



## Patient-reported outcomes in 645 patients after laparoscopic fundoplication up to 10 years



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### ABSTRACT

**Background:** Laparoscopic fundoplication is the gold-standard surgical management for gastroesophageal reflux disease. Optimal patient outcomes include resolution of symptoms with minimal postoperative side effects of dysphagia or gas-bloat. This study aims to review outcomes at a single institution up to 10 years after surgery.

**Methods:** This is a retrospective review of a prospectively maintained quality database. Patients who underwent laparoscopic fundoplication from 2009 to 2021 were included. Transition in surgical practice mid-2017 with incorporation of fundoplication algorithm and impedance planimetry. Patient-reported outcome scores include Reflux Symptom Index, gastroesophageal reflux disease–health-related quality of life, and dysphagia score. Comparisons were made using two-tailed Wilcoxon rank sum tests.

**Results:** Six hundred forty-five patients underwent laparoscopic fundoplication (2009–July 2017 n = 355, July 2017–November 2021 n = 290) from January 2009 to November 2021. Patients had an improvement in patient-reported outcomes and did not worsen from 2 to 10 years after surgery. Comparison of each time period showed that the second time period had fewer gas-bloat symptoms at 2 years ( $P = .04$ ). Paraesophageal hernia was present in 66% of patients. Preoperative patient-reported outcomes in non-paraesophageal hernia include worse Reflux Symptoms Index ( $P < .01$ ) and gastroesophageal reflux disease–health-related quality of life ( $P < .01$ ) than the paraesophageal hernia group. Patient-reported outcomes were similar between the 2 except for worse gas-bloat in non-paraesophageal hernia patients at 2 years ( $P = .02$ ). Endoscopy was performed in 10.9% (n = 58) of the study population at a median of 16 months, with 1.5% of patients (n = 8) from the entire cohort with abnormal DeMeester Scores. Median (interquartile range) preoperative DeMeester Score of 31 (17–51) decreased to 5 (2–14) at postoperative evaluation.

**Conclusion:** This single-institution study reports excellent long-term patient-reported outcomes after laparoscopic fundoplication that persist up to 10 years.

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### Introduction

Gastroesophageal reflux disease (GERD) plagues people worldwide, with an estimated prevalence rate of 8% to 33%.<sup>1</sup> About 30% to

40% of patients on proton pump inhibitors gain suboptimal symptomatic relief.<sup>2</sup> Patients may benefit from further evaluation and laparoscopic anti-reflux surgery in these cases.<sup>3,4</sup> Laparoscopic fundoplication is the surgical management for medical refractory GERD.<sup>5–7</sup> However, patients may avoid surgery because of the postoperative side effects, such as dysphagia and gas bloat.<sup>8</sup> In those instances, patients are left with chronic medical therapy and inadequate treatment of symptomatic GERD. Therefore, surgeons must continue to refine the field of anti-reflux surgery to optimize patient outcomes.

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Modifying surgical techniques, such as creating a shorter fundoplication over a larger stiff bougie and complete fundus mobilization, has yielded good patient outcomes.<sup>5</sup> Toupet fundoplication has been reported to be just as effective as the traditional Nissen fundoplication, with decreased side effects.<sup>9,10</sup> Adoption of the Toupet fundoplication varied because of heterogeneous practices and techniques within the surgical community. Therefore, patient hesitation for surgery is not unwarranted. We review outcomes from up to 10 years after laparoscopic fundoplication at a single institution.

## Methods

### Data collection

All laparoscopic Nissen or Toupet fundoplications between January 2009 and November 2021 were included. There was an evolution in surgical management within our practice during this period. Prior to 2017, Nissen fundoplication was the predominant operation. Then, there was a change to adopt Toupet fundoplication and impedance planimetry in our practice. Our dedicated research team gathered patient health information during the preoperative, perioperative, and postoperative phases. Patient medical history, diagnostic workup, operative findings, readmission rates, and patient-reported outcomes (PROs) were recorded. Also, objective postoperative diagnostic data were documented. Radiologic hiatal hernia recurrence was identified on postoperative esophagram or computed tomography (CT) scan, with top of fundoplication herniating greater than 2 cm above the diaphragm. Surgeon group adjudication was required in ambiguous cases. Clinical information was maintained in an institutional quality database. This was an Institutional Review Board-approved study.

### Operative steps

A comprehensive esophageal workup was recommended before operation, which would include an esophagram or CT scan, manometry, acid-reflux testing, and upper endoscopy. Not all patients completed this workup, and the decision to operate was at the surgeon's discretion. Operations were performed by a group of 4 surgeons. The majority of patients received a Nissen fundoplication before 2017 unless a patient demonstrated severe esophageal motility issues on manometry reports, such as peristalsis <60% with abnormal bolus transit. After this point, our practice became more selective in performing Nissen fundoplication and increased the number of Toupet fundoplications. Impedance planimetry was incorporated into intraoperative decision-making as well. Our criteria for a Nissen fundoplication after 2017 included a patient having normal esophageal motility (peristalsis of >70% and no diffuse esophageal spasm or Jackhammer Esophagus based on Chicago Classification 3.0) and a gastroesophageal junction distensibility index of greater than 7.0 mm<sup>2</sup>/mm Hg after hiatal dissection. The theory behind this practice revolves around the lower esophageal sphincter (LES). The higher distensibility index represents a looser sphincter, which may be more susceptible to pathologic acid reflux, so a tighter sphincter is chosen to address the issue. The LES pressure was shown to be higher, and DeMeester scores lower after a Nissen fundoplication than the Toupet.<sup>9</sup>

