

Chapter 36

Partial Versus Total Fundoplication for GERD in Patients with Normal Esophageal Motility

Marco E. Allaix and Marco G. Patti

Abstract A laparoscopic total fundoplication is considered today the gold standard for the surgical treatment of gastroesophageal reflux disease (GERD). Short-term outcome is excellent, with low perioperative morbidity and fast recovery; symptom relief and reflux control are achieved in about 80–90 % of patients 10 years after surgery. However, a small but clinically relevant incidence of postoperative dysphagia and gas-related symptoms is reported. Debate still exists about the best antireflux operation and during the last two decades the surgical outcomes of laparoscopic partial fundoplication (anterior or posterior) have been compared to those achieved after a laparoscopic total fundoplication. This chapter reviews the results of partial and total fundoplication for the treatment of GERD in patients with normal esophageal motility.

Keywords Gastroesophageal reflux disease • Total fundoplication • Partial anterior fundoplication • Partial posterior fundoplication • Dysphagia • Gas bloating

Introduction

A laparoscopic total fundoplication (LTF) is considered today the procedure of choice for the surgical treatment of gastroesophageal reflux disease (GERD): it increases the resting pressure and length of the lower esophageal sphincter (LES), decreases the number of transient LES relaxations, and improves quality of

Conflict of Interest The authors have no conflicts of interest to declare.

M.E. Allaix, MD • M.G. Patti, MD (✉)

Department of Surgery, Center for Esophageal Diseases, University of Chicago

Pritzker School of Medicine,

5841 S. Maryland Ave, MC 5031, Room G-207, Chicago, IL 60637, USA

e-mail: mpatti@surgery.bs.d.uchicago.edu

esophageal peristalsis [1, 2]. A LTF is associated with less morbidity and similar long-term outcomes compared with open fundoplication [3]. Long follow-up studies have shown that control of symptoms is achieved in about 80–90 % of patients 10 years after surgery [4, 5], with similar safety and efficacy in young and elderly patients [6].

Several randomized clinical trials (RCTs), mostly from Australia, have found that a LTF is as effective in controlling reflux as a laparoscopic partial fundoplication (LPF), but it is associated with a higher incidence of postoperative dysphagia and gas-related symptoms. [7] On the other hand, many studies from the United States have reported similar rates of postoperative dysphagia after LTF and LPF, with a LPF being less effective in controlling reflux than a LTF. [1, 8, 9] The following chapter reviews the surgical outcomes of LTF and LPF in the treatment of GERD in patients with normal esophageal motility.

Search Strategy

Full text articles in English were selected from searches of the Pub-Med database (from 1991 to present) using the following search terms, either alone or in combination: “gastroesophageal reflux disease”, “laparoscopic”, “total fundoplication”, “partial anterior fundoplication”, “partial posterior fundoplication”, “dysphagia”, “recurrent reflux”, “gas-bloat syndrome”. The reference list of all the identified papers was checked for additional articles for inclusion in this review.

Results

Laparoscopic Fundoplication: Total or Partial?

LTF is a very effective surgical procedure for the treatment of GERD with excellent results in most patients; however it is associated with a small but significant incidence of postoperative dysphagia and gas-related symptoms. Several strategies have been proposed to minimize or prevent these adverse effects, such as division of short gastric vessels during LTF, and use of several variants of LPF (posterior, anterior 90°, anterior 180°) (Table 36.1).

Short gastric vessels division has been suggested as possible factor that might improve postoperative outcomes. Long-term results of several RCTs failed to demonstrate any reduction of postoperative dysphagia in patients undergoing total fundoplication with short gastric division compared with those who underwent total fundoplication without short gastric vessel division [20–22]. Two of these RCTs have shown an association between short gastric vessel division and wind-related effects [20, 22]. However, the studies were characterized by heterogeneity and

Table 36.1 Surgical outcomes after laparoscopic anterior partial fundoplication and laparoscopic total fundoplication (LTF)

