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Trends in laparoscopic anti-reflux surgery: a Korea nationwide study

Min Seo Kim[1] · Youjin Oh[1] · Jun-Hyun Lee[2] · Joong-Min Park[3] · Jin-Jo Kim[2] · Kyo Young Song[2] · Seung Wan Ryu[5] · Kyung Won Seo[6] · Hyoung-Il Kim[7] · Dong Jin Kim[2] · Sungsoo Park[8] · Sang-Uk Han[4] · Korean Anti-reflux Surgery Study (KARS) group

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Abstract

Background In 2014, the results derived from the nationwide data of the Korean Anti-reflux Surgery Study (KARS) demonstrated short-term feasibility and safety of anti-reflux surgery. This study aimed to update the longer-term safety and feasibility of laparoscopic anti-reflux surgery up to 1-year follow-up with the KARS nationwide cohort.

Methods The data of 310 patients with GERD who received anti-reflux surgery up to 2018 were analyzed. Baseline patient characteristics, postoperative symptom resolution, and postoperative complications were evaluated at postoperative 3 months and 1 year using the questionnaire designed by KARS. We divided the patients into two groups according to the operation period (up to and after 2014) to identify changes in the trends of the characteristics of surgical patients and operative qualities.

Results The typical preoperative symptoms were present in 275 patients (91.7%), and atypical symptoms were present in 208 patients (71.0%). Ninety-seven (35.5%) and 124 patients (46.1%) had inadequate PPI responses and hiatal hernia, respectively. At postoperative 1 year, typical and atypical symptoms were either completely or partially controlled in 90.3% and 73.5.0% of patients, respectively. Moderate-to-severe dysphagia, inability to belch, gas bloating, and flatulence at postoperative 1 year were identified in 23.5%, 29.4%, 23.2%, and 22.0% of patients, respectively. The number of surgical patients continuously increased from 2011 to 2018 in Korea. The proportion of patients with hiatal hernia and comorbidities increased ($p < 0.01$, $p = 0.053$), and the operation time decreased significantly ($p < 0.01$) in the late period (2015–2018) as compared with the early period (2011–2014). Symptom control and complication rate were equivalent between the two periods.

Conclusions Anti-reflux surgery was effective with > 90% of typical symptom resolution and posed a comparable postoperative complication rate with those in Western studies with mid-term to long-term follow-up. This result supports the feasibility and safety of anti-reflux surgery as a treatment for GERD in the Korean population.

Keywords Laparoscopic fundoplication · Gastroesophageal reflux disease · Trend · Nissen fundoplication · Dysphagia · Complications

Introduction

Gastroesophageal reflux disease (GERD) is one of the most common diseases of the gastrointestinal tract, which distracts one's daily life and reduces the quality of life substantially. Although the incidence of GERD in the Eastern Asian population was reported to be lower than that in the Western population, it was as high as 15.7% [1] and continues to increase [2]. Chronic and severe GERD can increase the risk of esophageal adenocarcinoma, and this further makes GERD not neglectable [3, 4].

Currently, the primary treatment for GERD is medical therapy with a proton pump inhibitor (PPI), which is well tolerated and safe. However, a relative portion of patients

Min Seo Kim and Youjin Oh have contributed equally to this work.

Sungsoo Park and Sang-Uk Han have contributed equally to this work.

✉ Sungsoo Park
kugspss@korea.ac.kr

✉ Sang-Uk Han
hansu@ajou.ac.kr

Extended author information available on the last page of the article

refractory to PPI [5] and the non-curative nature of PPI urged clinicians to find alternative and curative treatment modalities. Furthermore, repetitive relapse of symptoms while not taking PPI compels patients to seek long-term control of GERD. From this point, laparoscopic Nissen fundoplication (LNF) emerged as a potential treatment in Western countries. According to the literature, LNF was cost-effective in the long term [6, 7], and demonstrated similar or better efficacy as compared with long-term use of PPI with up to 87% of postoperative satisfaction [8–10]. Despite the wealth of information regarding the efficacy and safety of LNF, most studies come from Western communities that reached technical maturity, and limited evidence supports the effectiveness of LNF in the Eastern countries currently undergoing the learning curve for LNF.

