balanced between the two groups (all *P*>0.05), minimizing the risk of selection bias. The baseline results of the two groups of patients are presented in Table 1.

In terms of operative outcomes, the operative time was significantly longer in the LNF-V group compared to the LNF group [137 min (89, 164) vs. 100 min (90, 114), *Z*=4.184, *P*<0.001]. Intraoperative blood loss was similar between groups [15 ml (11, 20) vs. 15 ml (10, 20), *Z*=0.157, *P*=0.875]. The time to first postoperative flatus was significantly longer in the LNF-V group [37 h (31, 44) vs. 24 h (24, 36), *Z*=4.665, *P*<0.001]. The length of hospital stay was similar in both groups [7 days (7, 8) vs. 7 days (7, 8), *Z* = -0.184, *P*=0.854]. There were no significant differences in postoperative complications, including abdominal distension (χ^2 = 0.216, *P*=0.642), diarrhea (χ^2 = 0.159, *P*=0.690), constipation (χ^2 = 0.105, *P*=0.746), and belching (χ^2 = 0.276, *P*=0.599). The intraoperative and postoperative conditions are summarized in Table 2; Fig. 4.

The preoperative Saeed scores were not significantly different between the groups (4.92±0.27 vs. 4.95±0.22, *P*=0.468), suggesting similar baseline swallowing function. At 1 month postoperatively, the Saeed score was significantly higher in the LNF-V group (3.50±1.01 vs. 2.92±0.72, *P*<0.001). This trend continued at 3 months

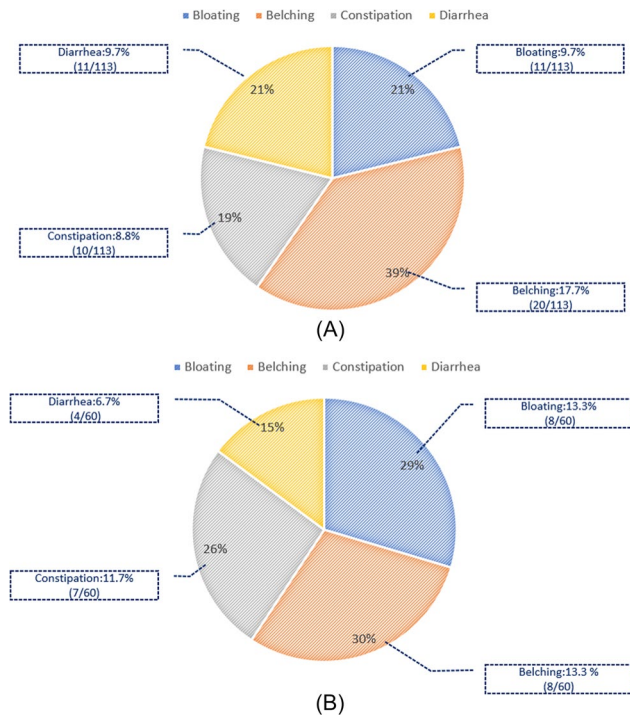


Fig. 4 Incidence and Proportion of Postoperative Complications in the LNF-V and LNF Groups. (A) LNF-V group. (B) LNF group

Table 3 Summary of preoperative and postoperative Saeed scores in the LNF-V and LNF groups

Follow-up time	LNF-V group	LNF group	Z/t	P
Pre-operation	4.92 ± 0.27	4.95 ± 0.22	0.727	0.468
Post-operation(1 month)	3.50 ± 1.01	2.92 ± 0.72	-3.998	<0.001
Post-operation(3 month)	4.43 ± 0.67	3.72 ± 0.59	-7.018	<0.001
Post-operation(6 month)	4.98 ± 0.132	4.68 ± 0.47	-6.330	<0.001
Post-operation(12 month)	4.87 ± 0.39	4.88 ± 0.32	0.273	0.785

(4.43 ± 0.67 vs. 3.72 ± 0.59, $P < 0.001$) and 6 months (4.98 ± 0.132 vs. 4.68 ± 0.47, $P < 0.001$). By 12 months, the scores converged (4.87 ± 0.39 vs. 4.88 ± 0.32, $P = 0.785$). These results indicate that LNF-V may offer superior short-term (1–6 months) postoperative swallowing recovery compared to conventional LNE, but this advantage diminishes by 12 months. The Saeed scores of the patients before and after the operation are shown in Table 3.