Reference	Fundoplication	N	Follow-up	Heartburn	Acid exposure	Dysphagia	Quality of evidence
Watson et al. [10]	Anterior LTF	180° 53	54 6 months	Partial = LTF	Partial = LTF	Partial < LTF	Moderate
Ludemann et al. [11]	Anterior LTF	180° 51	50 5 years	Partial = LTF	NP	Partial < LTF	Moderate
Cai et al. [12]	Anterior LTF	180° 48	41 10 years	Partial = LTF	NP	Partial = LTF	Moderate
Broeders et al. [13]	Anterior LTF	180° 41	36 14 years	Partial > LTF	Partial > LTF ^a	Partial < LTF	Moderate
Baigrie et al. [14]	Anterior LTF	180° 84	79 2 years	Partial = LTF	NP	Partial < LTF	Moderate
Watson et al. [15]	Anterior LTF	90° 52	60 6 months	Partial > LTF	Partial = LTF	Partial < LTF	Moderate
Watson et al. [16]	Anterior LTF	90° 44	53 5 years	Partial > LTF	NP	Partial = LTF	Moderate
Spence et al. [17]	Anterior LTF	90° 39	40 1 year	Partial = LTF	Partial > LTF	Partial < LTF	Moderate
Watson et al. [18]	Anterior LTF	90° 37	37 5 years	Partial = LTF	NP	Partial < LTF	Moderate
Broeders et al. [19] ^b	Anterior LTF	90° 81	90 5 years	Partial > LTF	NP	Partial < LTF	Moderate

NP not performed

^aPerformed in 8 LPF and 10 LTF

^bCombined analysis of Refs [16], and [18]

inherent poor methodological quality, and experts in North America advocate routine division of the short gastric vessels [23]. In the open era, small RCTs with short follow-up periods did not show significant differences in the incidence of dysphagia between a total and a posterior partial fundoplication [24–26]. In the laparoscopic era, several RCTs aimed to find the ideal antireflux technique, comparing LTF to posterior LPF, 180° anterior LPF, and 90° anterior LPF.

Anterior 180° vs. LTF

Watson et al. [10] reported in 1999 the short-term results of a prospective double-blind RCT that compared 53 GERD patients treated with LTF and 54 GERD patients undergoing an anterior 180° LPF. Patients with a severe esophageal motility disorder were excluded. Postoperative dysphagia, heartburn and patients satisfaction were assessed using standardized clinical grading systems. At 6 months, LPF patients experienced significantly less dysphagia for solid food (15 % vs. 40 %, $p=0.008$), were more likely to belch normally, reported less flatulence, and their level of satisfaction was higher than in patients treated with LTF. No differences

were observed in terms of heartburn (9 % in both groups), and mean acid exposure at 24-h pH monitoring. The authors concluded that anterior 180° LPF achieves equivalent control of reflux and is associated with improved clinical outcomes at 6 months.

The 5-year follow-up results of this RCT based on standardized questionnaires confirmed in 101 patients (51 LTF, 50 LPF) similar heartburn control in the two groups (10 % LTF vs. 20 % LPF, $p=0.172$), lower incidence of dysphagia, abdominal bloating and inability to belch among LPF patients, with high patients satisfaction scores in both groups, proving the durability of anterior 180° LPF. [11]

Finally, 10-year follow-up data obtained in 89 patients (48 LTF and 41 LPF) using a standard clinical questionnaire showed that both LTF and anterior 180° LPF are durable, safe and effective, with no significant differences in terms of heartburn control, use of Proton Pump Inhibitors (PPIs), incidence of dysphagia, and overall satisfaction [12]. However, when patients were tested with manometry and ambulatory 24-h impedance- pH monitoring at 14 years follow-up, mean LES resting and relaxation pressures were lower and acid, weakly acidic, liquid and mixed reflux episodes were more common after LPF. LPF patients experienced more frequent heartburn than LTF patients, while dysphagia was less common. [13]

Similar results were obtained by Baigrie et al. [14] They randomized 163 GERD patients, regardless of motility findings, to a LTF (84 patients) or an anterior 180° LPF (79 patients), with no division of the short gastric vessels. There were no significant differences in heartburn according to the assessment by visual analogue scale between the two groups at 3, 12, and 24 months. Patients after LPF had significantly less dysphagia at each follow-up interval. No differences were reported in patient satisfaction scores.

Anterior 90° vs. LTF

Although postoperative dysphagia and gas-related problems are reduced after anterior 180° LPF compared to LTF, they are still reported in some patients. This led in the late 1990s to the development of a 90° anterior LPF, that was compared to LTF in several RCTs.