To address the aforementioned issues, the Korean Anti-reflux Surgery Study (KARS) Group was organized in 2010 and collected nationwide data from 2011 to 2018. This study aimed to evaluate the safety and feasibility of laparoscopic anti-reflux surgery in Korea by using up-to-date KARS nationwide data.

Materials and methods

The validated questionnaires introduced by the KARS Group were used to collect the patients' clinical history and severity of subjective symptoms before, 3 months after, and 1 year after the operation. This data survey was performed among the surgical patients of eight surgeons. The data of 310 primary anti-reflux surgeries were collected and analyzed, including the patients' characteristics, surgical procedures, surgical outcomes, postoperative complications, and postoperative adverse symptoms. The response to PPI was graded into five groups as "none," "poor," "fair," "good," and "excellent." Patients with "none" or "poor" responses were included in the group of PPI poor responders. Comorbidities were documented as whether the patients were having single or multiple diseases among cardiopulmonary, pulmonary, renal, hepatic disease, and diabetes mellitus.

GERD was diagnosed on the basis of symptoms and endoscopy, barium esophagography, esophageal manometry, and 24-h pH monitoring findings. Typical and atypical GERD symptoms were explained to the patients by physicians or educated nurses, and the patients were asked to report any symptoms they had, including the frequency and severity. Typical and atypical symptoms were recorded separately. GERD symptom resolution after surgery was assessed as poor, fair, good, or excellent for typical and atypical symptoms. As we defined and applied in the previous study [11], symptoms in this study were defined as "excellent" and "good," indicating complete symptom control; "fair" indicating partial symptom control; "poor" indicating treatment failure. In addition, the use of medication related to gastrointestinal symptoms was investigated. The types of medication were prokinetic drugs, antacids, histamine 2 receptor antagonists, and PPI.

The frequency and severity of adverse symptoms after anti-reflux surgery, including dysphagia, inability to belch, gas bloating, and flatulence, were assessed using a 5-point scale (no symptom, mild, moderate, severe, very severe) in the KRAS validated questionnaire at 3 months and 1 year after surgery.

Moreover, we divided the whole study period into two periods, the early period from 2011 to 2014 and the late period from 2015 to 2018. The patient characteristics and surgical outcomes of these periods were compared for trend analysis.

The primary objective of this study was to evaluate the efficacy and safety of anti-reflux surgery in South Korea. The differences of the symptoms evaluated using the questionnaire at each follow-up time (at discharge, after 3 months, and 1 year after surgery) were analyzed using the Pearson chi-square test and Fisher exact test in both groups of PPI responder and non-responder.

To analyze the trends of the overall rates of surgery, Sen's slope test and the Buishand *U* test were performed for analyzing linear trends and change points, respectively. In addition, we compared the operative and treatment-related parameters between the early and late periods to understand the changes in the surgical environment and efficacy. For most of the parameters, the Pearson chi-square test, Fisher exact test, and Welch two-sample *t*-test were performed in accordance with the characteristics of the parameters.

All statistical analyses were conducted using R software version 3.5.2. The R Statistics Program (R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.) was used for performing the Buishand *U* test and Sen slope test, *t*-test, Pearson chi-square test, Welch two-sample *t*-test, and Fisher exact test. For the continuous variables, an *F* test was performed to compare variances before considering normal distributions. A two-tailed p-value of < 0.05 indicated statistical significance.

Results

Characteristics of the patients and procedures

A total of 316 patients underwent primary laparoscopic fundoplication for the treatment of GERD by eight Korean surgeons from January 2011 to 2018. The mean age was

49.3 years (range 16–88 years), and the mean body mass index (BMI) was 23.0 kg/m^2 (range 15.3–32.5 kg/m^2). Of all patients, 67.5% were less than 60 years old, and only 2.6% had a BMI above 30 kg/m^2. Calculated based on the record on GERD symptom control, the response rates were 77% and 56% at the time of discharge and 3 months after the operation, respectively.