The operation includes 5 incisions—1 for liver retraction, 2 for the assistant (camera and retraction), and 2 working ports for the surgeon. Hiatal dissection is complete after exposure of both crura, reduction of hiatal hernia, if present, and mobilization of at least 3 cm of intra-abdominal esophagus. Vagus nerves are identified and preserved along with the hepatic branch, if possible. The short gastric vessels are ligated to fully mobilize the fundus. The diaphragmatic hiatus is closed with permanent suture. When a

paraesophageal hernia (PEH) is identified, type 2 to 4, mesh is used for repair. The authors acknowledge that there is a paucity of long-term evidence for routine use of mesh cruroplasty in PEH repair.<sup>11,12</sup> There is variation in technique for mesh incorporation and lack of standardization. The surgeons in our practice elect to use a rectangular configured biosynthetic mesh that is laid over the crura and incorporated in 3 horizontal mattress closures, with pledgets for a tension-free closure. This reinforcing technique with biosynthetic mesh has shown low hernia recurrence at 1 year.<sup>13</sup> All fundoplications are created over a bougie, sized 52 to 60 Fr upon surgeon discretion, and, in some cases, the impedance planimetry balloon catheter was used as a soft bougie from November 2018 to January 2019.

During a Nissen fundoplication, the posterior fundus is sutured to the crus, and coronal stitches are placed between the esophagus and fundus bilaterally. Then, 3 interrupted permanent sutures that included the left fundus, partial-thickness bite of the esophagus, and right fundus were performed. During a Toupet fundoplication, bilateral permanent coronal sutures, incorporating the fundus, crus, and esophagus, were placed. Two additional sutures were placed on each side, a centimeter inferior to the prior stitch, which incorporated the fundus and esophagus. The resulting length is 2 to 3 cm for each fundoplication. Lastly, a posterior gastropexy to the median arcuate ligament is done with a permanent suture.

### Patient-reported outcomes (PROs)

Patients are given a set of quality-of-life questionnaires to be completed after their initial evaluation and designated time points after surgery. Postoperative time points include 3 weeks, 6 months, 1 year, 2 years, 5 years, 7 years, and 10 years. Patients would receive questionnaires through electronic mail or phone call. Scheduled alerts within the prospectively maintained quality database would prompt our research fellows for updated electronic medical record reviews. The Reflux Symptom Index (RSI) assesses for “atypical” reflux symptoms such as asthma, cough, globus sensation, or chest pain. An RSI score >13 represents severe reflux.<sup>14</sup> Gastroesophageal Reflux Disease–Health-Related Quality of Life Questionnaire (GERD-HRQL) evaluates for “typical” reflux symptoms, such as heartburn and regurgitation, and a higher score indicates worse symptomatic disease.<sup>15</sup> The gas-bloat score is extracted from the GERD-HRQL; the question asks about bloating or gassy feelings with a response of 0 as no symptoms and 1 as symptoms noticeable but not bothersome to 5 as symptoms are incapacitating. The dysphagia score measures the severity of dysphagia on a 5-point scale from 1 (“I am able to eat a normal diet/no dysphagia”) to 5 (“I am unable to swallow anything/total dysphagia”).<sup>16</sup>

### Statistical analysis

Descriptive statistics were used to summarize the results, including mean with standard deviation, median with interquartile range, and frequency with percentage. Differences between surgical procedure groups at different time points were made using independent samples *t* tests, Wilcoxon rank-sum tests,  $\chi^2$  analysis, and Fisher exact tests. Subgroup analyses included comparison of surgical procedure groups stratified by those who did and did not have a PEH. All statistical tests were two-tailed and performed using SAS 9.4 (SAS Institute, Cary, NC).

## Results

### Patient demographics

Six hundred forty-five patients underwent laparoscopic fundoplication (2009–July 2017 *n* = 355, July 2017 to November 2021

**Table 1**  
Patient characteristics by time period

	All	Time of Surgery		P value
		Before July 2017	After July 2017	
Total patients, n	645	355	290	—
Age, mean $\pm$ SD, y	67 $\pm$ 3	66 $\pm$ 13	67 $\pm$ 13	.123
Body mass index, mean $\pm$ SD, kg/m <sup>2</sup>	29.2 $\pm$ 4.8	29.2 $\pm$ 4.9	29.1 $\pm$ 4.8	.954
Female sex, n (%)	455 (70.5)	251 (70.7)	204 (70.3)	.921
Smoking status, n (%)				.817
Never	364 (56.4)	203 (57.2)	161 (55.5)	—
Former	266 (41.2)	143 (40.3)	123 (42.4)	—
Current	15 (2.3)	9 (2.5)	6 (2.1)	—
Steroid use for chronic condition, n (%)	45 (7.0)	4 (1.1)	41 (14.1)	<.001
Ph (acid) test, n (%)	179 (27.8)	85 (23.9)	94 (32.4)	.017
BRAVO (wireless acid probe), n (%)	79 (44.1)	12 (14.1)	67 (71.3)	<.001
Positive result, n (%)	136 (83.4)	66 (83.5)	70 (83.3)	.971
Preoperative DeMeester Score, median (IQR)	31.0 (18.1–51.1)	31.2 (18.1–53.4)	30.5 (18.8–45.6)	.447
Motility, n (%)				.255
Normal	440 (68.2)	251 (70.7)	189 (65.2)	—
Abnormal	125 (19.4)	61 (17.2)	64 (22.1)	—
Unknown/no manometry	80 (12.4)	43 (12.1)	37 (12.8)	—
Esophagram, n (%)	351 (54.4)	195 (54.9)	156 (53.8)	.773
Hernia found	297 (84.6)	164 (84.1)	133 (85.3)	.766
Upper endoscopy, n (%)	510 (79.1)	285 (80.3)	225 (77.6)	.403
Esophagitis	174 (34.1)	99 (34.7)	75 (33.3)	.740
Barrett's esophagus	40 (7.8)	22 (7.7)	18 (8.0)	.907
Hiatal hernia type, n (%)				.103
No hernia	43 (6.7)	24 (6.8)	19 (6.6)	—
1	174 (27.0)	91 (25.6)	83 (28.6)	—
2	12 (1.9)	6 (1.7)	6 (2.1)	—
3	378 (58.6)	205 (57.7)	173 (59.7)	—
4	38 (5.9)	29 (8.2)	9 (3.1)	—

