

Clinical Outcomes of a Laparoscopic Total vs a 270° Posterior Partial Fundoplication in Chronic Gastroesophageal Reflux Disease

A Randomized Clinical Trial

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IMPORTANCE The efficacy of fundoplication operations in the management of gastroesophageal reflux disease (GERD) has been documented. However, few prospective, controlled series report long-term (>10 years) efficacy and postfundoplication concerns, particularly when comparing various types of fundoplication.

OBJECTIVE To compare long-term (>15 years) results regarding mechanical complications, reflux control, and quality of life between patients undergoing posterior partial fundoplication (PF) or total fundoplication (TF) (270° vs 360°) in surgical treatment for GERD.

DESIGN, SETTING, AND PARTICIPANTS A double-blind randomized clinical trial was performed at a single center (Ersta Hospital, Stockholm, Sweden) from November 19, 2001, to January 24, 2006. A total of 456 patients were recruited and randomized. Data for this analysis were collected from August 1, 2019, to January 31, 2021.

INTERVENTIONS Laparoscopic 270° posterior PF vs 360° TF.

MAIN OUTCOMES AND MEASURES The main outcome was dysphagia scores for solid and liquid food items after more than 15 years. Generic (36-Item Short-Form Health Survey) and disease-specific (Gastrointestinal Symptom Rating Scale) quality of life and proton pump inhibitor consumption were also assessed.

RESULTS Among 407 available patients, relevant data were obtained from 310 (response rate, 76%; mean [SD] age, 66 [11.2] years; 184 [59%] men). A total of 159 were allocated to a PF and 151 to a TF. The mean (SD) follow-up time was 16 (1.3) years. At 15 years after surgery, mean (SD) dysphagia scores were low for both liquids (PF, 1.2 [0.5]; TF, 1.2 [0.5]; $P = .58$) and solids (PF, 1.3 [0.6]; TF, 1.3 [0.5]; $P = .97$), without statistically significant differences between the groups. Reflux symptoms were equally well controlled by the 2 types of fundoplications as were the improvements of quality-of-life scores.

CONCLUSIONS AND RELEVANCE The long-term findings of this randomized clinical trial indicate that PF and TF are equally effective for controlling GERD and quality of life in the long term. Although PF was superior in the first years after surgery in terms of less dysphagia recorded, this difference did not prevail when assessed a decade later.

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Worldwide, surgical practice has long advocated total fundoplication, as originally designed by Nissen,¹ to be the criterion standard surgical procedure in the management of chronic gastroesophageal reflux disease (GERD).²⁻⁴ Adverse effects of the procedure, predominantly of a mechanical nature,⁵⁻⁷ have not only raised some concern about the procedure but also stimulated further research to control those adverse effects by, for example, technical modifications.⁸

One of these modifications was to perform a partial wrap, either anterior or posterior.^{9,10} A series of randomized clinical trials¹¹⁻¹⁴ have reported that partial fundoplication (PF) is followed by fewer postoperative adverse effects and complications of a mechanical nature and associated with fewer problems with flatulence and bloating compared with a total fundoplication (TF). A critical observation was that the advantages of a partial posterior wrap were not gained at the expense of an inferior control of reflux, assessed by symptoms or objective means.^{15,16} However, on the basis of data from single-institution experiences as well as retrospective analyses, TF has been claimed to be superior to PF in terms of gastroesophageal reflux control, durability of wrap function, number of subsequent herniations, and recurrence rates of GERD.¹⁷⁻²¹ This claim prompted attempts to further modify PF to encircle 270° of the esophageal circumference. The objective was to maintain the mechanical advantages of the partial wrap without compromising the efficacy to control gastroesophageal reflux.²²

Five-year outcomes from a large, double-blind randomized clinical trial²² of 456 patients with chronic GERD found no difference between a 270° posterior PF and a Nissen TF in terms of acid reflux control, GERD symptom control, or improvement of quality of life (QoL). However, the finding of a statistically significant difference in dysphagia scorings in favor of PF after 1 and 2 years suggested that PF can be recommended before the more commonly performed TF for surgical treatment of GERD. The issue of durability of these effects is, however, always of highest concern. In this article, we report on the outcome from this trial cohort after more than 15 years of follow-up.

Methods

Originally, 456 patients with chronic GERD were recruited into this randomized clinical trial, of whom 229 were randomized to receive a PF and 227 to receive a TF. The trial was performed at a single center (Ersta Hospital, Stockholm, Sweden) from November 19, 2001, to January 24, 2006. Relevant clinical characteristics, surgical details, and clinical outcomes have been described in detail previously.²² The Regional Ethics Committee in Stockholm approved the study protocol. The study was performed in accordance with the Declaration of Helsinki.²³ Patients were invited by mail to participate in the study, and after receiving written information, patients who were willing to participate returned their signed informed consent form together with the completed study questionnaires. The study protocol and an English-translated version can be found in [Supplement 1](#). The study

Key Points

Question Does the previously reported advantage of a partial 270° fundoplication, in terms of fewer mechanical adverse effects at 2 years after operation, remain after more than 15 years of follow-up?

Findings Long-term follow-up data were obtained from 310 of 456 patients with chronic gastroesophageal reflux disease originally enrolled and randomized in this double-blind randomized clinical trial. Partial fundoplication and total fundoplication controlled long-term gastroesophageal reflux disease symptoms and quality of life equally well; however, the superiority of a partial fundoplication, as reflected by less dysphagia previously recorded during the first years after surgery, seemed to have disappeared when assessed a decade later.