According to the linear trend analysis, the overall rates of the procedures increased from 2011 to 2018 in a linear trend ($p = 0.024$). A significant increase in procedure rates was observed between 2016 and 2017, according to the change point analysis ($p = 0.016$; Fig. 1). After the operation, typical symptoms (heartburn, regurgitation, and epigastric pain) were present in 275 patients (91.7%), and atypical symptoms were present in 208 patients (71.0%). Both typical and atypical symptoms were present in 191 patients (66.3%). The median duration of the GERD symptoms was 48 months (range, 0–120 months). The median duration of PPI use was 12 months (range, 5–48 months). Ninety-seven patients (35.5%) had a history of poor response to PPI therapy (Table 1).

All surgical procedures were performed laparoscopically, with no open conversions. Most surgeries were laparoscopic Nissen fundoplication, and Toupet and Dor fundoplications were performed in 6 and 13 patients, respectively. The crural repair was performed by manual suturing with a non-absorbable suture material in 184 cases, and prosthetic repair was performed in 73 patients with giant hiatal hernias. The mean surgical time was 103.9 ± 36.8 min, and the mean postoperative hospital stay was 4.0 ± 3.0 days (Table 2).

Postoperative symptom control and complications

At the point of discharge, typical and atypical symptoms were controlled either completely or partially in 95.6% and 91.0% of the patients, respectively. For typical symptoms, > 90% of the patients responded to the surgery by 1 year. However, the atypical symptom was not controlled

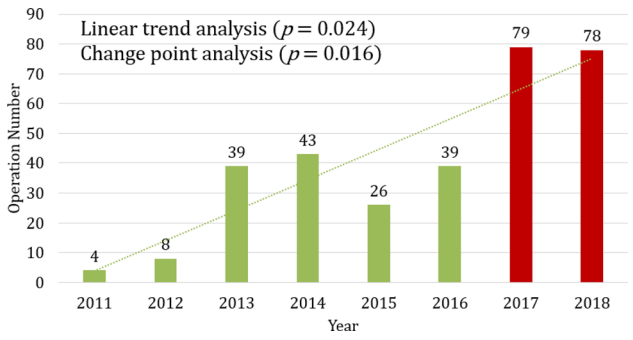

Fig. 1 Annual number of anti-reflux surgery procedures performed in South Korea, based on the nationwide data collected from 2011 to 2018

Table 1 Patients' demographic and baseline characteristics

Characteristics	Values
Age, years ($n = 316$)	49.3 ± 18.0
Male/female ($n = 316$)	174 (55.1)/142 (44.9)
Body mass index ($n = 306$)	23.0 ± 3.5
History of GERD symptoms, years ($n = 290$)	4 (1.5–10)*
1 <	42 (14.5)
1–5	109 (37.6)
> 5	139 (47.9)
Duration of PPI treatment, months ($n = 280$)	12 (5–48)*
< 6	73 (26.1)
6–12	39 (13.9)
> 12	168 (60.0)
PPI response ($n = 273$)	
None or poor	97 (35.5)
Fair	95 (34.8)
Good to excellent	81 (29.7)
GERD symptom	
Typical symptom (n = 300)	275 (91.7)
Atypical symptom (n = 293)	208 (71.0)
Mixed symptom ($n = 288$)	191 (66.3)
Los Angeles grade of esophagitis ($n = 258$)	
Minimal or no esophagitis	137 (53.1)
A	86 (33.3)
B	22 (8.5)
C	11 (4.3)
D	2 (0.8)
Hiatal hernia ($n = 269$)	
No hiatal hernia	145 (53.9)
Type 1	115 (42.8)
Type 2	2 (0.7)
Type 3	7 (2.6)
Complication on endoscopy ($n = 247$)	
None	228 (92.3)
Barrett esophagus	13 (5.3)
Ulcer	5 (2.0)
Stricture	1 (0.4)
pH monitoring study ($n = 125$)	
DeMeester score	23.5 ± 47.4 (2.2–29.3)
Pathologic acid reflux (DeMeester score > 14.7)	50 (40)
Esophageal manometry (n = 152)	
LES pressure (mmHg)	22.4 ± 13.5 (13.4–30.0)

Values were presented as mean ± SD (range) or number (%)

GERD Gastroesophageal reflux disease

*Values are presented as median (interquartile range)

in > 10% of the patients at 3 months and 1 year after operation (Table 3).