BRAVO, wireless esophageal acid probe test; IQR, interquartile range; SD, standard deviation.

n = 290) from January 2009 to November 2021. There were no significant differences in body mass index, smoking status, or preoperative symptoms between the 2 time periods (Table 1). Diagnostic studies included esophagram or CT scan, esophageal manometry, acid monitoring (ambulatory acid monitoring or wireless acid probe), and upper endoscopy. There were no differences in diagnostic results between both groups. PEH was present in 66% of patients, with a type 3 hernia being the most prevalent within the study population.

Nissen fundoplication was performed in over 80% of the cases in the first time period (Nissen n = 289, Toupet n = 66) Toupet fundoplication increased from 18% to over 73% in the second time period (Nissen n = 77, Toupet n = 213). There were no differences in operating time (approximately 2 hours) or intraoperative complications (bleeding from short gastric arteries, serosal injury of the fundus, capnotherax, inadvertent vagotomy). However, there was a small difference in median estimated blood loss between the 2 time periods. Biosynthetic absorbable mesh was used for hiatal hernias type 2 to 4 (Table 2). Redo operation refers to patients who had a previous PEH repair with anti-reflux surgery—8 patients were identified in this study population. The time between operations ranged from 5 months to 8 years, with a median of 14 months. The reasons for reoperation included recurrent symptomatic PEH, severe persistent acid-reflux, and slipped fundoplication.

For short-term postoperative data (Table 3), the median length of stay for the second time period was 1 day vs 2 days ( $P < .001$ ). The median days for return to activities of daily living was 4 vs 7 days ( $P = .006$ ). In addition, there was a lower 30-day complication rate in the second time period (6.9% vs 12.1%,  $P = .03$ ). There were no differences in 30-day emergency department visits or readmission rates. There was a 90.6% rate of patients being off of proton pump inhibitors by the 6-week follow-up visit. In patients who reported heartburn or regurgitation as their main symptom, 80% reported resolution by 6-week follow-up. Dysphagia, cough, and

epigastric pain resolved in about 70% of patients who reported these symptoms initially. Interestingly, the second time period reported higher resolution of heartburn and regurgitation. The 30-day mortality rate was 0.6%, which included non-surgery-related sepsis, aspiration pneumonia, and intraoperative cardiac arrest.

Objective postoperative data are shown in Table 4; radiologic recurrence within the whole cohort was 11.8% found at a median time of 34 months. In the first time period, there was a 15.5% radiologic recurrence rate up to 134 months and 7.2% in the second time period up to 49 months. Seventy patients, about 10% of the study population, had endoscopic surveillance of GERD, with increased numbers in the second time period. These patients returned at a median of 15 months after surgery, with the second time period having shorter follow-ups. Upper endoscopy with dilation was performed in 10 patients. Forty-five patients received acid monitoring tests. Abnormal acid test results were identified in 10 patients, with a median DeMeester score of 28.2. These patients were restarted on a proton pump inhibitor and continued follow-up. Lastly, a median (IQR) preoperative DeMeester Score of 31 (17–51) decreased to 5.1 (2–14) at postoperative evaluation.

#### Fundoplication has excellent long-term patient-reported outcomes

Long-term PROs for all fundoplications improved from preoperative scores and did not worsen during this study period (Figure 1). There was a decreasing amount of PROs with each further time point. For RSI and GERD-HRQL, the 3-month to 7-year postoperative surveys are all significantly different from preoperative surveys (5-year postoperative  $P < .01$ ). For gas-bloat, the 3-month to 5-year postoperative surveys are all significantly different from preoperative surveys (5-year postoperative  $P = .01$ ). For the dysphagia score, 3-week postoperative score ( $P < .01$ ) is the only significant difference from preoperative score (5-year postoperative  $P = .78$ ). The dysphagia Score increased within a short

**Table II**  
Operative data by time period

	All	Time of Surgery		P value
		Before July 2017	After July 2017	
Total patients, n	645	355	290	–
ASA class 3 or 4, n (%)	264 (40.9)	136 (38.3)	128 (44.1)	.134
Fundoplication type, n (%)				<.001
Nissen	366 (56.7)	289 (81.4)	77 (26.6)	–
Toupet	279 (43.3)	66 (18.6)	213 (73.4)	–
Operating time, mean ± SD, min	125 ± 36	124 ± 39	126 ± 33	.246
Estimated blood loss, median (IQR), mL	10 (5–25)	25 (10–50)	10 (5–20)	<.001
Redo operation, n (%)	8 (1.2)	2 (0.6)	6 (2.1)	.149
Mesh use, n (%)	383 (59.4)	209 (58.9)	174 (60.0)	.772
Intraoperative complication, n (%)	27 (4.2)	16 (4.5)	11 (3.8)	.652
Follow-up, median (IQR), months	22 (8–54)	50 (19–78)	14 (3–23)	<.001

ASA, American Society of Anesthesiologists; IQR, interquartile range; SD, standard deviation.