Meaning There seem to be no important long-term differences in the functional outcomes of the 2 studied antireflux surgical procedures.

followed the Consolidated Standards of Reporting Trials (CONSORT) reporting guideline.

Available patients were invited to participate in the long-term follow-up study. Patients who were deceased, who had been unregistered from the study, or who had emigrated were excluded from the follow-up. Data for this study were collected from August 1, 2019, to January 31, 2021. All included patients completed the same QoL questionnaires as in the original study.²² These questionnaires included the Swedish version of the generic 36-Item Short-Form Health Survey (SF-36),²⁴ the disease-specific Gastrointestinal Symptom Rating Scale (GSRS),²⁵ and a specific dysphagia score questionnaire.²⁶ In the SF-36, data are presented as physical component score (PCS) and mental component score (MCS), respectively. Each subscale score reaches a maximum value of 100, where higher values reflect better health status.²⁴ The GSRS is a validated questionnaire containing 5 dimensions of abdominal symptoms (gastroesophageal reflux, abdominal pain, indigestion, obstipation, and diarrhea).²⁵ The subscales are presented by use of a 7-point Likert scale, and the mean item scores of the respective domains were used throughout the study. A higher value represents more severe symptoms.

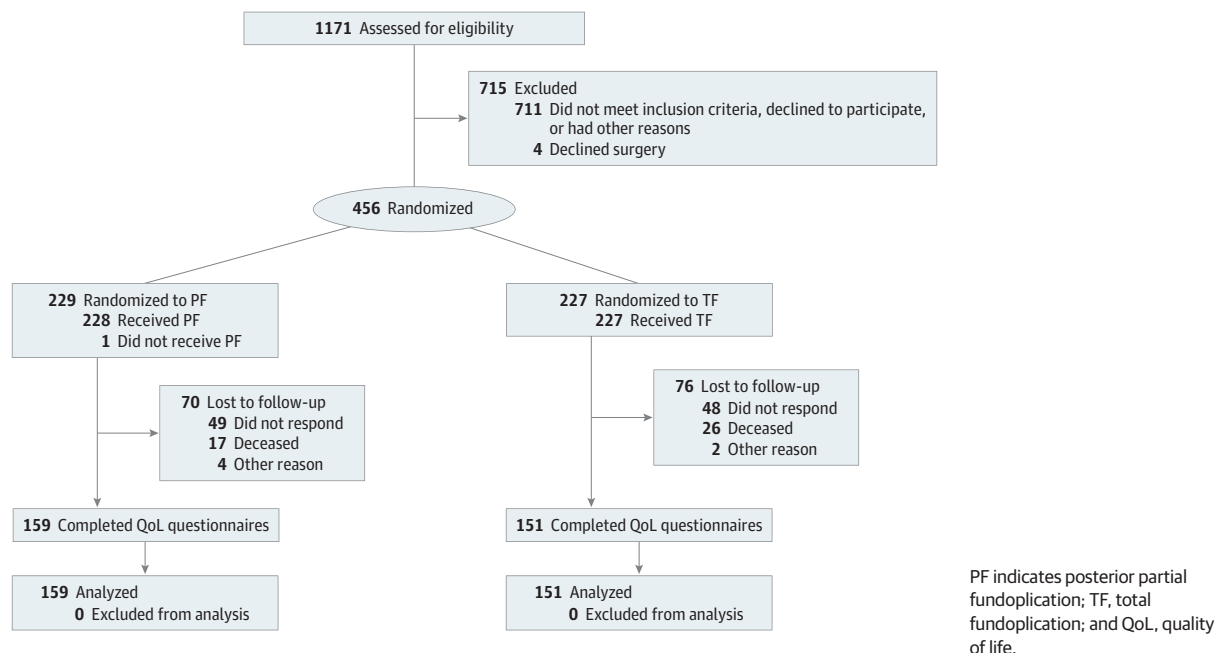
For the dysphagia scoring, a standardized specific questionnaire was used, which includes a 4-graded scale to describe dysphagia for solid and liquid food components, respectively, as follows: 1 indicates no episodes of dysphagia; 2, less than 1 episode of dysphagia per day; 3, 1 to 3 episodes of dysphagia per day; and 4, more than 3 episodes of dysphagia per day.²⁶

Based on the predominant finding during the first 2 years after surgery,²² the primary outcome for this specific long-term follow-up was dysphagia scoring for solid food and liquid items 15 years after the surgery. Secondary outcomes were QoL, reflux symptoms, proton pump inhibitor (PPI) consumption, and additional operation rates.

Statistical Analysis

Values are presented as means and standard deviations unless otherwise stated. An intention-to-treat analysis was ap-

Figure 1. Flowchart of Patients Enrolled in the Trial



plied. Comparisons of parametric data were performed by use of a 2-sided *t* test, whereas for nonparametric data, the Mann-Whitney test and χ^2 or Fisher exact test were used when appropriate. For intragroup comparisons vs the baseline at the various follow-up time points (repeated measures), the Friedman test was used, and post hoc analysis was performed by using the Wilcoxon matched pair test. A 2-tailed $P < .05$ was considered statistically significant. Patients with missing values were not included in the analysis for the time point(s) during which data were missing. Statistical analysis was performed using the SPSS software, version 26.0 (SPSS Inc).