Watson et al. [15] published in 2004 the short-term outcomes of a multicenter, prospective, double-blind RCT: 112 GERD patients were randomized to anterior 90° LPF (60 patients) or LTF with division of the short gastric vessels (52 patients). Patients with esophageal motility disorders were excluded from the study. Clinical outcomes in terms of dysphagia, heartburn and overall satisfaction were measured using multiple clinical grading systems at 1, 3, and 6 months postoperatively. Esophageal manometry, 24-h pH monitoring, and upper endoscopy were performed 3–4 months after surgery. No significant differences were observed in terms of early postoperative morbidity and length of postoperative stay. At 6 months, dysphagia and flatulence were more frequently experienced by patients undergoing LTF. LES pressure, acid exposure and endoscopic findings were similar at 3–4 months after both procedures. The incidence of heartburn assessed by yes/no questions was

similar in the two groups at 1 and 3 months, while it was significantly higher after LPF at 6 months (19 % vs. 4 %, $p=0.03$). Overall satisfaction was higher after LPF. Based on these data, the authors concluded that anterior 90° LPF provides effective reflux control, and it is followed by less dysphagia and gas-related symptoms than LTF. The 12-month follow-up of clinical outcome based on analog scales showed that patients after LPF were less likely to experience dysphagia than patients treated with LTF, while no differences were observed at 5 years. A reduced incidence of heartburn was reported after LTF compared to LPF at 12 months and 5 years. Overall satisfaction was similar in both groups of patients over time. [16]

Spencer et al. [17] published in 2006 the short-term results of a RCT that compared 40 patients undergoing anterior 90° LPF and 39 patients treated with LTF without division of the short gastric vessels. Patients with severe esophageal motility that contraindicated a LTF were excluded from the study. At 1-year follow-up, LTF was associated with higher rates of dysphagia, while no differences were reported for the assessment of heartburn by the visual analogue scale. However, 24-h pH monitoring showed a significantly lower percentage time with pH less than four in the LTF group. At manometry, postoperative LES resting pressure was similar in the two groups, while LES residual relaxation pressure was significantly higher after LTF. Seventy-four patients were available for analysis of clinical outcome using standardized questionnaires at 5 years [18]. The authors found that the incidence of dysphagia and bloating was higher after LTF when measured by an analogue score. There were no significant differences in terms of heartburn control and overall satisfaction, although PPIs were more frequently used after LPF (29.7 % vs. 8.1 %). However, manometry and pH monitoring were not performed.

Broeders et al. [19] combined raw data sets from these 2 RCTs, and used the original data to determine the clinical outcomes at 5 years follow-up. Data were available from a subset of 90 patients undergoing LPF and 82 patients treated with LTF. Heartburn scores were significantly higher after LPF, and the use of PPIs was more common. In this group of patients, however, dysphagia and gas-related symptoms were less frequent. Overall satisfaction with the surgical outcomes was similar. No differences were observed in terms of endoscopic dilatations performed for dysphagia (2 % vs. 6 %, $p=0.202$), and the number of reoperations (10 % vs. 4.9 %, $p=0.212$). In particular, the most frequent indication for reoperation was recurrent reflux in the LPF group, and dysphagia in the LTF group.

Summary

Both 180° and 90° anterior LPF are associated with less postoperative dysphagia than LTF at 5 year follow-up. However, at 10 years after surgery, the outcome following anterior 180° LPF and LTF are not significantly different [12]. At 5 years, the incidence of reflux symptoms (i.e. heartburn) and use of PPIs after anterior 180° LPF and LTF were similar, but higher after 90° anterior LPF than LTF. Recurrent reflux is the most common indication for surgical revision of an anterior LPF, while persistent dysphagia is the leading cause for reoperation after LTF. However, the overall number

of surgical revisions is not significantly different comparing LPF and LTF. Overall patient satisfaction rating is similar after both subtypes of anterior LPF and LTF.