**Table III**  
Short-term postoperative data by time period

	All	Time of Surgery		P value
		Before July 2017	After July 2017	
Total patients, n	645	355	290	–
LOS, median (IQR), d	1 (1–2)	2 (1–2)	1 (1–2)	<.001
Pain at discharge, median (IQR), VAS	2 (0–4)	2 (0–4)	2 (0–4)	.420
Return to ADL, median (IQR), d	5 (3–7)	7 (3–7)	4 (2–7)	.006
30-d mortality, n (%)	3 (0.5)	3 (0.8)	0 (0.0)	.257
30-d complication, n (%)	63 (9.8)	43 (12.1)	20 (6.9)	.026
30-d ER visit, n (%)	96 (14.9)	61 (17.2)	35 (12.1)	.070
30-d readmission, n (%)	53 (8.2)	33 (9.3)	20 (6.9)	.270
Postoperative off PPI (n = 577), n (%)	523 (90.6)	283 (90.1)	240 (91.3)	.643
Resolution of symptoms at FU1 or FU2, n (%)				
Heartburn (n = 303)	243 (80.2)	85 (65.9)	158 (90.8)	<.001
Regurgitation (n = 271)	218 (80.4)	90 (69.2)	128 (90.8)	<.0001
Dysphagia (n = 187)	128 (68.5)	70 (68.0)	58 (69.1)	.874
Cough (n = 133)	91 (68.4)	41 (70.7)	50 (66.7)	.621
Epigastric chest pain (n = 141)	100 (70.9)	52 (66.7)	48 (76.2)	.216

ADL, activities of daily living; ED, emergency department; FU1, first follow-up, 3 weeks; FU2, second follow-up, 6 weeks; LOS, length of stay; PPI, proton pump inhibitor; VAS, visual analog scale.

**Table IV**  
Objective postoperative data by time period

	All	Time of Surgery		P value
		Before July 2017	After July 2017	
Total patients, n	645	355	290	–
Radiologic recurrence, n (%)	76 (11.8)	55 (15.5)	21 (7.2)	.001
Postoperative upper endoscopy, n (%)	70 (10.9)	10 (2.8)	60 (20.7)	<.001
Months from surgery to endoscopy, median (IQR)	15 (11–20)	45 (17–68)	15 (11–17)	.008
Esophagitis, n (%)	12 (17.1)	3 (30.0)	9 (15.0)	.359
Postop endoscopy with dilation, n (%)	10 (1.6)	4 (1.1)	6 (2.1)	.357
BRAVO (wireless acid probe), n (%)	45 (7.0)	4 (1.1)	41 (14.1)	<.001
Positive BRAVO, n (%)	10 (22.2)	1 (25.0)	9 (22.0)	.791
Highest DeMeester score, median (IQR)	5.1 (2.2–13.8)	1.5 (0.6–21.1)	5.2 (2.4–13.8)	.309
Positive DeMeester score, median (IQR)	28.2 (16.8–39.9)	39.9 (39.9–39.9)	20.3 (16.8–37.0)	.295
Negative DeMeester score, median (IQR)	4.4 (1.5–5.5)	0.7 (0.5–2.3)	4.6 (2.0–5.8)	.068

BRAVO, wireless esophageal acid probe test; IQR, interquartile range.

time period after surgery (3-week postoperative score  $P < .01$ ). This is expected because of the postoperative edema that eventually resolves with time resulting in similar scores after 3 weeks (5-year postoperative,  $P = .78$ ).

Both time periods were compared up to 2 years in Figure 2. Preoperative RSI and GERD-HRQL were similar and improved after surgery without significant difference up to 2 years. The dysphagia Score in both groups increased after surgery, as expected. Both

groups did not have a difference in dysphagia scores after 1 year. For the gas-bloat score, there was a statistically significant difference at 2 years, with the second time period reporting fewer gas-bloat symptoms ( $1.5 \pm 1.3$  vs  $1.9 \pm 1.5$ ,  $P = .04$ ). It is difficult to define a single cause for the decrease in gas-bloat and no difference dysphagia because of the increased number of Toupet fundoplications, use of impedance planimetry, and experience with the operation during the second time period.