Until 3 months after the surgery, the typical GERD symptoms were controlled similarly in both the PPI responders

and non-responders, with completely or partially controlled rates of 93.6% and 87.2%, respectively. Regarding the atypical GERD symptoms, the symptoms were controlled better in the PPI responders, with marginal statistical significance. While > 90% of the PPI responders reported that their atypical symptoms were managed, only 78% of the non-responders reported controlled symptoms. However, typical and atypical symptoms were controlled at similar rates irrespective of PPI response after one year of surgery (Table 4).

The resolution of the typical individual symptoms was analyzed (Table 5). Among the patients with heartburn, 119 (95.8%) and 25 patients (99.3%) showed complete or partial control of their typical symptoms 3 months and 1 year after surgery, respectively. For the patients who had regurgitation, typical symptoms were controlled similarly 3 months and 1 year after surgery in 93 (93.0%) and 13 patients (92.9%), respectively. Similarly, in > 90% of the patients with epigastric pain, the typical symptom control rates remained stable up to 1 year after surgery.

After an operation, four complications occurred and were investigated. We regarded complications to have occurred when the patients reported moderate, severe, or very severe grade (Table 6). Dysphagia and inability to belch developed in 10.5% and 7.1% of the patients after 3 months of surgery, respectively. About one-fifth of the patients reported gas bloating and flatulence. However, the incidence rates of all complications increased at 1 year after the operation as compared with 3 months after operation; however, the complication rates for all types of adverse events remained to be < 30%.

Regarding the use of medication, 32 (18.3%) of 174 patients and 10 (17.5%) of 57 patients took PPI at 3 months and 1 year after surgery, indicating that symptoms were not controlled or were controlled incompletely after anti-reflux surgery in some patients.

Comparison between the early and late periods

Compared with the early period, more patients with hiatal hernia and without reflux esophagitis underwent surgery in the late period ($p < 0.01$ and $p < 0.05$, respectively; Table 7). The operation time decreased significantly from 113.3 min to 99.4 min ($p < 0.01$), with no significant differences in typical and atypical symptom control rates after 3 months of surgery. Similarly, the postoperative complication rates were comparable (Table 7).

Discussion

Pooled analysis of Korea nationwide data from 2011 to 2018 revealed that LNF demonstrated a tolerable efficacy of 90.3% for typical symptom resolution at a 1-year follow-up. The complication rates of common postoperative adverse events, including dysphagia, inability to belch, gas bloating, and flatulence, after LNF were also not inferior to those in Western trials. This study supports the favorable efficacy and safety profile of LNF in Korea and

Table 2 Operative procedures

Characteristics	Values
Type of fundoplication ($n = 309$)	
Nissen	290 (93.9)
Dor (anterior partial)	13 (4.2)
Toupet (posterior partial)	6 (1.9)
Crural repair ($n = 293$)	
Natural repair[a]	184 (62.8)
Prosthetic repair	73 (24.9)
Others	4 (1.4)
Not done	32 (10.9)
Operation time (min) ($n = 308$)	103.66 ± 36.6
Open conversion ($n = 316$)	0
Liquid diet start (postoperative days) ($n = 270$)	1.3 ± 0.7
Soft diet start (postoperative days) ($n = 279$)	2.1 ± 1.1
Postoperative hospital stay (days) ($n = 280$)	4.0 ± 3.0

Values are presented as mean ± SD (range) or number (%)

[a]Natural repair included repair primarily with sutures with or without the use of mesh made of non-prosthetic or biodegradable materials