Regarding reflux control, the preoperative Gerd-Q scores did not differ significantly between groups (11.22 ± 2.20 vs. 10.90 ± 2.01, $P = 0.348$), suggesting comparable baseline symptom severity. At 3 months postoperatively, the LNF-V group showed significantly lower Gerd-Q scores (5.20 ± 1.17 vs. 5.70 ± 1.15, $P = 0.008$), indicating better short-term reflux symptom control. However, at 6 and 12 months, the scores were similar (5.81 ± 1.32 vs. 6.18 ± 1.27, $P = 0.078$; 6.19 ± 1.33 vs. 6.32 ± 1.36, $P = 0.541$), suggesting equivalent mid- to

Table 4 Summary of preoperative and postoperative Gerd-Q scores in the LNF-V and LNF groups

Follow-up time	LNF-V group	LNF group	Z/t	P
Pre-operation	11.22 ± 2.20	10.90 ± 2.01	0.941	0.348
Post-operation(3 month)	5.20 ± 1.17	5.70 ± 1.15	-2.663	0.008
Post-operation(6 month)	5.81 ± 1.32	6.18 ± 1.27	-1.320	0.078
Post-operation(12 month)	6.19 ± 1.33	6.32 ± 1.36	-0.612	0.541

long-term reflux control between the two surgical techniques. The Gerd-Q scores of the patients before and after the operation can be seen in Table 4.

Discussion

Dysphagia following fundoplication is a common complication of anti-reflux surgery. It can be categorized into short-term dysphagia—typically occurring within a few weeks to three months postoperatively due to edema and local inflammation—and long-term dysphagia, which persists beyond six months and is often attributed to structural or functional factors such as an overly tight wrap, excessive wrap length, wrap migration, or pre-existing esophageal motility disorders [9, 11]. Previous studies have shown that short-term dysphagia is primarily related to excessive intraoperative suture tension and postoperative tissue edema, whereas long-term dysphagia is more commonly associated with unrecognized esophageal motility abnormalities, a wrap length exceeding 2 cm, overtight crural closure, or wrap migration resulting in functional obstruction at the gastroesophageal junction [12, 13]. In our study, both short-term (1 month postoperatively) and long-term (6 months postoperatively) dysphagia scores were significantly better in the LNF-V group compared to the conventional LNF group (4.43 ± 0.67 vs. 3.72 ± 0.59; 4.98 ± 0.132 vs. 4.68 ± 0.47), suggesting that the LNF-V group results in less dysphagia within the first postoperative year. However, this difference diminished by the 12-month follow-up (see Fig. 5), which is consistent with the randomized trial by Analatos et al. [6], where early differences in dysphagia between partial and total fundoplication attenuated with longer follow-up. The convergence may be explained by gradual resolution of postoperative edema and patient adaptation over time, as well as differences in surgical design—our LNF-V being a modified complete wrap, while the RCT compared a 270° partial wrap with a 360° total wrap. Among patients with significant dysphagia (Saeed score ≤ 2), the incidence was also markedly lower in the LNF-V group compared to the LNF group at 1, 3, and 6 months postoperatively (3.3% vs. 15%, 1.6% vs. 11.6%, and 1.6% vs. 8.3%, respectively). These findings indicate that the “floppy” Nissen fundoplication combined with V-flap Suturing may effectively reduce early postoperative dysphagia by minimizing anterior esophageal compression. Previous literature has reported