The sample size calculation was based on the findings of a difference of 30% (1.3 [0.9] vs 1.7 [1.2]) in dysphagia scores for solids at 2 years postoperation in the original study.²² To detect this difference at the time of the long-term follow-up with a 95% probability and power of 80%, 141 patients were needed in each group.

Results

Of the 456 originally enrolled patients, 43 patients were deceased, and 6 patients were not available for inclusion at the time of the follow-up for other reasons. Thus, 407 patients were available and invited to participate in the long-term follow-up (Figure 1). Specifically, during the time elapsed since the operation, 70 patients were lost to follow-up in the PF group (17 patients died, 2 patients developed dementia, 2 emigrated, and 49 patients did not respond to the invitation to participate), and 76 patients were lost in the TF group (26 died, 1 emigrated, 1 unregistered from the study, and 48 did not respond). The causes of death in both groups were cardiopulmonary (n = 11), nongastrointestinal malignant neoplasms

(n = 7), gastrointestinal malignant neoplasms except esophageal cancer (n = 6), and unidentified causes (n = 18). One patient in the PF group died of esophageal adenocarcinoma. The final response rate was 76% (310 of 407 patients). Of these 310 patients (mean [SD] age, 66 [11.2] years; 184 [59%] male), 159 were originally allocated to a PF and 151 to a TF.

The demographic characteristics are presented in Table 1, showing well-matched groups from which follow-up information was retrieved. The mean (SD) follow-up time was 16 (1.3) years in both groups ($P = .64$), and the mean (SD) age at follow-up was 65 (11.0) years in the PF group and 67 (11.3) years in the TF group ($P = .11$). During the follow-up, 4 patients (3%) underwent additional operations in the PF group and 10 (7%) in the TF group, all because of recurrent GERD ($P = .08$).

The mean dysphagia scores for solid and liquid food items during the entire follow-up period are presented in Table 2. Compared with before surgery, marked improvements were found in dysphagia scores in both groups at 1 year after surgery, which were maintained during the entire follow-up period. Over time, there were only minor changes in the dysphagia scores. Some small differences between the groups were noted, including a statistically significant difference in favor of PF for liquid dysphagia at 1 year postoperation (mean [SD] score for PF, 1.0 [0.3]; for TF, 1.1 [0.4]; $P = .04$) and for solids at 1 year (mean [SD] score for PF, 1.1 [0.4]; for TF, 1.3 [0.6]; $P = .01$) and 2 years (mean [SD] score for PF, 1.1 [0.4]; for TF, 1.3 [0.6]; $P = .01$) postoperation. At 15 years after the surgery, mean (SD) dysphagia scores for solid and liquid remained low but now without statistically significant differences between the groups (liquids: mean [SD] score for PF, 1.2 [0.5]; for TF, 1.2 [0.5]; $P = .58$; solids: mean [SD] score for PF, 1.3 [0.6]; for TF, 1.3 [0.5]; $P = .97$).

Table 1. Demographic Characteristics of 310 Patients With GERD for Whom 15-Year Follow-up Data Were Retrieved

Characteristic	Posterior partial fundoplication (n = 159)	Total fundoplication (n = 151)	P value
Sex, No. (%)			
Male	93 (59)	91 (60)	.75 ^a
Female	66 (41)	60 (40)	
Age, mean (SD), y			
At operation	49 (11.0)	51 (11.1)	.13 ^b
At follow-up	65 (11.0)	67 (11.3)	.11 ^b
Follow-up, mean (SD), y	16 (1.3)	16 (1.3)	.64 ^b
Additional operation during follow-up, No. (%)	4 (3)	10 (7)	.08 ^a
Barrett esophagus, No. (%)			
Yes	33 (21)	28 (19)	.55 ^a
No	121 (79)	122 (81)	
Total acid exposure at baseline, median (IQR), % of time with pH <4	14.5 (9.8-22.5)	16.7 (10.4-22.7)	.39 ^b

Abbreviation: GERD, gastroesophageal reflux disease.
^a The χ^2 or Fisher exact test.
^b The Mann-Whitney U test.

Table 2. Mean (SD) Dysphagia Scores for Solid Food and Liquid Items During the 15 Years of Follow-up^a

Allocation	Preoperation			1 y Postoperation			2 y Postoperation			3 y Postoperation			15 y Postoperation		
	PF (n = 112)	TF (n = 109)	P value ^b	PF (n = 145)	TF (n = 135)	P value ^b	PF (n = 141)	TF (n = 126)	P value ^b	PF (n = 144)	TF (n = 146)	P value ^b	PF (n = 158)	TF (n = 149)	P value ^b
Dysphagia for liquids	1.5 (0.8)	1.3 (0.7)	.07	1.0 (0.3)	1.1 (0.4)	.04	1.1 (0.4)	1.1 (0.4)	.63	1.1 (0.4)	1.1 (0.3)	.69	1.2 (0.5)	1.2 (0.5)	.58
P value vs baseline ^c	NA	NA	NA	<.001	.01	NA	<.001	<.001	NA	.00	<.001	NA	<.001	.12	NA
Dysphagia for solids	1.7 (0.9)	1.5 (0.9)	.25	1.1 (0.4)	1.3 (0.6)	.01	1.1 (0.4)	1.3 (0.6)	.01	1.2 (0.6)	1.2 (0.5)	.36	1.3 (0.6)	1.3 (0.5)	.97
P value vs baseline ^c	NA	NA	NA	<.001	.03	NA	<.001	.02	NA	.00	<.001	NA	<.001	<.001	NA

Abbreviations: NA, not applicable; PF, posterior partial fundoplication; TF, total fundoplication.