However, these results should be interpreted with caution. Indeed, most RCTs included small number of patients, did not perform 24-h pH monitoring to evaluate the incidence of reflux at long-term follow-up, and used symptom control and use of PPIs as a marker of surgical outcome. Many studies have in fact shown that when ambulatory 24-h pH monitoring is performed to test patients with recurrent heartburn, pathological reflux is present in less than 40 % of cases [27–30]. On the other hand, long-term studies have shown a less effective control of gastroesophageal reflux with a LPF rather than a LTF. [1, 8, 9] Recurrence of gastroesophageal reflux confirmed by pH monitoring at 5 years is reported in more than 50 % of patients after LPF. [1, 8, 9] Based on these data, we feel that a LTF is the procedure of choice for the treatment of GERD in patients with normal esophageal motility.

Posterior vs. LTF

Laparoscopic posterior fundoplication has been proposed as an alternative to LTF to reduce the incidence of postoperative dysphagia and gas-related symptoms in GERD patients with normal esophageal peristalsis. Several large RCTs have been published, but the results of these studies did not show significant differences and did not permit definitive conclusion (Table 36.2). Broeders et al. [7] recently published a systematic review and meta-analysis of RCTs that compared LTF to Toupet

Table 36.2 Surgical outcomes after laparoscopic posterior partial fundoplication (Toupet) and laparoscopic total fundoplication (LTF)

Reference	Fundoplication	N	Follow-up (months)	Heartburn	Acid exposure	Dysphagia	Quality of evidence
Booth et al. [31]	Toupet	63	12	Toupet = LTF	Toupet = LTF	Toupet = LTF	Low
	LTF	64					
Chrysos et al. [32]	Toupet	19	12	NA	NA	Toupet = LTF	Low
	LTF	14					
Guérin et al. [33]	Toupet	63	12	Toupet = LTF	NA	Toupet = LTF	Low
	LTF	77					
Laws et al. [34]	Toupet	16	27	Toupet = LTF	NA	Toupet = LTF	Low
	LTF	23					
Mickevicius et al. [35]	Toupet	77	12	Toupet = LTF	NA	Toupet = LTF	Low
	LTF	76					
Shaw et al. [36]	Toupet	50	60	Toupet = LTF	Toupet = LTF	Toupet = LTF	High
	LTF	50					
Strate et al. [37]	Toupet	100	24	Toupet = LTF	Toupet > LTF	Toupet < LTF	Low
	LTF	100					
Broeders et al. [7] ^a	Toupet	388		Toupet = LTF	Toupet = LTF	Toupet < LTF	Low
	LTF	404					

NA not available

^aMeta-analysis of the RCTs included in the table

(posterior partial) for GERD, aiming to establish the best surgical procedure of choice according to the highest level of evidence. They identified 7 RCTs comparing 404 LTF patients and 388 Toupet patients [31–37]. The methodological quality of the included RCTs ranged from poor to excellent, with a median Jadad score of 2 (range, 1–5). Follow-up ranged between 12 (4 RCTs) and 60 months (1 RCT). LTF was associated with a significantly higher prevalence of dysphagia, inability to belch and gas bloating after surgery, more endoscopic dilatations and more surgical reoperations. No differences were observed for recurrent pathological acid exposure, esophagitis, reflux symptoms, and overall patient satisfaction.

Summary

Toupet fundoplication and LTF achieve similar reflux control. Toupet fundoplication is associated with reduced postoperative dysphagia, need for endoscopic dilatation, reoperation rates and prevalence of gas-related symptoms compared with LTF. These initial mechanical advantages however seem to disappear over time, as recently demonstrated by Mardani et al. [38]

However, this metanalysis presents some major limitations. There was heterogeneous methodological quality of the RCTs included in the study. The studies included different indications for surgery (GERD proven on 24-h pH monitoring, GERD proven on upper endoscopy, GERD requiring daily PPI therapy). The follow-up was short-term. Only a small number of patients was enrolled in each RCT. There was no objective evaluation of heartburn by 24-h pH monitoring after antireflux surgery.