Table 3 Postoperative symptom control

Response	Typical symptom			Atypical symptom		
	Discharge $n = 273$	PO 3 m $n = 195$	PO 1 yr $n = 41$	Discharge $n = 212$	PO 3 m $n = 156$	PO 1 yr $n = 34$
Complete	233 (85.3)	157 (80.5)	33 (80.6)	166 (78.3)	115 (73.7)	25 (73.5)
Partial	28 (10.3)	22 (11.3)	4 (9.7)	27 (12.7)	20 (12.8)	0 (0)
Not controlled	12 (4.4)	16 (8.2)	4 (9.7)	19 (9.0)	21 (13.5)	9 (26.5)

Data are presented as number (%)

GERD, gastroesophageal reflux disease; PO 3 m, postoperative three months; PO 1 yr, postoperative one year

Table 4 Postoperative symptom control for PPI responders and non-responders

Response	Typical symptom			Atypical symptom		
Response to PPI	*R*	NR	*p*-value[a]	*R*	NR	*p*-value[a]
PO 3 m	*n* = 126	*n* = 54		*n* = 98	*n* = 50	
Complete	105 (83.3)	40 (74.0)	0.21	76 (77.6)	33 (66.0)	0.04
Partial	13 (10.3)	7 (13.0)		13 (13.3)	6 (12.0)	
Not controlled	8 (6.4)	7 (13.0)		9 (9.1)	11 (22.0)	
Response	Typical symptom			Atypical symptom		
Response to PPI	*R*	NR	*p*-value[a]	*R*	NR	*p*-value[a]
PO 1 yr	n = 23	n = 17		n = 20	n = 13	
Complete	19 (82.6)	13 (76.4)	1[b]	15 (75.0)	9 (69.2)	1[b]
Partial	2 (8.7)	2 (11.8)		0 (0)	0 (0)	
Not controlled	2 (8.7)	2 (11.8)		5 (25.0)	4 (30.8)	

Data are presented as number (%)

R Responder, *NR* non-responder, *PO 3 m* postoperative three months, *PO 1 yr* postoperative one year

[a]Pearson chi-square test

[b]A Fisher's exact test was performed between the PPI responders and non-responders

Table 5 Postoperative symptom control of specific typical symptoms

Typical symptom	Heartburn		Regurgitation		Epigastric pain	
	PO 3 m	PO 1 yr	PO 3 m	PO 1 yr	PO 3 m	PO 1 yr
	n = 131	*n* = 28	*n* = 100	*n* = 14	*n* = 65	*n* = 10
Complete	106 (80.9)	22 (78.6)	83 (83.0)	12 (85.8)	50 (76.9)	9 (90)
Partial	13 (9.9)	3 (10.7)	10 (10.0)	1 (7.1)	10 (15.4)	1 (10)
Not controlled	12 (9.2)	3 (10.7)	7 (7.0)	1 (7.1)	5 (7.7)	0 (0)

Data were presented as number (%)

PO 3 m Postoperative three months, *PO 1 yr* postoperative one year

Table 6 Postoperative complications

	Dysphagia		Inability to belch		Gas bloating		Flatulence	
	PO 3 m *n* = 209	PO 1 yr *n* = 51	PO 3 m *n* = 209	PO 1 yr *n* = 51	PO 3 m *n* = 209	PO 1 yr *n* = 56	PO 3 m *n* = 209	PO 1 yr *n* = 50
None to mild	187 (89.5)	39 (76.5)	194 (92.9)	36 (70.6)	166 (79.5)	43 (76.8)	162 (77.1)	39 (78.0)
Moderate to severe	22 (10.5)	12 (23.5)	15 (7.1)	15 (29.4)	43 (20.5)	13 (23.2)	47 (22.9)	11 (22.0)

Data are presented as number (%)

PO 3 m Postoperative three months, *PO 1 yr* postoperative one year

implies that the learning curve has been overcome after LNF was first introduced to tertiary referral hospitals in Korea in 2009.