^b The Mann-Whitney U test.

^c The Friedman and Wilcoxon signed rank test.

^a Patients were originally randomized to a PF or a TF. Scores range from 1 to 4, where 1 indicates no dysphagia episodes and 4 indicates more than 3.

The SF-36 scores recorded during the 15 years after surgery are presented in **Figure 2** and in the eTable in **Supplement 2**. Both the mean (SD) PCS and MCS were significantly improved compared with baseline at all follow-up points and without statistically significant differences between the groups (mean [SD] baseline PCS scores of 42.0 [10.3] in the PF group and 41.3 [9.8] in the TF group and mean [SD] baseline MCS scores of 41.6 [12.9] in the PF group and 41.5 [12.8] in the TF group vs mean [SD] PCS scores 15 years postoperatively of 44.4 [11.4] in the PF group and 44.1 [13.1] in the TF group and mean [SD] MCS scores 15 years postoperatively of 48.2 [11.1] in the PF group and 48.5 [11.9] in the TF group; $P < .001$).

At 15 years after surgery, all of the scores in the various domains of the GSRS were low, without any statistically significant differences between the 2 groups (**Table 3**). The reflux domain was immediately and markedly reduced after surgery and remained so throughout the long-term follow-up. For the remaining domains, only abdominal pain (mean [SD] abdominal pain, 2.1 [1.1] in the PF group vs baseline and 1.9 [1.0] in the TF group vs baseline; $P < .001$) and indigestion (mean [SD] indigestion, 2.7 [1.2] in the PF group vs baseline and 2.6 [1.1] in the TF group vs baseline; $P < .001$) were significantly improved compared with baseline values at 15 years postoperatively, again without any intergroup differences.

Fifteen years after surgery, 38 of 159 patients (24%) in the PF group and 42 of 149 patients (28%) in the TF group used PPIs daily. Among these patients, 25 of 38 (66%) in PF group and 28 of 42 (67%) in the TF group reported that they used PPIs to control GERD symptoms. The remaining 13 patients in the PF group and 14 patients in the TF group reported daily PPI intake for a variety of reasons, such as swallowing difficulties and/or abdominal pain.

Discussion

The main finding in this prospective, double-blind randomized clinical trial with a long follow-up is that irrespective of whether a 270° posterior PF or a 360° TF was used, the effects in terms of reflux control, swallowing function, and self-reported QoL were well sustained after more than 15 years of follow-up. In addition, the previously observed advantage of a posterior partial repair, in the form of fewer mechanical adverse effects, disappeared over time.

In the current long-term follow-up, we observed the same differences in dysphagia for liquid and solid food as were previously reported at 1 and 2 years after surgery for the entire patient cohort during the 5-year follow-up.²² This finding indi-

cates that the current study cohort is representative of the entire group of patients initially included. Moreover, our findings are also in corroboration with previous studies^{13,27} with smaller groups of patients with GERD presented at 11.5 and 18 years of follow-up.

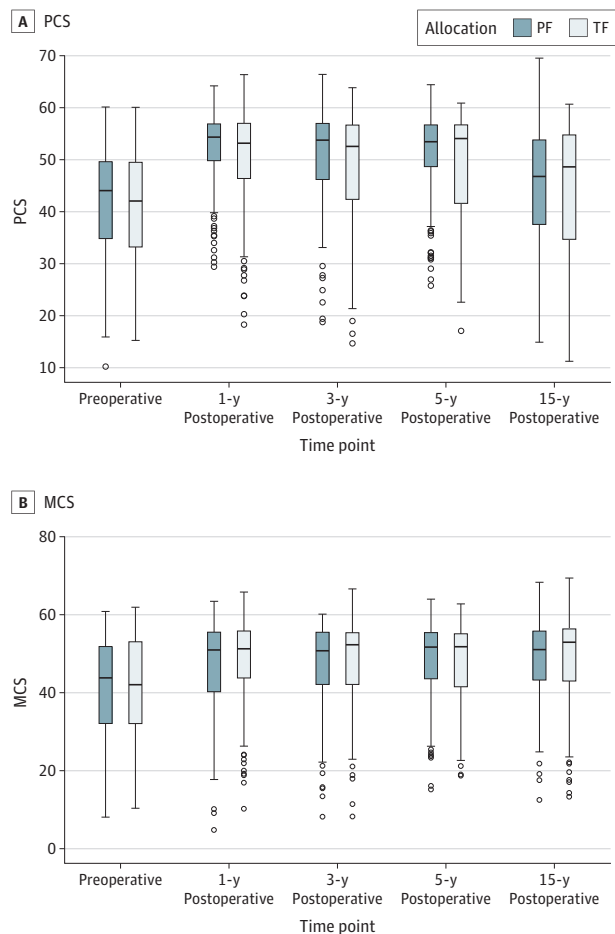
In this study, we focused on swallowing difficulties and did not capture specific information on other alleged adverse postoperative concerns, such as bloating and flatulence. On the other hand, by the use of the well-validated GSRS instrument, we were able to monitor general abdominal symptoms and complaints and found a similar improvement in both groups for dimensions that could be considered relevant for patients after antireflux surgery, such as reflux, abdominal pain, and indigestion.