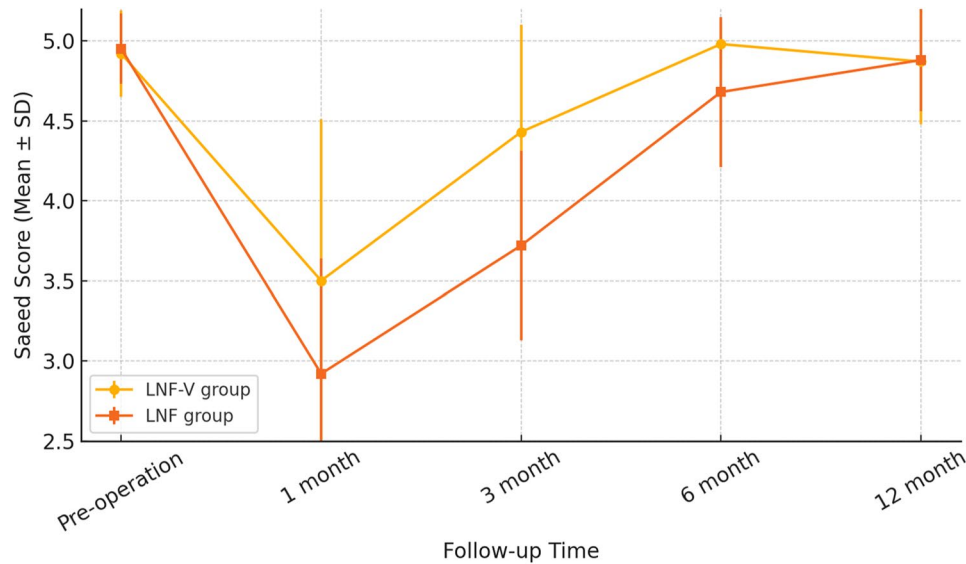


Fig. 5 Postoperative changes in Saeed Scores in the LNF-V and LNF Groups

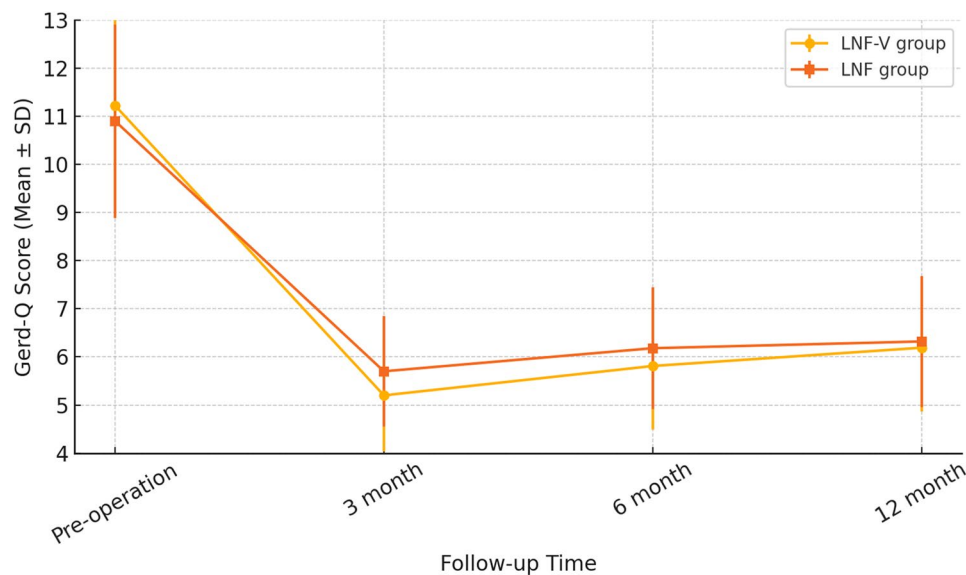


Fig. 6 Postoperative changes in Gerd-Q score in the LNF-V and LNF Groups

a 2–6% incidence of long-term severe dysphagia following standard LNF [9, 11]; however, assessment criteria have varied across studies. For example, Nikolic et al. also utilized the Saeed scoring system and defined a score of ≤ 2 as indicative of long-term dysphagia, but their study reported a lower incidence (2%) than our LNF group (3.3%), likely due to longer follow-up duration and possibly limited sample size. Overall, our findings suggest that the LNF-V technique significantly reduces both the incidence and severity of postoperative dysphagia compared to traditional LNF.