Korean practitioners were particularly cautious about the unfavorable prognosis after LNF owing to their insufficient experience and knowledge of the procedure, as it was introduced only lately and had not been implanted robustly in the Korean clinical ground until 2010. Owing to the initial learning phase for LNF, adherence to PPI remains the mainstay GERD treatment, and the need to establish the efficacy and safety profiles of LNF in the Korean population has emerged. Thereby, the KARS Group collected nationwide

Table 7 Comparison of patient characteristics and surgical outcomes for early and late period

	2011–2014 *n* (%)	2015–2018 *n* (%)	*p*-value*
Age (mean [sd])	51.9 (18.0)	48.2 (17.9)	0.102
BMI (mean [sd])	23.0 (3.38)	23.0 (3.50)	0.872
Comorbidity	*n* = 89	*n* = 205	0.053
No	71 (79.8)	141 (68.8)	
Yes	18 (20.2)	64 (31.2)	
Hiatal hernia	*n* = 86	*n* = 183	0.004
No hiatal hernia	54 (62.8)	91 (49.7)	
Type I sliding hernia	26 (30.2)	89 (48.6)	
Type II paraesophageal hernia	1 (1.2)	1 (0.6)	
Type I + II giant hiatal hernia	5 (5.8)	2 (1.1)	
Reflux esophagitis[c]	*n* = 87	*n* = 171	0.041
None to mild	42 (48.3)	95 (55.5)	
Grade A	26 (29.9)	60 (35.1)	
Grade B	12 (13.8)	10 (5.9)	
Grade C	5 (5.7)	6 (3.5)	
Grade D	2 (2.3)	0 (0)	
PPI response	*n* = 86	*n* = 192	0.300[a]
None to poor	25 (29.1)	77 (39.5)	
Fair	34 (39.5)	61 (32.6)	
Good excellent	27 (31.4)	54 (28.9)	
Type of fundoplication	*n* = 94	*n* = 215	1
Anterior	4 (4.3)	9 (4.2)	
Posterior	2 (2.1)	4 (1.8)	
Total	88 (93.6)	202 (94.0)	
Operation time (min) (mean [SD])	113.3 (42.0)	99.4 (33.4)	0.005[b]
Length of hospital stay (days) (mean [SD])	4.1 (3.9)	3.9 (2.8)	0.467[b]
Symptom control at discharge			
Typical symptom control	*n* = 86	*n* = 187	0.05
Completely	80 (93.0)	153 (81.8)	
Partial	5 (5.8)	23 (12.3)	
No	1 (1.2)	11 (5.9)	
Atypical	*n* = 54	*n* = 158	0.720
Complete	44 (81.5)	122 (77.2)	
Partial	5 (9.3)	22 (13.9)	
No	5 (9.3)	14 (8.9)	
Symptom control after three months			
Typical symptom	*n* = 60	*n* = 135	0.621
Completely	49 (81.7)	108 (80.0)	
Partial	5 (8.3)	17 (12.6)	
No	6 (10.0)	10 (7.4)	
Atypical	*n* = 40	*n* = 116	0.833
Complete	30 (75.0)	85 (73.3)	
Partial	4 (10.0)	16 (13.8)	
No	6 (15.0)	15 (12.9)	
Complication after 3 months	*n* = 66	*n* = 143	
Dysphagia			1
None to moderate	63 (95.5)	136 (95.1)	
Severe to extremely severe	3 (4.5)	7 (4.9)	
Flatulence			0.797
None to moderate	61 (92.4)	130 (90.9)	

Table 7 (continued)

	2011–2014 *n* (%)	2015–2018 *n* (%)	*p*-value*
Severe to extremely severe	5 (7.6)	13 (9.1)	
Inability to belch			0.060
None to moderate	66 (100)	134 (93.7)	
Severe to extremely severe	0 (0)	9 (6.3)	
Gas bloating*			0.235
No	64 (97.0)	132 (92.3)	
Severe to extremely severe	2 (3.0)	11 (7.7)	

*For all the values without the specific mark, the Fisher's exact test was performed considering the cells with expected frequencies < 5

[a]By Pearson chi-square test

[b]By the Welch two-sample *t*-test

[c]Evaluated using the Los Angeles Classification system

data to evaluate surgical outcomes, including symptom resolution and postoperative complications.