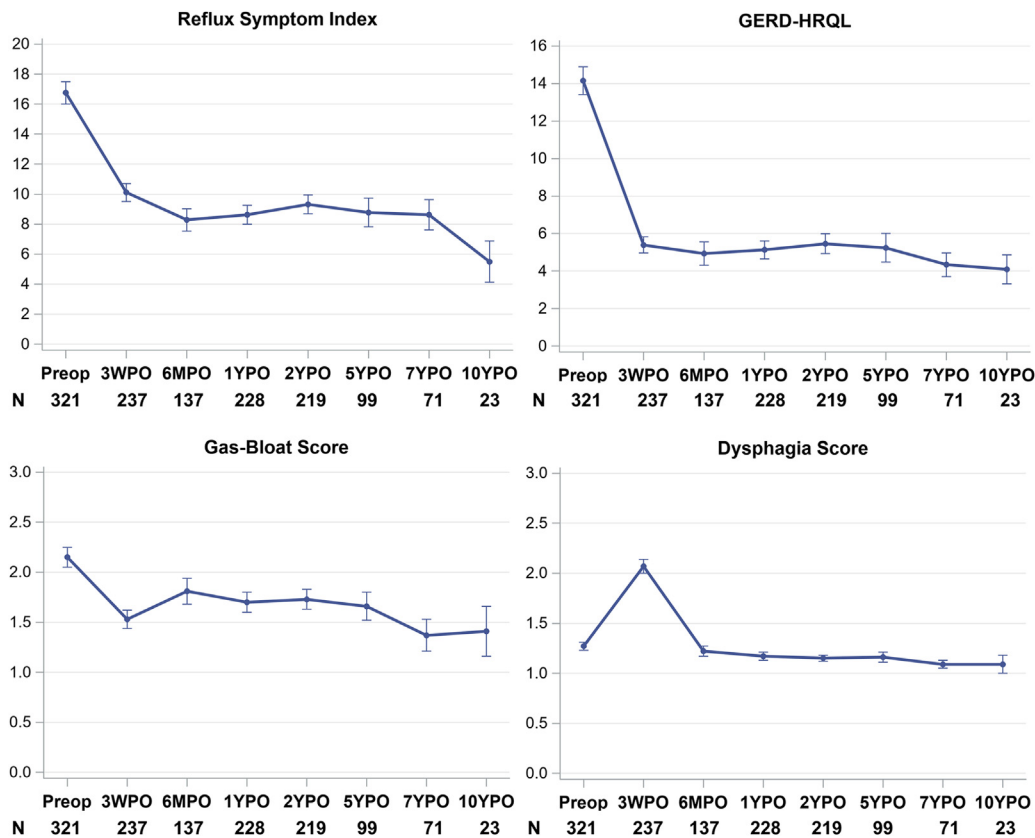


Figure 1. Patient-reported outcomes up to 10 years. MPO, months postoperative; WPO, weeks postoperative; YPO, year(s) postoperative.

### Subgroup analysis on the presence of PEH

Patients with PEH reported less severe preoperative typical and atypical GERD symptoms than patients with no PEH, GERD-HRQL ( $12.6 \pm 10.2$  vs  $17.1 \pm 11.8$ ,  $P < .01$ ), RSI ( $15.1 \pm 10.6$  vs  $19.8 \pm 10.3$ ,  $P < .01$ ), and similar dysphagia scores. Longer-term PRO scores were similar between the 2 except for worse gas-bloat in non-PEH patients at 2 years ( $2.0 \pm 1.5$  vs  $1.5 \pm 1.4$ ,  $P < .01$ ), which later resolved.

### Subgroup analysis on fundoplication type by time period

When analyzing the fundoplications within the first time period (Table 5), Toupet patients did not have any PROs that were worse than the Nissen patients and had a significantly lower RSI score at 5 years, Toupet ( $N = 15$ )  $4.1 \pm 5.9$  vs Nissen ( $N = 82$ )  $9.3 \pm 9.5$  ( $P = .022$ ). This meant that the Toupet patients reported better control of atypical GERD symptoms. Fundoplications performed in the second period had similar PROs up to 2 years (Table 6); Toupet and Nissen selected in this group improved from their preoperative baseline scores. There were no significant differences in dysphagia scores between each fundoplication in the second time period, which may be due to reasons outlined above.

## Discussion

GERD is a multifactorial disease based on an incompetent lower esophageal sphincter. An incompetent sphincter can be due to erosion of the LES from chronic pathologic reflux or the lack of extrinsic barriers that form the gastroesophageal junction because of a hiatal hernia. Patients come in for surgical evaluation because of medical refractory GERD or severe life-altering symptoms. The

definitive management of GERD is laparoscopic anti-reflux surgery. In this study, we explored the quality of life after laparoscopic fundoplication through the use of PROs.

Six hundred forty-five patients underwent laparoscopic fundoplication for GERD or symptomatic PEH. Although Toupet fundoplication was adopted during the study period, a single surgeon performed the majority of the operations, so there was consistency in practice and technique. At least 80% of patients reported preoperative symptom resolution upon initial postoperative clinic visits. Laparoscopic fundoplication is highly effective in treating GERD. There was a significant reduction in the DeMeester score for patients who returned for endoscopic surveillance at a median follow-up of 16 months. A minimal percentage of patients had issues that needed additional intervention after surgery. The authors understand that these results may not be a complete representation of the study cohort since routine surveillance of patients after anti-reflux surgery presents significant challenges, such as patients lost to follow-up, switching of medical providers, and approval by medical insurance for GERD surveillance.

Eight patients in this analysis were found to have a redo operation, which was a laparoscopic fundoplication with or without a PEH repair. This does not reflect the reoperation rate at any time point; however, it is a description of the patients who had a redo operation within the selected cohort. The selection of patients in this study did not include all patients who had redo or revisional surgery. The small number of patients who had a redo operation in this review would make it difficult to yield any meaningful analysis. The radiologic recurrence rate was found to be 11.8% found at a median time of 34 months. The number of patients who were symptomatic from recurrence and required a revisional operation are to be updated.