Our study demonstrated that at 3 months postoperatively, the LNF-V group showed a significantly lower Gerd-Q score (5.20 ± 1.17) compared to the LNF

group (5.70 ± 1.15), with the difference reaching statistical significance ($P=0.008$), indicating a short-term symptomatic advantage of the LNF-V procedure. At 6 months postoperatively, the difference in Gerd-Q scores between the two groups narrowed ($P=0.08$), and by 12 months, the scores were nearly identical (6.19 ± 1.33 vs. 6.32 ± 1.36), with no statistically significant difference ($P=0.541$). Given the number of outcomes analyzed, the borderline finding at 6 months ($P=0.08$) should be interpreted with caution, and the possibility of type I error cannot be excluded. The changes of Gerd-Q score over time are shown in Fig. 6. Spechler et al. reported that Nissen fundoplication significantly alleviated symptoms within 3 to 6 months after surgery and maintained

lasting efficacy over long-term follow-up in patients with refractory GERD [14]. Previous studies have primarily focused on comparing different surgical techniques, and many have found no significant differences in typical symptom control or patient satisfaction among them. For example, Wang et al. and Kamolz et al. compared floppy Nissen fundoplication and Toupet fundoplication and found comparable outcomes in terms of symptom relief and patient satisfaction [15, 16]. These findings were further supported by a meta-analysis conducted by Li et al., which included follow-up durations ranging from 6 months to 1 year. Their results indicated that while Nissen and Toupet fundoplication differed significantly in terms of postoperative complications, dysphagia, and LES pressure, these differences might translate into variations in long-term symptom control and recurrence rates [15, 17]. In our study, the superior Gerd-Q score in the LNF-V group at 3 months suggests that LNF-V may offer better short-term symptom control compared to standard LNF. However, this advantage diminished over time and was no longer evident at 6 and 12 months, aligning with previous findings. Since LNF-V is a modified version of the Nissen fundoplication, it appears to significantly reduce early postoperative dysphagia without compromising the long-term efficacy in GERD symptom control. Although the operative time and time to first flatus were slightly longer in the LNF-V group, these differences likely reflect the additional suturing steps and prolonged pneumoperitoneum. The clinical impact appears limited, as hospital stay, complication rates, and overall recovery profiles were comparable between the two groups. Beyond fundoplication, magnetic sphincter augmentation (MSA) has emerged as an alternative surgical option for GERD. Recent studies report that MSA provides durable reflux control and quality-of-life improvements comparable to Nissen fundoplication, while preserving more physiological swallowing function [18]. However, it carries device-related risks, higher costs, and dysphagia remains the most frequently reported complication despite overall fewer side effects compared with Nissen [19]. By contrast, our LNF-V modification avoids prosthetic material and aims to reduce dysphagia through an anatomical refinement of the wrap. Both approaches reflect ongoing efforts to improve functional outcomes in GERD surgery, but prospective trials are needed to determine their relative long-term value.

Naturally, we have also reflected on the underlying mechanisms and anatomical modifications behind this improved Nissen technique. The key change in LNF-V lies in securing the gastric wrap with two sutures directed upward toward the left and right diaphragmatic crura. Notably, the fixation on the left side resembles the reconstruction of the angle of His. Existing studies have demonstrated that a blunted angle of His is frequently

associated with severe GERD symptoms and erosive esophagitis, whereas intraoperative restoration of the angle of His can significantly alleviate symptoms and improve quality of life in GERD patients [20–22]. The superior Gerd-Q scores observed in the LNF-V group at 3 months postoperatively support this hypothesis. Jani et al. suggested that an ideal Nissen fundoplication would create a perfectly circular wrap of the stomach around the esophagus, but in practice, it should form an elliptical shape [23]. However, this characterization is not entirely accurate. Given that the gastric fundus is sutured only on the anterior aspect of the esophagus during Nissen fundoplication, the actual shape of the wrap more closely resembles a teardrop—narrow in the front and wider in the back.