The results from the Korea nationwide data revealed that LNF demonstrated tolerable resolution of both typical and atypical symptoms; 90.3% of the typical symptoms and 73.5% of the atypical symptoms were either completely or partially resolved at 1-year follow-up (Table 3). The resolution rate of the atypical symptoms was relatively low as compared with that of the typical symptoms, and a similar phenomenon was observed in a study by Rakita et al. [12] in that the resolution rates of hoarseness and cough were as low as 66.6% and 78.2%, respectively, after LNF at 1-year follow-up. This may be possible since atypical symptoms, also known as extraesophageal manifestations, are theoretically related to structures above the upper esophageal sphincter (UES) [13, 14], and LNF does not manipulate the UES or the structures above it. While previous studies reported less favorable outcomes after LNF for PPI non-responders [15–17], our result does not support such findings with statistical significance, while a trend of a lesser degree of symptom resolution was apparent in the PPI non-responders (Table 4). Although the PPI responders had significantly better outcomes than the PPI non-responders exclusively for atypical symptoms, the difference between the PPI responders and non-responders diminished as the follow-up period extended from 3 months to 1 year, thereby requiring further confirmation after more follow-up data are collected.

Notably, the characteristics of patients should be considered relevant while interpreting the results of anti-reflux surgery. As the prevalence of obesity is increasing at an alarming rate, its impact on anti-reflux surgery has been studied extensively. Obese patients were found to have a longer operative time and hospital stay after anti-reflux surgery [18]. The recurrence of reflux was more prevalent in obese patients than in non-obese patients [19, 20]. Further, advanced age in patients poses an additional challenge of increased surgical care of older patients during anti-reflux surgery [21]. The influence of LARS on surgical outcomes is still controversial. Some evidence support that LARS in patients of > 65 years of age is feasible and safe, while others have shown a high rate of intraoperative complications and postoperative mortality [22–25]. Specifically, surgical patients who were above 75 years old had a higher risk of intraoperative complications, reoperation rates, as well as longer operative times and lengths of hospital stay [26]. Therefore, the fact that most of the patients in our study were non-obese and relatively young might have contributed to the faster recovery and improved control of reflux symptoms after surgery.

We further analyzed specific symptoms and postoperative complications in depth. Heartburn, regurgitation, and epigastric pain, which represent typical symptoms, were resolved either completely or partially in 89.3%, 92.9%, and 100% of patients, respectively, at 1-year follow-up (Table 5). A safety profile was also gained after a 1-year follow-up, and moderate to severe dysphagia (23.5%), inability to belch (29.4%), gas bloating (23.2%), and flatulence (22%) were reported (Table 6). According to a meta-analysis of randomized controlled trials [27] in Western countries, the pooled prevalence rates of postoperative dysphagia, inability to belch, gas bloating, and flatulence at 1-year follow-up were 27%, 31%, 18%, and 25%, respectively [28, 29]. A comparison of complication rates between the Korean and Western populations demonstrated similar control of postoperative complications by Korean surgeons. Considering that Korean surgeons have less experience with LNF and premature learning curves compared to those of the western surgeons, the comparable manageability of the postoperative complications could be attributed to the Korean surgeons' patient selection. In diverse surgical disciplines, surgeons in their initial learning phase are prone to select safe and easy cases to minimize adverse surgical outcomes [30–32], and

such tendencies in Korean surgeons are palpable from the more frequent selection of surgical patients who are younger and have decreased presence of hiatal hernia compared to that in western surgeons [33].