An explanatory factor behind the observed convergence toward equality for mechanical adverse effects between the procedures may be related to chronic functional adaptation and coping with the postoperative situation. An additional explanation may be some loosening of the total wrap over time, thereby allowing a more smooth passage of the bolus through the gastroesophageal junction.²⁸ This possibility is supported by the observation in another study²⁹ that an increasing number of patients undergoing TF reported an ability to vomit at a late follow-up.²⁹ However, our data suggest that a slight increase in dysphagia scores in the PF group rather than a reduction of the scores in the TF group might account for the lack of difference between the groups at long-term follow-up.

This study contributes to the growing number of randomized trials with a sufficiently long follow-up period to allow firm conclusions regarding the efficacy over time of reflux control related to the design of the repair. Previous reports^{30,31} have often focused on the surgical reduction and repair of the hiatal hernia. Thus, it does not seem to be of major relevance whether an anterior or a posterior crural repair is performed.^{32,33} Our study protocol mandated a crural repair be performed, which may have contributed to the low risk of paraesophageal reherniation, irrespective of which of the 2 types of reconstructions patients were allocated to. Suffice to say that we did not specifically monitor any long-term changes in the hiatal anatomy, but none of our patients had a subsequent operation for a paraesophageal hernia.

Some concern has been raised about the level of reflux control offered by the partial fundoplication compared with the pronounced effect reported after a total wrap.²¹ From a symptom control perspective, it seems reasonable to conclude that these previously reported differences in esophageal acid exposure do not necessarily translate into a clinically relevant difference in symptom control.^{11,29} In addition, the 270° wrap has been reported to offer the same degree of pH control as the 360° counterpart.²² The findings in the current study of well-controlled reflux symptoms after a 270° posterior PF at more than 15 years further corroborate this notion. However, there remains a worrying continuous increase over time in the number of patients who are prescribed PPIs, presumably to control recurrent GERD symptoms.³⁴⁻³⁶ During the first 5 years of follow-up for patients in the current study, this figure was at the 10% level, which increased to 25% at 15 years. Previous ob-

Figure 2. 36-Item Short-Form Health Survey (SF-36) Outcomes at 15 Years After Surgery



A, Physical component score (PCS). B, Mental component score (MCS). Patients were randomized to either a posterior partial fundoplication (PF, n = 159) or a total fundoplication (TF, n = 151). Box and whisker plots indicate the median value (horizontal line), IQR (box), and 10th and 90th percentile range (whiskers). The circles represent outliers.

servations indicate that few of those who are prescribed PPIs after antireflux surgery are ultimately found to have recurrent GERD,³⁷⁻³⁹ which was also confirmed in our study cohort. Nevertheless, this trend over time, which has also been observed in population-based studies,^{35,36} constitutes a concern that needs to be addressed in future studies aiming to identify underlying specific causes of the need for PPI treatment and specifying relevant management strategies.

Strengths and Limitations

Strengths of the study include a large cohort of well-matched, randomized patients who were followed for more than 15 years and the use of a well-validated instrument for assessment of multiple aspects of outcome after antireflux surgery.

The study also has some limitations. Adherence to the follow-up protocol is always a problem when covering such a long period as in the current study (>15 years). Among the 456 patients with GERD originally enrolled, 407 were available for

Table 3. Gastrointestinal Symptom Rating Scale Outcomes at Different Follow-up Time Points

Outcome	Mean (SD)		P value between groups ^a	P value vs baseline PF ^b	P value vs baseline TF ^b
	PF	TF			
Baseline					
No.	150	142	NA	NA	NA
Reflux	4.3 (1.5)	4.4 (1.4)	.93	NA	NA
Abdominal pain	3.6 (1.3)	3.6 (1.2)	.56	NA	NA
Indigestion	3.7 (1.3)	3.6 (1.3)	.79	NA	NA
Obstipation	2.1 (1.2)	2.3 (1.3)	.43	NA	NA
Diarrhea	2.3 (1.4)	2.3 (1.5)	.78	NA	NA
1 y Postoperation					
No.	148	140	NA	NA	NA
Reflux	1.4 (0.7)	1.3 (0.7)	.37	<.001	<.001
Abdominal pain	2.0 (0.9)	2.1 (1.1)	.76	<.001	<.001
Indigestion	3.3 (1.1)	3.2 (1.2)	.81	<.001	<.001
Obstipation	1.8 (1.0)	2.1 (1.3)	.12	<.001	.07
Diarrhea	2.1 (1.3)	2.0 (1.2)	.51	.38	.09
3 y Postoperation					
No.	146	145	NA	NA	NA
Reflux	1.5 (1.0)	1.5 (1.0)	.68	<.001	<.001
Abdominal pain	2.1 (1.1)	2.0 (1.0)	.98	<.001	<.001
Indigestion	3.2 (1.2)	3.0 (1.2)	.30	<.001	<.001
Obstipation	1.9 (1.0)	1.9 (1.2)	.40	.02	<.001
Diarrhea	2.2 (1.3)	1.9 (1.2)	.06	.46	.01
5 y Postoperation					
No.	143	130	NA	NA	NA
Reflux	0.4 (0.3)	0.4 (0.3)	.18	<.001	<.001
Abdominal pain	0.9 (0.4)	0.9 (0.5)	.94	<.001	<.001
Indigestion	1.7 (0.7)	1.7 (0.7)	.50	<.001	<.001
Obstipation	0.8 (0.4)	0.9 (0.5)	.37	<.001	<.001
Diarrhea	1.0 (0.9)	0.9 (0.6)	.83	<.001	<.001
15 y Postoperation					
No.	159	151	NA	NA	NA
Reflux	1.9 (1.2)	1.7 (1.1)	.18	<.001	<.001
Abdominal pain	2.1 (1.1)	1.9 (1.0)	.43	<.001	<.001
Indigestion	2.7 (1.2)	2.6 (1.1)	.66	<.001	<.001
Obstipation	2.1 (1.1)	2.1 (1.1)	.45	.86	.11
Diarrhea	2.4 (1.3)	2.2 (1.3)	.06	.45	.27

Abbreviations: NA, not applicable; PF, posterior partial fundoplication; TF, total fundoplication.