Longer follow-up data are necessary to confirm similar long-term outcomes after Toupet and LTF beyond 5 years, since several large prospective and retrospective studies suggested poorer long-term reflux control after Toupet fundoplication. For instance, Jobe et al. [39] found in 100 consecutive GERD patients that 24-h pH monitoring was abnormal in 51 % of all patients and in 39 % of asymptomatic patients after laparoscopic Toupet fundoplication. Similarly, Patti et al. [1] found that at 70 months after surgery, 56 % of patients after laparoscopic posterior fundoplication but only 28 % after LTF had persistent reflux confirmed by 24-h pH monitoring. After posterior fundoplication, more patients took PPIs (25 % vs. 8 %) or required a second operation (9 % vs. 3 %). The incidence of postoperative dysphagia was similar in the two groups, showing that the type of fundoplication (total vs. partial) is not a risk factor for dysphagia. Based on these data, we feel that a LTF is today the procedure of choice for the treatment of GERD in patients with normal esophageal motility.

Laparoscopic Partial Fundoplication: Anterior or Posterior?

Based on the similar reflux control and reduced postoperative dysphagia after LTF reported in several RCTs, a few studies investigated the surgical outcomes of different partial fundoplications. Hagedorn et al. [40] looked at the efficacy and

mechanical consequences in 95 GERD patients who were randomized to have an anterior 120° LPF (47 patients) or a posterior (Toupet) LPF (48 patients). At 12-months, both procedures were effective in reducing reflux symptoms. However, significantly fewer patients experienced postoperative heartburn and regurgitation after a posterior LPF. Similarly, significant differences were observed in 24-h pH monitoring in favor of posterior LPF: even if acid exposure was reduced after both operations, normal levels were achieved only after a posterior LPF. No significant differences between the two groups were recorded in terms of postoperative dysphagia and ability to belch. At 5 years, the long-term results of this RCT showed that a posterior LPF provided significantly better heartburn and regurgitation control, with lower number of reoperations and use of PPIs. [41]

In summary, posterior LPF achieves better reflux control, with no increase in postoperative dysphagia at short- and long-term follow-up. However, further large RCTs with long-term follow-up are needed to confirm these results. Based on these limited data, we feel that a posterior LPF is superior to an anterior LPF.

Conclusions

A LTF is the procedure of choice for the treatment of GERD patients. A LPF, either anterior (180°) or posterior, should be performed only in patients with GERD secondary to scleroderma and in patients with achalasia, since a LTF would impair esophageal emptying and cause dysphagia.

A Personal View of the Data

In patients with GERD and normal esophageal peristalsis I perform a total fundoplication. In my experience, long term follow up has shown that a total fundoplication is superior to a partial fundoplication in terms of reflux control, and it is associated to a similar incidence of post-operative dysphagia.

Recommendation

- A total laparoscopic fundoplication is recommended for patients in whom surgical therapy of gastroesophageal reflux disease is indicated. (Evidence quality moderate; weak recommendation)

References

1. Patti MG, Robinson T, Galvani C, Gorodner MV, Fisichella PM, Way LW. Total fundoplication is superior to partial fundoplication even when esophageal peristalsis is weak. *J Am Coll Surg*. 2004;198:863–9.