The patients were subdivided according to the operation period for trend analysis (Fig. 1 and Table 7). As we published our previous study based on KARS nationwide data in 2014 [11], we selected 2014 as the cutoff period for identifying any shift in patient characteristics, surgeons' patient selection, and surgical outcomes. The number of patients undergoing LNF has continuously increased from 2011 to 2018 with statistical significance in linear trend analysis ($p = 0.024$). Compared with the patients from 2010 to 2014, the surgical patients from 2015 to 2018 more frequently presented hiatal hernia (50.3%; Table 7), which suggests that Korean surgeons have increasingly considered hiatal hernia to be an important surgical indication as they obtained collective knowledge and cumulative experiences. Although still controversial, GERD patients with hiatal hernia are more likely to experience better prognosis after LNF than those without hiatal hernia [34–36]. Furthermore, patients with hiatal hernia composed 55%–90% [37–39] of the operated patients of the Western cohort, indicating the increasing liability of hiatal hernia as a surgical indication in the cohort. The increment in the proportion of hiatal hernia cases among surgical patients after 2014 may reflect the shift of the Korean clinical ground toward such a trend. The symptom resolution after LNF was comparable between the two periods, and the operation time significantly shortened after 2014, implying an increased proficiency in LNF.

Further, the proportion of patients with comorbidities increased during 2015–2018 compared to 2011–2018. Comorbidity has been regarded as one of the risk factors of recurrence along with other factors such as female sex and old age [40]. In a retrospective study, patients without comorbidity and aged under 45 years had a lower rate of reflux recurrence [41]. However, in our study, among patients with more comorbidities, the operation time was shorter, and the symptom control rate was comparable, which could be due to an increase in the effectiveness and safety of the surgery. Further, comorbidities in patients who underwent anti-reflux surgery were not associated with an increase in mortality, reoperation, or hospital stay [42]. This finding implies that the impact of comorbidities on the outcome of an anti-reflux surgery could be perceived as a factor controllable with improvement in surgical skill and patient selection.

Although this is a nationwide study, its retrospective nature and reduced sample size at a 1-year follow-up may have limited our interpretation. Patients were given the questionnaire when they visited the clinic after the surgery. Considering that GERD is not a life-threatening disease in most cases, patients might have missed their appointments since their symptoms improved even though follow-up protocols were implemented regularly. Thus, more proactive methods, including telecommunications and online surveys, should be implemented to rectify the lower response rate and prevent gradual patient follow-up loss.

The present study represents the largest scale so far of nationwide data on LNF from the Korean population collected over eight years. The study provides information on the efficacy and safety outcomes of LNF, which can potentially be extrapolated to any other surgical community where LNF is initiated, and the learning curve is applied. Future research with a prospective nature and longer-term outcomes in the Korean population is needed for further confirmation.

Author contributions This manuscript has been read and approved by all authors. Study conception and design: SP and SWH. Data collection: JHL, HMP, JJK, KYS, SWR, KWS, HK, DJK, SP, and SUH. Statistical analysis: YO and MSK. Data interpretation: YO, MSK, and SP. Drafting of the manuscript: MSK and YO. Critical revision: SP and SUH.

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Compliance with ethical standards

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Affiliations

Min Seo Kim[1] · Youjin Oh[1] · Jun-Hyun Lee[2] · Joong-Min Park[3] · Jin-Jo Kim[2] · Kyo Young Song[2] · Seung Wan Ryu[5] · Kyung Won Seo[6] · Hyoung-Il Kim[7] · Dong Jin Kim[2] · Sungsoo Park[8] · Sang-Uk Han[4] · Korean Anti-reflux Surgery Study (KARS) group

1 Korea University College of Medicine, Seoul, Republic of Korea

2 Department of Surgery, The Catholic University of Korea College of Medicine, Seoul, Republic of Korea

3 Department of Surgery, Chung-Ang University College of Medicine, Seoul, Republic of Korea

4 Department of Surgery, Ajou University School of Medicine, 206 WorldCup-ro, Yeongtong-gu, Suwon 443-749, Republic of Korea

5 Department of Surgery, Keimyung University School of Medicine, Daegu, Republic of Korea

6 Department of Surgery, Kosin University College of Medicine, Busan, Republic of Korea

7 Department of Surgery, Yonsei University College of Medicine, Seoul, Republic of Korea

8 Division of Upper Gastrointestinal Surgery, Department of Surgery, Korea University Anam Hospital, Korea University College of Medicine, Inchon-ro 73, Seongbuk-gu, Seoul 136-705, Republic of Korea