^a The Mann-Whitney *U* test.

^b The Friedman and Wilcoxon signed rank test.

long-term follow-up. Of these, we obtained data from 310, resulting in a response rate of 76%. This significant but inevitable loss of patients for long-term follow-up may be 1 factor contributing to the observed convergence toward equity between the procedures regarding mechanical adverse effects over time. Furthermore, it cannot be excluded that those who did not respond may experience more adverse effects and failures, but we have no reason to believe that patients allocated to a particular study group should be overrepresented in this respect. Indeed, higher response rates are always aimed for, but because we obtained long-term follow-up data for approximately 150 patients in both groups, the follow-up rate should be considered acceptable. We were unable to obtain objective measurements

regarding reflux control, such as ambulatory 24-hour pH monitoring, but the GSRS reflux domain represents a strong and valid instrument to monitor the level of reflux control.

Conclusions

In this randomized clinical trial of patients with GERD, laparoscopic PF and TF led to similar long-term outcomes for dysphagia control and QoL improvement. Although PF was superior in the first years after surgery in terms of less dysphagia recorded, this difference did not prevail when assessed a decade later.

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REFERENCES

- Ellis FH Jr. The Nissen fundoplication. *Ann Thorac Surg*. 1992;54(6):1231-1235. doi:10.1016/0003-4975(92)90112-H
- Booth MI, Jones L, Stratford J, Dehn TCB. Results of laparoscopic Nissen fundoplication at 2-8 years after surgery. *Br J Surg*. 2002;89(4):476-481. doi:10.1046/j.0007-1323.2002.02074.x
- Bloomston M, Niels W, Rosemurgy AS. Symptoms and antireflux medication use following laparoscopic Nissen fundoplication: outcome at 1 and 4 years. *JLS*. 2003;7(3):211-218.
- Dallemagne B, Weerts JM, Jehaes C, Markiewicz S, Lombard R. Laparoscopic Nissen fundoplication: preliminary report. *Surg Laparosc Endosc*. 1991;1(3):138-143.
- Richter JE. Gastroesophageal reflux disease treatment: side effects and complications of fundoplication. *Clin Gastroenterol Hepatol*. 2013;11(5):465-471. doi:10.1016/j.cgh.2012.12.006
- Funch-Jensen P, Jacobsen B. Dysphagia after laparoscopic Nissen fundoplication. *Scand J Gastroenterol*. 2007;42(4):428-431. doi:10.1080/00365520600955120
- Anvari M, Allen C. Postprandial bloating after laparoscopic Nissen fundoplication. *Can J Surg*. 2001;44(6):440-444.
- DeMeester SR. Laparoscopic hernia repair and fundoplication for gastroesophageal reflux disease. *Gastrointest Endosc Clin N Am*. 2020;30(2):309-324. doi:10.1016/j.giec.2019.12.007
- Bona D, Aiolfi A, Asti E, Bonavina L. Laparoscopic Toupet fundoplication for gastroesophageal reflux disease and hiatus hernia: proposal for standardization using the "critical view" concept. *Updates Surg*. 2020;72(2):555-558. doi:10.1007/s13304-020-00732-7
- Patti MG, De Bellis M, De Pinto M, et al. Partial fundoplication for gastroesophageal reflux. *Surg Endosc*. 1997;11(5):445-448. doi:10.1007/s004649900387
- Broeders JA, Mauritz FA, Ahmed Ali U, et al. Systematic review and meta-analysis of laparoscopic Nissen (posterior total) versus Toupet (posterior partial) fundoplication for gastro-oesophageal reflux disease. *Br J Surg*. 2010;97(9):1318-1330. doi:10.1002/bjs.7174
- Cai W, Watson DI, Lally CJ, Devitt PG, Game PA, Jamieson GG. Ten-year clinical outcome of a prospective randomized clinical trial of laparoscopic Nissen versus anterior 180(degrees) partial fundoplication. *Br J Surg*. 2008;95(12):1501-1505. doi:10.1002/bjs.6318
- Hagedorn C, Lönnroth H, Rydberg L, Ruth M, Lundell L. Long-term efficacy of total (Nissen-Rossetti) and posterior partial (Toupet) fundoplication: results of a randomized clinical trial. *J Gastrointest Surg*. 2002;6(4):540-545. doi:10.1016/S1091-255X(02)00037-9
- Andreou A, Watson DI, Mavridis D, Francis NK, Antoniou SA. Assessing the efficacy and safety of laparoscopic antireflux procedures for the management of gastroesophageal reflux disease: a systematic review with network meta-analysis. *Surg Endosc*. 2020;34(2):510-520. doi:10.1007/s00464-019-07208-9