Under normal physiological conditions, the esophagus lies between the trachea anteriorly and the spine posteriorly, subject to anatomical compression, resulting in a flattened anteroposterior axis and an oblate, elliptical lumen with a wider left-right diameter [24]. In the case of an overly tight fundoplication, this natural front-to-back flattening may be reversed into a side-to-side compression, altering the esophageal lumen from its normal physiological shape. By securing the wrap to both diaphragmatic crura, the LNF-V technique may distribute tension more evenly and help preserve the esophagus's natural geometry. We also hypothesize an alternative mechanism. During LNF-V, the upper esophageal lumen may adopt a funnel-like configuration, facilitating more direct flow toward the outlet. Although the outlet diameter is similar in conventional LNF, the absence of this guiding shape may limit flow efficiency, analogous to how a funnel directs liquid smoothly into a bottle compared with pouring without one (see Fig. 7). This physical model may provide a theoretical hypothesis to explain the reduced incidence of postoperative dysphagia in the LNF-V group. However, these remain speculative and are not supported by intraoperative measurements or postoperative imaging. Future biomechanical studies and imaging-based analyses will be required to validate these assumptions.

This study has several limitations. First, it was a retrospective cohort study with a modest sample size, which inherently introduces risks of selection bias, incomplete data capture, and residual confounding due to the absence of randomization and blinding. In addition, the relatively small overall cohort, when stratified for less common outcomes such as dysphagia, may have limited statistical power to detect clinically meaningful differences, particularly at later follow-ups. Second, the primary outcomes were assessed using subjective symptom-based questionnaires (Saeed and Gerd-Q scores) without complementary objective tests such as manometry, pH monitoring, or postoperative imaging, and no

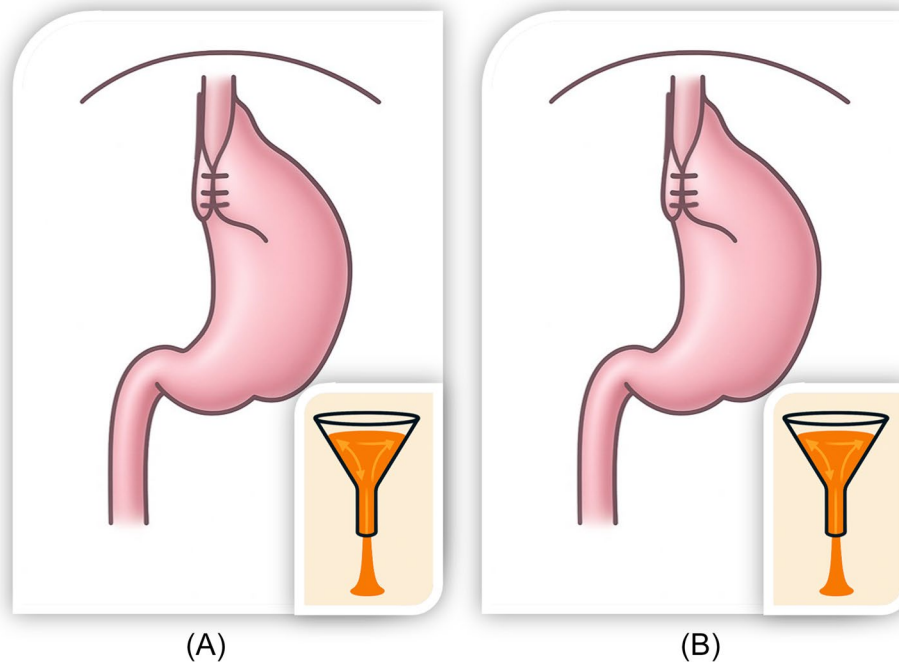


Fig. 7 Illustrations and Mechanisms of LNF-V and LNF Procedures. **(A)** LNF-V. **(B)** LNF