2. Herbella FA, Tedesco P, Nipomnick I, Fisichella PM, Patti MG. Effect of partial and total laparoscopic fundoplication on esophageal body motility. *Surg Endosc.* 2007;21:285–8.
3. Broeders JA, Rijnhart-de Jong HG, Draaisma WA, Bredenoord AJ, Smout AJ, Gooszen HG. Ten-year outcome of laparoscopy and conventional Nissen fundoplication: randomized clinical trial. *Ann Surg.* 2009;250(5):698–706.
4. Dallemagne B, Weerts J, Markiewicz S, Dewandre JM, Wahlen C, Monami B, Jehaes C. Clinical results of laparoscopic fundoplication at ten years after surgery. *Surg Endosc.* 2006;20:159–65.
5. Morgenthal CB, Shane MD, Stival A, Gletsu N, Milam G, Swafford V, Hunter JG, Smith CD. The durability of laparoscopic Nissen fundoplication: 11-year outcomes. *J Gastrointest Surg.* 2007;11:693–700.
6. Tedesco P, Lobo E, Fisichella PM, Way LW, Patti MG. Laparoscopic fundoplication in elderly patients with gastroesophageal reflux disease. *Arch Surg.* 2006;141:289–92.
7. Broeders JAJL, Mauritz FA, Ahmed Ali U, Draaisma WA, Ruurda JP, Gooszen HG, Smout AJ, Broeders IA, Hazebroek EJ. Systematic review and meta-analysis of laparoscopic Nissen (posterior total) versus Toupet (posterior partial) fundoplication for gastro-oesophageal reflux disease. *Br J Surg.* 2010;97:1318–30.
8. 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;3:583–91.
9. Oleynikov D, Eubanks TR, Oelschlagel BK, Pellegrini CA. Total fundoplication is the operation of choice for patients with gastroesophageal reflux and defective peristalsis. *Surg Endosc.* 2002;16:909–13.
10. Watson DI, Jamieson GG, Pike GK, Davies N, Richardson M, Devitt PG. Prospective randomized double-blind trial between laparoscopic Nissen fundoplication and anterior partial fundoplication. *Br J Surg.* 1999;86:123–30.
11. Ludemann R, Watson DI, Jamieson GG, Game PA, Devitt PG. Five-year follow-up of a randomized clinical trial of laparoscopic total versus anterior 180° fundoplication. *Br J Surg.* 2005;92:240–3.
12. Cai W, Watson DI, Lally CJ, Devitt PG, Game PA, Jamieson GG. Ten-year clinical outcomes of a prospective randomized clinical trial of laparoscopic Nissen versus anterior 180° partial fundoplication. *Br J Surg.* 2008;95:1501–5.
13. 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):233–9.
14. Baigrie RJ, Cullis SNR, Ndhluni AJ, Cariem A. Randomized double-blind trial of laparoscopic Nissen fundoplication versus anterior partial fundoplication. *Br J Surg.* 2005;92:819–23.
15. Watson DI, Jamieson GG, Lally C, Archer S, Bessell JR, Booth M, Cade R, Cullingford G, Devitt PG, Fletcher DR, Hurley J, Kiroff G, Martin CJ, Martin IJ, Nathanson LK, Windsor JA, International Society for Diseases of the Esophagus–Australasian Section. Multicenter, prospective, double-blind, randomized trial of laparoscopic Nissen vs. anterior 90 degrees partial fundoplication. *Arch Surg.* 2004;139(11):1160–7.
16. Nijjar RS, Watson DI, Jamieson GG, Archer S, Bessell JR, Booth M, Cade R, Cullingford GL, Devitt PG, Fletcher DR, Hurley J, Kiroff G, Martin IJ, Nathanson LK, Windsor JA, International Society for the Diseases of the Esophagus–Australasian Section. Five-year follow-up of a multicenter, double-blind randomized clinical trial of laparoscopic Nissen vs anterior 90 degrees partial fundoplication. *Arch Surg.* 2010;145(6):552–7.
17. Spence GM, Watson DI, Jamieson GG, Lally CJ, Devitt PG. Single center prospective randomized trial of laparoscopic Nissen versus anterior 90 degrees fundoplication. *J Gastrointest Surg.* 2006;10(5):698–705.
18. Watson DI, Devitt PG, Smith L, Jamieson GG. Anterior 90° partial vs Nissen fundoplication—5 year follow-up of a single-centre randomised trial. *J Gastrointest Surg.* 2012;16(9):1653–8.
19. Broeders JA, Roks DJ, Jamieson GG, Devitt PG, Baigrie RJ, Watson DI. Five-year outcome after laparoscopic anterior partial versus Nissen fundoplication: four randomized trials. *Ann Surg.* 2012;255(4):637–42.