- Lundell L, Abrahamsson H, Ruth M, Rydberg L, Lönnroth H, Olbe L. Long-term results of a prospective randomized comparison of total fundic wrap (Nissen-Rossetti) or semifundoplication (Toupet) for gastro-oesophageal reflux. *Br J Surg*. 1996;83(6):830-835. doi:10.1002/bjs.1800830633
- Catarci M, Gentileschi P, Papi C, et al. Evidence-based appraisal of antireflux fundoplication. *Ann Surg*. 2004;239(3):325-337. doi:10.1097/01.sla.0000114225.46280.fe
- Dallemagne B, Weerts J, Markiewicz S, et al. Clinical results of laparoscopic fundoplication at ten years after surgery. *Surg Endosc*. 2006;20(1):159-165. doi:10.1007/s00464-005-0174-x
- Farrell TM, Archer SB, Galloway KD, Branum GD, Smith CD, Hunter JG. Heartburn is more likely to recur after Toupet fundoplication than Nissen fundoplication. *Am Surg*. 2000;66(3):229-236.
- Fein M, Bueter M, Thalheimer A, et al. Ten-year outcome of laparoscopic antireflux surgery. *J Gastrointest Surg*. 2008;12(11):1893-1899. doi:10.1007/s11605-008-0659-8
- Fernando HC, Luketich JD, Christie NA, Ikramuddin S, Schauer PR. Outcomes of laparoscopic Toupet compared to laparoscopic Nissen fundoplication. *Surg Endosc*. 2002;16(6):905-908. doi:10.1007/s004640080007
- Horvath KD, Jobe BA, Herron DM, Swanstrom LL. Laparoscopic Toupet fundoplication is an inadequate procedure for patients with severe reflux disease. *J Gastrointest Surg*. 1999;3(6):583-591. doi:10.1016/S1091-255X(99)80079-1
- Håkanson BS, Lundell L, Bylund A, Thorell A. Comparison of laparoscopic 270° posterior partial fundoplication vs total fundoplication for the treatment of gastroesophageal reflux disease: a randomized clinical trial. *JAMA Surg*. 2019;154(6):479-486. doi:10.1001/jamasurg.2019.0047
- World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA*. 2013;310(20):2191-2194. doi:10.1001/jama.2013.281053
- Garratt AM, Ruta DA, Abdalla MI, Buckingham JK, Russell IT. The SF36 health survey questionnaire: an outcome measure suitable for routine use within the NHS? *BMJ*. 1993;306(6890):1440-1444. doi:10.1136/bmj.306.6890.1440
- Kulich KR, Madisch A, Pacini F, et al. Reliability and validity of the Gastrointestinal Symptom Rating Scale (GSRs) and Quality of Life in Reflux and Dyspepsia (QOLRAD) questionnaire in dyspepsia: a six-country study. *Health Qual Life Outcomes*. 2008;6:12. doi:10.1186/1477-7525-6-12
- Thor KB, Silander T. A long-term randomized prospective trial of the Nissen procedure versus a modified Toupet technique. *Ann Surg*. 1989;210(6):719-724. doi:10.1097/00000658-198912000-00005
- Mardani J, Lundell L, Engström C. Total or posterior partial fundoplication in the treatment of GERD: results of a randomized trial after 2 decades of follow-up. *Ann Surg*. 2011;253(5):875-878. doi:10.1097/SLA.0b013e3182171c48
- Ayazi S, DeMeester SR, Hagen JA, et al. Clinical significance of esophageal outflow resistance imposed by a nissen fundoplication. *J Am Coll Surg*. 2019;229(2):210-216. doi:10.1016/j.jamcollsurg.2019.03.024
- Tan G, Yang Z, Wang Z. Meta-analysis of laparoscopic total (Nissen) versus posterior (Toupet) fundoplication for gastro-oesophageal reflux disease based on randomized clinical trials. *ANZ J Surg*. 2011;81(4):246-252. doi:10.1111/j.1445-2197.2010.05481.x
- Attwood SEA, Lundell L, Ell C, et al; LOTUS Trial Group. Standardization of surgical technique in antireflux surgery: the LOTUS Trial experience. *World J Surg*. 2008;32(6):995-998. doi:10.1007/s00268-007-9409-4
- Ugllione E, Rebecchi F, Seno E, Morino M. Large hiatal hernia: minimizing early and long-term complications after minimally invasive repair. *Mini-invasive Surg*. 2021;5:2. doi:10.20517/2574-1225.2020.93
- Armijo PR, Pokala B, Misdeldt M, Pagkratis S, Oleynikov D. Predictors of hiatal hernia recurrence after laparoscopic anti-reflux surgery with hiatal hernia repair: a prospective database analysis. *J Gastrointest Surg*. 2019;23(4):696-701. doi:10.1007/s11605-018-04073-0
- Dunne N, Stratford J, Jones L, et al. Anatomical failure following laparoscopic antireflux surgery (LARS): does it really matter? *Ann R Coll Surg Engl*. 2010;92(2):131-135. doi:10.1308/003588410X12518836440126
- Sandbu R, Sundbom M. Nationwide survey of long-term results of laparoscopic antireflux surgery in Sweden. *Scand J Gastroenterol*. 2010;45(1):15-20. doi:10.3109/00365520903342158

35. Maret-Ouda J, Wahlin K, El-Serag HB, Lagergren J. Association between laparoscopic antireflux surgery and recurrence of gastroesophageal reflux. *JAMA*. 2017;318(10):939-946. doi:10.1001/jama.2017.10981