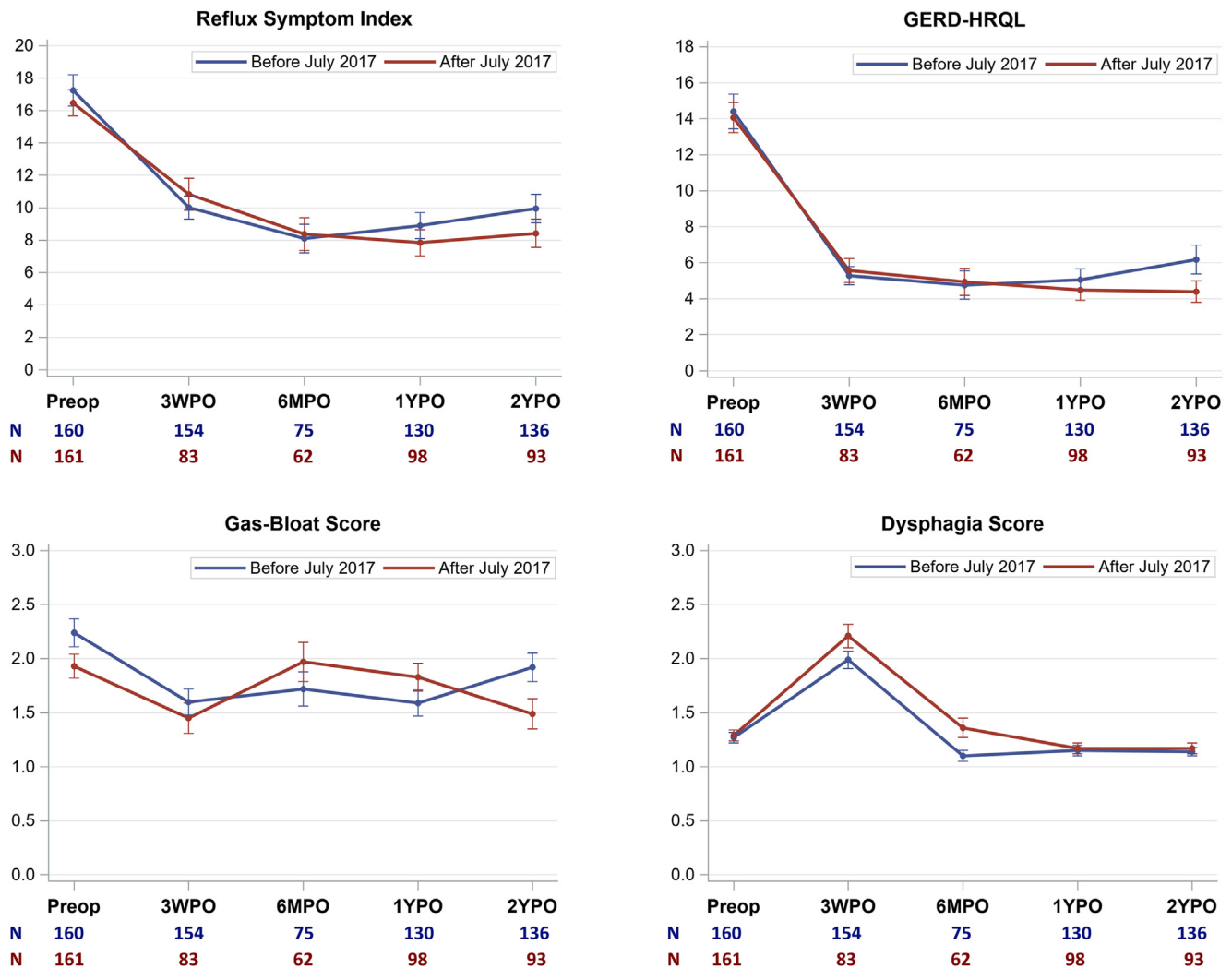


Figure 2. Patient-reported outcomes by time period. MPO, months postoperative; WPO, weeks postoperative; YPO, year(s) postoperative.

PROs allow patients the opportunity to define and document symptoms that are bothering them. It remains an important tool to characterize good and poor post-anti-reflux surgery outcomes from preoperative baseline within our patients. The authors acknowledge that questionnaires may be completed at a higher rate in symptomatic patients and patients with access to electronic mail. Difficulties to questionnaire completion may include patients lost to follow-up, access to a language interpreter, health system change, or deferment from contact. At this point, patients may receive a series of phone calls for final follow-up. The responses are recorded in a prospectively maintained quality database, which continues to be improved with scheduled alerts to review patients reaching long-term follow-up time points.

The laparoscopic fundoplication affected patients' lives by alleviating symptomatic GERD, which is reflected in improved quality-of-life questionnaire scores. The improvement of scores persisted long-term. Collecting outcomes data at longer-term time points continues to be an obstacle, as shown in our graphical representation of the PROs. This study showed that RSI and GERD-HRQL had improvements that continue to be significant from preoperative baseline at 7 years for all funduplications performed. The study cohort was separated into 2 time periods to define a transition in the surgical practice in the group. The adoption of impedance planimetry to tailor surgical management and propensity for Toupet fundoplication are shown in the presented data. In order to

assess the efficacy of these changes, the 2 time periods were analyzed, revealing a decrease in gas-bloat score along with no difference in dysphagia. In the second time period, dysphagia scores were similar in Nissen and Toupet patients, even though it is expected that Nissen would have higher rates of dysphagia short term. The authors' reason that impedance planimetry may have an effect on post-fundoplication dysphagia, which was explored in previous work.<sup>16</sup> The utility of impedance planimetry will continue to be refined and perhaps predict outcomes in specific patient populations. For instance, performing a PEH repair with a gastropexy and without a fundoplication in patients aged greater than 70 years since there would be an objective range of crural tightness with or without mesh for optimal outcomes.