20. Luostarinen ME, Isolauri JO. Randomized trial to study the effect of fundic mobilization on long-term results of Nissen fundoplication. *Br J Surg.* 1999;86(5):614–8.
21. Blomqvist A, Dalenbäck J, Hagedorn C, Lönroth H, Hylander A, Lundell L. Impact of complete gastric fundus mobilization on outcome after laparoscopic total fundoplication. *J Gastrointest Surg.* 2000;4(5):493–500.
22. O'Boyle CJ, Watson DI, Jamieson GG, Myers JC, Game PA, Devitt PG. Division of short gastric vessels at laparoscopic Nissen fundoplication: a prospective double-blind randomized trial with 5-year follow-up. *Ann Surg.* 2002;235(2):165–70.
23. Patti MG, Arcerito M, Feo CV, De Pinto M, Tong J, Gantert W, Tyrrell D, Way LW. An analysis of operations for gastroesophageal reflux disease. Identifying the important technical elements. *Arch Surg.* 1998;133:600–6.
24. Thor KB, Silander T. A long-term randomized prospective trial of the Nissen procedure versus a modified Toupet technique. *Ann Surg.* 1989;210(6):719–24.
25. Walker SJ, Holt S, Sanderson CJ, Stoddard CJ. Comparison of Nissen total and Lind partial transabdominal fundoplication in the treatment of gastro-oesophageal reflux. *Br J Surg.* 1992;79(5):410–4.
26. Lundell L, Abrahamsson H, Ruth M, Rydberg L, Lönroth 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):830–5.
27. Khajanchee YS, O'Rourke RW, Lockhart B, Patterson EJ, Hansen PD, Swanstrom LL. Postoperative symptoms and failure after antireflux surgery. *Arch Surg.* 2002;137:1008–14.
28. Lord RV, Kaminski A, Oberg S, Bowrey DJ, Hagen JA, DeMeester SR, Sillin LF, Peters JH, Crookes PF, DeMeester TR. 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.
29. Galvani C, Fisichella PM, Gorodner MV, Perretta S, Patti MG. Symptoms are a poor indicator of reflux status after fundoplication for gastroesophageal reflux disease: role of esophageal functions tests. *Arch Surg.* 2003;138:514–8.
30. 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;11:642–7.
31. Booth MI, Stratford J, Jones L, Dehn TC. Randomized clinical trial of laparoscopic total (Nissen) versus posterior partial (Toupet) fundoplication for gastro-oesophageal reflux disease based on preoperative oesophageal manometry. *Br J Surg.* 2008;95(1):57–63.
32. Chrysos E, Tsioussis J, Zoras OJ, Athanasakis E, Mantides A, Katsamouris A, Xynos E. Laparoscopic surgery for gastroesophageal reflux disease patients with impaired esophageal peristalsis: total or partial fundoplication? *J Am Coll Surg.* 2003;197(1):8–15.
33. Guérin E, Bétroune K, Closset J, Mehdi A, Lefèbvre JC, Houben JJ, Gelin M, Vaneukem P, El Nakadi I. Nissen versus Toupet fundoplication: results of a randomized and multicenter trial. *Surg Endosc.* 2007;21(11):1985–90.
34. Laws HL, Clements RH, Swillie CM. A randomized, prospective comparison of the Nissen fundoplication versus the Toupet fundoplication for gastroesophageal reflux disease. *Ann Surg.* 1997;225(6):647–53.
35. Micekivicius A, Endzinas Z, Kiudelis M, Jonaitis L, Kupcinskas L, Maleckas A, Pundzius J. Influence of wrap length on the effectiveness of Nissen and Toupet fundoplication: a prospective randomized study. *Surg Endosc.* 2008;22(10):2269–76.
36. Shaw JM, Bornman PC, Callanan MD, Beckingham IJ, Metz DC. Long-term outcome of laparoscopic Nissen and laparoscopic Toupet fundoplication for gastroesophageal reflux disease: a prospective, randomized trial. *Surg Endosc.* 2010;24(4):924–32.
37. Strate U, Emmermann A, Fibbe C, Layer P, Zornig C. Laparoscopic fundoplication: Nissen versus Toupet two-year outcome of a prospective randomized study of 200 patients regarding preoperative esophageal motility. *Surg Endosc.* 2008;22(1):21–30.

38. 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):875–8.
39. Jobe BA, Wallace J, Hansen PD, Swanson LL. Evaluation of laparoscopic Toupet fundoplication as a primary repair for all patients with medically resistant gastroesophageal reflux. *Surg Endosc.* 1997;11(11):1080–3.
40. Hagedorn C, Jönson C, Lönroth H, Ruth M, Thune A, Lundell L. Efficacy of an anterior as compared with a posterior laparoscopic partial fundoplication: results of a randomized, controlled clinical trial. *Ann Surg.* 2003;238(2):189–96.
41. Engström C, Lönroth H, Mardani J, Lundell L. An anterior or posterior approach to partial fundoplication? Long-term results of a randomized trial. *World J Surg.* 2007;31y:1221–5.