36. Lødrup A, Pottegård A, Hallas J, Bytzer P. Use of proton pump inhibitors after antireflux surgery: a nationwide register-based follow-up study. *Gut*. 2014;63(10):1544-1549. doi:10.1136/gutjnl-2013-306532

37. Lord RVN, Kaminski A, Oberg S, et al. Absence of gastroesophageal reflux disease in a majority of patients taking acid suppression medications after Nissen fundoplication. *J Gastrointest Surg*. 2002;6(1):3-9. doi:10.1016/S1091-255X(01)00031-2

38. Bonatti H, Bammer T, Achem SR, et al. Use of acid suppressive medications after laparoscopic antireflux surgery: prevalence and clinical indications. *Dig Dis Sci*. 2007;52(1):267-272. doi:10.1007/s10620-006-9379-7

39. Thompson SK, Jamieson GG, Myers JC, Chin KF, Watson DI, Devitt PG. Recurrent heartburn after laparoscopic fundoplication is not always recurrent reflux. *J Gastrointest Surg*. 2007;11(5):642-647. doi:10.1007/s11605-007-0163-6

Invited Commentary

Long-term Efficacy of Total and Partial Posterior Fundoplication to Treat Gastroesophageal Reflux Disease

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In this issue of *JAMA Surgery*, Analatos et al¹ report the results of a randomized clinical trial that compared total and 270° partial posterior fundoplication in patients with chronic gastroesophageal reflux disease (GERD) with more than 15 years of follow-up.¹ Clinical control of GERD and dysphagia rates were comparable, whereas dysphagia was higher after total fundoplication at the 3-year follow-up reported by the same group.² These results corroborate the evidence from a comparable study³ in open surgery and a meta-analysis⁴ of long-term results of laparoscopic fundoplication. One might therefore think that the debate between total vs partial fundoplication is finally over, at least as far as the 270° partial fundoplication is concerned, with the results for other partial valves being certainly less favorable in terms of reflux control.⁵

Analatos et al¹ do not mention or stress the importance of the surgical technique used in this study, which is clearly accountable for the consistent and homogenous results. It seems important to emphasize that the authors applied the principles of a tension-free repair, namely that of a floppy valve, total or partial, based on the correct identification and freeing of the upper part of the gastric fundus and extensive esophageal

mobilization.^{2,6} The combination of various (mis)interpretations of the adequate technique to build a partial or total fundoplication, together with a short follow-up, can largely explain the variety and inconsistency of the results reported in the literature.⁷

Although the subjective evaluation of clinical results is fundamental when assessing the effect of surgery on a functional disease, the lack of objective measures in this report is a limiting factor. Although difficult to collect, objective data could have helped refine the analysis of the results for each technique, in particular with regard to the reasons leading to use of proton pump inhibitors (25% of patients in both groups) and the small but consistent increase in dysphagia rate over time in the partial fundoplication group. At a time when the long-term use of proton pump inhibitors is under scrutiny and sometimes has a role in the argumentation of the surgical option, it seems important to understand the reasons for their use after antireflux surgery, because they may be related to anatomical failures and/or extraesophageal factors, as mentioned by the authors.

In conclusion, this study provides additional evidence of the long-term equivalence in terms of efficacy of total and 270° partial fundoplication in the treatment of GERD when the surgical technique and key steps are respected.

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REFERENCES

1. Analatos A, Håkanson BS, Ansoerge C, Lindblad M, Lundell L, Thorell A. Clinical outcomes of a laparoscopic total vs a 270° posterior partial

fundoplication in chronic gastroesophageal reflux disease: a randomized clinical trial. *JAMA Surg*. Published online April 20, 2022. doi:10.1001/jamasurg.2022.0805

2. Håkanson BS, Lundell L, Bylund A, Thorell A. Comparison of laparoscopic 270° posterior partial fundoplication vs total fundoplication for the treatment of gastroesophageal reflux disease: a randomized clinical trial. *JAMA Surg*. 2019;154(6):479-486. doi:10.1001/jamasurg.2019.0047

3. Mardani J, Lundell L, Engström C. Total or posterior partial fundoplication in the treatment of GERD: results of a randomized trial after 2 decades of follow-up. *Ann Surg*. 2011;253(5):875-878. doi:10.1097/SLA.0b013e3182171c48

4. Du X, Hu Z, Yan C, Zhang C, Wang Z, Wu J. A meta-analysis of long follow-up outcomes of laparoscopic Nissen (total) versus Toupet (270°

fundoplication for gastro-esophageal reflux disease based on randomized controlled trials in adults. *BMC Gastroenterol*. 2016;16(1):88. doi:10.1186/s12876-016-0502-8

5. Broeders JA, Broeders EA, Watson DI, Devitt PG, Holloway RH, Jamieson GG. Objective outcomes 14 years after laparoscopic anterior 180-degree partial versus nissen fundoplication: results from a randomized trial. *Ann Surg*. 2013;258(2):233-239. doi:10.1097/SLA.0b013e318278960e

6. Hunter JG, Swanstrom L, Waring JP. Dysphagia after laparoscopic antireflux surgery. The impact of operative technique. *Ann Surg*. 1996;224(1):51-57. doi:10.1097/00006658-199607000-00008

7. Dallemagne B, Perretta S. Twenty years of laparoscopic fundoplication for GERD. *World J Surg*. 2011;35(7):1428-1435. doi:10.1007/s00268-011-1050-6