validated quality-of-life scales were included. Recent work by Park et al. (2023) identified preoperative lower esophageal sphincter (LES) length and resting pressure as quantitative predictors of symptom resolution after laparoscopic Nissen fundoplication, suggesting that anatomical and manometric factors may objectively correlate with postoperative success [25]. Although our study did not include postoperative pH or manometry assessments, these findings highlight the potential value of integrating preoperative physiological parameters into patient selection and prognostic evaluation in future prospective studies. Third, the follow-up period was limited to 12 months, which is relatively short for anti-reflux surgery, as late complications such as recurrent reflux, wrap failure, or persistent dysphagia may emerge beyond 2–5 years. Finally, although all procedures were performed by an experienced surgical team across three centers, the introduction of the LNF-V technique may have been subject to a learning curve, and the study population—restricted to Beijing centers and excluding patients with large hiatal hernia or esophageal motility disorders—limits the external generalizability of our findings. All data were prospectively recorded in institutional databases and retrospectively analyzed. Missing data were minimal and therefore not subjected to imputation; no formal sensitivity analyses were performed, which represents an additional limitation of the study. In summary, our study suggests that the LNF-V technique may provide advantages in early postoperative outcomes, particularly in reducing dysphagia and improving short-term reflux

control, compared with conventional LNF. However, these findings are preliminary and should be interpreted with caution due to the retrospective study design, limited sample size, and relatively short follow-up period. Furthermore, while the consistency ensured by a single surgical team across three centers reduces intra-operator variability, outcomes might differ if the LNF-V technique were adopted by surgeons with different experience levels. Future prospective, multicenter studies with longer follow-up are warranted to validate the efficacy, safety, and generalizability of the LNF-V technique, and should also assess its cost-effectiveness and reproducibility across diverse surgical settings to determine its broader clinical value and feasibility.

Conclusion

Compared with conventional Nissen fundoplication, LNF-V is associated with a lower incidence of early postoperative dysphagia and offers superior short-term anti-reflux efficacy.

Abbreviations

GERD	Gastroesophageal reflux disease
LNF	Laparoscopic Nissen fundoplication
LNF-V	Laparoscopic floppy Nissen fundoplication with V-flap suturing
LES	Lower esophageal sphincter
PPI	Proton pump inhibitor
IQR	Interquartile range
SD	Standard deviation

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

Supplementary Material 5

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Authors' contributions

Hongyi Dong: Study design, data collection, statistical analysis, manuscript drafting. Haijun Du and Chuntao Liu: Surgical procedures, clinical supervision, data verification. Xing Du and Ying Gao: Data collection, patient follow-up, and figures preparation. Diangang Liu: Study conception, supervision, and critical revision of the manuscript. All authors read and approved the final manuscript.

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Data availability

All data generated and/or analysed during this study are included in this published article and its supplementary information files.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Xuanwu Hospital, Capital Medical University (Reference No. 2024-P2-097-02). The research was based on retrospectively collected, de-identified medical records and did not include any individual person's data in identifiable form (such as names, images, or case-specific details). Therefore, the ethics committee approved a waiver of written informed consent for this retrospective analysis. All patients had provided written informed consent for surgery and verbal consent for the anonymized use of their clinical data for research purposes at the time of treatment.

Consent for publication

All participants provided consent for publication of anonymized data.

Competing interests

The authors declare no competing interests.

Author details

¹Department of General Surgery, Xiongan Xuanwu Hospital, Xiong an 070001, China

²School of biomedical engineering, Capital Medical University, Beijing 100071, China

³Department of General Surgery, Beijing Fengtai Hospital of Traditional Chinese Medicine, Beijing 100071, China

⁴Department of General Surgery, Xuanwu Hospital, Capital Medical University, Beijing 100053, China

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