A significant number of patients had PEH in this study. These patients had notably lower scores in GERD-HRQL (along with a decreased gas-bloat score) and RSI at varying shorter-term time points after surgery than patients who did not have PEH. This may be because of the initial lower preoperative scores in PEH patients since they may not present with the same symptoms as GERD patients without PEH. These differences in scores became insignificant after 5 years.

Limitations of our study include it being a non-randomized retrospective review of a single institution. PROs are subjective, and not all patients complete each questionnaire at their designated time points, leading to a lower number of patients for analysis. It is difficult to find specific post-fundoplication or GERD-

**Table V**  
Quality of life by fundoplication type before July 2017

	Fundoplication Type		P value
	Nissen	Toupet	
	Mean ± SD	Mean ± SD	
1 y	n = 101	n = 30	
RSI	9.3 ± 9.6	7.5 ± 7.1	.622
GERD-HRQL	5.2 ± 7.3	4.4 ± 5.3	.725
Gas-bloat	1.6 ± 1.4	1.6 ± 1.5	.740
Dysphagia score	1.1 ± 0.4	1.2 ± 0.7	.517
2 y	N = 107	N = 21	
RSI	10.1 ± 10.0	9.4 ± 9.6	.972
GERD-HRQL	6.0 ± 9.0	6.9 ± 8.8	.805
Gas-bloat	1.9 ± 1.5	1.8 ± 1.6	.776
Dysphagia score	1.1 ± 0.4	1.2 ± 0.7	.491
5 y	N = 82	N = 15	
RSI	9.3 ± 9.5	4.1 ± 5.9	.022
GERD-HRQL	5.4 ± 7.5	3.3 ± 3.6	.537
Gas-bloat	1.6 ± 1.4	1.8 ± 1.3	.640
Dysphagia score	1.2 ± 0.6	1.1 ± 0.3	.525
7 y	N = 59	N = 13	
RSI	9.1 ± 8.7	6.3 ± 6.2	.356
GERD-HRQL	4.1 ± 5.2	5.3 ± 5.7	.729
Gas-bloat	1.4 ± 1.3	1.3 ± 1.6	.775
Dysphagia score	1.1 ± 0.4	1.1 ± 0.3	.752

GERD-HRQL, Gastroesophageal Reflux Disease–Health Related Quality of Life Questionnaire; RSI, Reflux Symptom Index; SD, standard deviation.

**Table VI**  
Quality of life by fundoplication type after July 2017

	Fundoplication Type		P value
	Nissen	Toupet	
	Mean ± SD	Mean ± SD	
Preoperative	N = 35	N = 126	
RSI	16.6 ± 10.3	16.4 ± 10.3	.965
GERD-HRQL	14.7 ± 12.1	13.9 ± 9.8	.990
Gas-bloat	2.1 ± 1.6	1.9 ± 1.4	.566
Dysphagia score	1.3 ± 0.6	1.3 ± 0.7	.969
1 y	n = 17	n = 81	
RSI	6.9 ± 5.3	8.0 ± 8.4	.857
GERD-HRQL	6.0 ± 6.9	4.2 ± 5.5	.255
Gas-bloat	1.8 ± 1.1	1.8 ± 1.3	.942
Dysphagia score	1.2 ± 0.4	1.2 ± 0.5	.557
2 y	N = 34	N = 59	
RSI	10.2 ± 10.6	7.4 ± 6.6	.583
GERD-HRQL	5.5 ± 7.0	3.7 ± 4.5	.373
Gas-bloat	1.7 ± 1.5	1.4 ± 1.2	.492
Dysphagia score	1.2 ± 0.5	1.2 ± 0.5	.442

GERD-HRQL, Gastroesophageal Reflux Disease–Health Related Quality of Life Questionnaire; RSI, Reflux Symptom Index; SD, standard deviation.

specific validated measures for dysphagia. Our dysphagia score can be answered with ease in a timely manner with patients; however, it is not a validated questionnaire. We chose to display the gas-bloat score, which is extracted from the GERD-HRQL questionnaire, because it can be a significant side effect after anti-reflux surgery. The authors understand that the gas-bloat score is a single item on a validated questionnaire, so it does not carry the same level of validation, so there may be unmeasured potential for error and bias. In addition, there is a lack of objective outcomes, such as post-operative acid monitoring and endoscopy, for the reasons previously stated. However, after 1 year, all patients are asked to return for GERD surveillance. Research fellows continue to contact patients for the completion of surveys and follow-ups.

Nissen fundoplication was performed in most patients in this study unless the patient demonstrated severe esophageal motility

issues. Some patients received a Nissen fundoplication when the manometry report stated mild esophageal motility issues. Several patients did not have a manometry study before their operation. Some manometry results were unattainable through chart review. So, it was at the operating surgeon's discretion to proceed with surgery and aimed to perform a loose Nissen fundoplication. Therefore, there was variability in surgical decision-making within different periods. However, a single surgeon did perform the majority of the operations in this study. The surgical practice transformed when adopting Toupet fundoplication and impedance planimetry. From 2017 on, a Nissen fundoplication was performed only after careful selection. A portion of patients from 2017 was analyzed in our previous impedance planimetry work.<sup>16</sup> Some form of bougie was used during surgery when creating a Nissen or Toupet fundoplication. Therefore, our surgical practice and technique may decrease the generalizability of this study.

In conclusion, this single-institution study reports excellent PROs after laparoscopic fundoplication that persist up to 10 years. The Nissen fundoplication is highly effective in the surgical management of GERD, while the Toupet fundoplication is proving to be just as efficacious. It is important to prospectively follow patients with appropriate measures to assess if innovations benefit patients in the long run.

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#### Conflict of interest/Disclosure

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## Discussion



### Invited Discussant: Anne Lidor

**Dr Anne Lidor** (University of Wisconsin): This is a topic that's really of great interest to all foregut surgeons, and it's a really large number of patients with a very impressive long-term follow-up, so I commend the authors on collecting and analyzing these data. It's important and of real value for surgeons who are offering antireflux surgery to patients because often they are inquiring about long-term durability of the repair.

In your manuscript, you mentioned that all patients who had a paraesophageal hernia received a mesh placement. I know you didn't mention that in your presentation, but I was wondering what's the justification for the routine use of mesh for PEH repairs since there's data that shows that it probably does not reduce long-term recurrence rate?

**Dr Hoover Wu** (NorthShore University Health System): I agree that in terms of the surgeons in their group, they accept the short-term effects of utilizing the mesh for paraesophageal hernia repairs and how that reduces recurrence in, I would say, the short-term. In terms of lowering long-term recurrence rates, I believe you pointed out the evidence that said that it doesn't necessarily reduce recurrence rates. We don't disagree with that, but I believe right now, for the surgical group, they believe in utilizing the mesh for paraesophageal hernia repairs, and I think, specifically for how they utilize or incorporate the mesh into the repair, they believe that that will help the patient in the long run. I think it is for us to see how that would affect patients given the surgical technique that we've been using for these patients and see how they are affected long-term, so that's something that I will continue to discuss with our surgeons.

**Dr Anne Lidor**: How did you account for any patients who had recurrent hernias or slipped wraps or needed any sort of revisional surgery in the long-term follow-up for the patient-reported outcomes? Were they excluded or were they all just lumped together? I think it would be more helpful to look at overall patient-reported outcomes and maybe a subgroup analysis for the patients who needed some sort of revision.

**Dr Hoover Wu**: Initially, when we did the data analysis, we lumped them all together. I will go back into the data and actually look at the specific patients who had revisional surgery.

**Dr Anne Lidor**: Finally, I thought it was really fascinating that the long-term dysphagia scores were similar between the Nissen and the Toupet groups because basically, every other study that has looked at this has shown that, at least in the short-term, that Toupets have less dysphagia. I'm wondering if you have any explanation for this.

**Dr Hoover Wu**: Toupet has been shown to have decreased dysphagia rates short term. In terms of the long-term outcomes here, I would speculate that Toupet fundoplication and Nissen fundoplication over time may loosen, and that may or may not bring them into similar dysphagia scores. In order for us to really get an answer for that, it will be up to our research team to really

follow up with each and every patient to see the effects of both of those operations long-term.

**Dr Michael Brunt** (Washington University School of Medicine in St. Louis): It looked to me like you combined the type 1 hernias and the type 2, 3, 4, and I think those, oftentimes, are somewhat different populations even though, yes, they can have heartburn or regurgitation. They have a lot of other symptoms, a lot of other things going on. It can be a little difficult to sort that out, and, in my own practice, I've just shifted to doing more partial wraps, Toupets, in the paraesophageal population. They're most often older women. Regardless of the motility, they often don't tolerate the full wrap as well, and it's just easier for them to swallow. My question to you is, did you look at the data for the type 1 standard reflux versus the paraesophageal hernias to see if there were any differences between the types of wraps in those populations?

**Dr Hoover Wu**: I haven't separated those two 2 to take a look at those patients and their outcomes, but I think that's something I can definitely do for this current project as well.

**Dr Kevin El-Hayek** (The MetroHealth System Cleveland Ohio): There has been a shift toward, in these same type 3, type 4 paras where you can't really get a good preoperative assessment of their esophageal motility to use EndoFLIP intraoperatively to assess at least their sphincter tone, which you can do after the hiatal dissection and then after closure. Your algorithm talked a little bit about the distensibility index (DI) over 7, less than 7, but I think even in your own work, you use DI of 2 as a marker for adequate antireflux mechanism, and some of these patients who you see a DI at the 2 margins right after you're doing your hiatal closure, are these patients that we could potentially forego a wrap on altogether? I think that's the question as we try to do less and less for these patients that are older; they struggle sometimes with even Toupets. Is that something that your group is starting to look at as well when you start to see that DI at about 2 after hiatal closure, after mesh, and maybe just doing an anterior gastropexy and calling it a day?

**Dr Hoover Wu**: That's a great point. With the different types of hernias that come, sometimes we see that the hiatal hernia is pretty significant, 6 cm, but sometimes we put in the EndoFLIP, and their DI happens to be 2 or 3. You know, at that point, we haven't necessarily reached that point where we would not do a fundoplication yet, but I think that's something that we can explore in the future.

**Dr Kevin El-Hayek**: I think what your group has also shown is that the largest drop is after the hiatal closure, so you see the drop after the hiatal closure. We're starting to learn that it's the diaphragmatic closure that's contributing to a significant portion of the antireflux mechanism, so I do think that's the logical next step as we try to become more and more minimally invasive with this.