

# Five-Year Outcome After Laparoscopic Anterior Partial Versus Nissen Fundoplication

## Four Randomized Trials

Joris A. Broeders, MD, PhD,\* David J. Roks, MD,\* Glyn G. Jamieson, MBBS, MS, FRACS,\*  
Peter G. Devitt, MBBS, MS, FRCS, FRACS,\* Robert J. Baigrie, MBBS, MD, FRCS,†  
and David I. Watson, MBBS, MD, FRACS‡

**Objective:** To compare longer term (5-year) outcomes for reflux control and postsurgery side effects after laparoscopic anterior (90° and 180°) partial versus Nissen fundoplication for gastroesophageal reflux.

**Background:** Laparoscopic Nissen fundoplication is the most frequently performed surgical procedure for gastroesophageal reflux. It achieves excellent control of reflux, but in some patients it is followed by troublesome side effects. To reduce the risk of side effects laparoscopic anterior partial fundoplication variants have been advocated, although some studies suggest poorer reflux control.

**Methods:** From 1995 to 2003, 461 patients with gastroesophageal reflux were enrolled in 4 randomized controlled trials comparing anterior partial versus Nissen fundoplication. Two trials evaluated anterior 180° and 2 anterior 90° partial fundoplication. The original trial data were combined, and a reanalysis from original data was undertaken to determine outcomes at 5 years follow-up. Reflux symptom control and side effects were evaluated in a blinded fashion using standardized questionnaires, including 0 to 10 analog scores (0 = no symptoms, 10 = severe symptoms).

**Results:** At 5 years, patients who underwent an anterior 90° or 180° partial fundoplication had less side effects than those who underwent Nissen fundoplication and were equally satisfied with the overall outcome. Reflux control, measured by heartburn scores and antisecretory medication use, was similar for anterior 180° partial versus Nissen fundoplication, but inferior after anterior 90° partial versus Nissen fundoplication.

**Conclusions:** Anterior 180° partial fundoplication achieves durable control of reflux symptoms and fewer side effects compared with Nissen fundoplication. Reflux control after anterior 90° partial fundoplication appears less effective than after Nissen fundoplication. This data supports the use of anterior 180° partial fundoplication for the surgical treatment of gastroesophageal reflux.

(*Ann Surg* 2012;255:637–642)

Laparoscopic fundoplication is the surgical approach of choice for the treatment of gastroesophageal reflux disease. It achieves similar long-term reflux control, with less short and long-term problems, compared with open fundoplication.<sup>1</sup> Laparoscopic Nissen fundoplication is the most frequently performed antireflux operation and alters the anatomy of the gastroesophageal junction. The gastroesophageal junction serves 3 functions. The first is to allow swallowed solids and

liquids to pass from esophagus to the stomach. The second is to allow venting of gas from the stomach to the mouth (ie, belching), and the third function is to prevent the backward flow of gastric contents into the esophagus (ie, gastroesophageal reflux). Nissen fundoplication restores the third function and provides excellent reflux control.<sup>1–3</sup> However, it delivers a supracompetent valve, which can impair the first 2 functions. Three meta-analyses have demonstrated that Nissen fundoplication is followed by a significant incidence of troublesome postfundoplication side effects, including troublesome postoperative dysphagia and gas-related problems.<sup>4–6</sup>

Laparoscopic partial fundoplication procedures have been proposed as alternatives and aim to reduce the incidence of postfundoplication side effects. Recently published American guidelines for antireflux surgery state that partial fundoplication provides similar 5-year reflux control, but with less postoperative dysphagia and fewer reoperations than Nissen fundoplication.<sup>7</sup> The guidelines suggested that laparoscopic anterior partial fundoplication may be less effective in the long-term. However, there may be important differences between different anterior partial fundoplication variants (eg, 90° vs 120° vs 180°), and therefore generalizing all anterior partial fundoplication procedures into a single category might not be appropriate. Furthermore, specific differences between different anterior partial fundoplication variants are not well understood. A recent meta-analysis also pooled anterior 90°, 120°, and 180° partial fundoplications, and compared this group to pooled results of posterior 180°, 200°, and Nissen fundoplication.<sup>8</sup> This analysis also suggested that reflux control for the pooled anterior fundoplication types was inferior to the pooled results of the posterior and Nissen fundoplication procedures.<sup>8</sup> However, this analysis failed to recognize and consider important differences between the fundoplication subtypes, and that technical differences might be important for achieving good clinical outcomes. Furthermore, this meta-analysis did not access raw data from the original trials. Hence, it is not appropriate to extrapolate its conclusions to specific fundoplication procedures.

To overcome the problems inherent in previous studies, we combined raw data sets from 4 randomized controlled trials of laparoscopic anterior partial versus laparoscopic Nissen fundoplication, and used the original data to determine the clinical outcomes at 5 years follow-up. Two of the trials compared anterior 90° partial with Nissen fundoplication,<sup>9,10</sup> and 2 compared anterior 180° with Nissen fundoplication.<sup>11,12</sup> These combined data sets allowed randomized comparisons of both anterior partial fundoplication variants with Nissen fundoplication.

## METHODS

### Study Design and Participants

Data sets from 4 previously reported randomized controlled trials of anterior 180°<sup>11,12</sup> or anterior 90°<sup>9,10</sup> partial fundoplication versus Nissen fundoplication were combined and reanalyzed (Fig. 1).

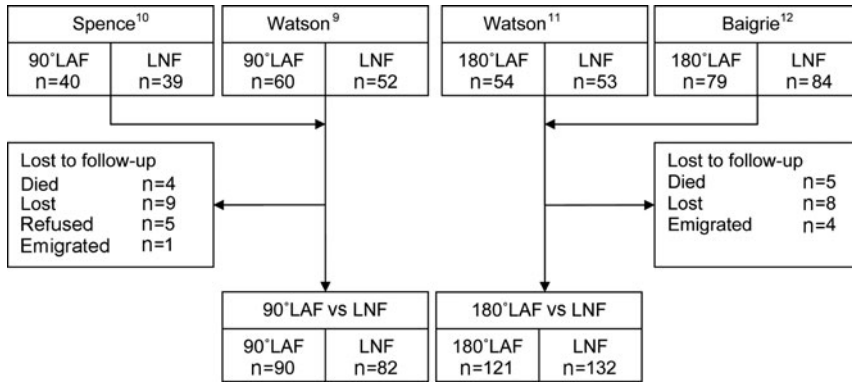
From the \*Discipline of Surgery, University of Adelaide, Royal Adelaide Hospital, Adelaide, South Australia; †Gastrointestinal Surgical Unit, Kingsbury Hospital, University of Cape Town, Cape Town, South Africa; and ‡Flinders University Department of Surgery, Flinders Medical Centre, Bedford Park, South Australia.

Disclosure: The authors declare no conflict of interest.

Reprints: Joris A.J.L. Broeders, MD, PhD, Department of Surgery, Royal Adelaide Hospital, Level 5, Eleanor Harrald Building, Adelaide, South Australia 5000, Australia. E-mail: joris.broeders@adelaide.edu.au.

Copyright © 2012 by Lippincott Williams & Wilkins  
ISSN: 0003-4932/12/25504-0637

DOI: 10.1097/SLA.0b013e31824b31ad



**FIGURE 1.** Study profile: CONSORT analysis 5-year follow-up for the anterior 90° partial (90° LAF), anterior 180° partial (180° LAF), and Nissen fundoplication (LNF) groups.

Patients presenting for primary antireflux surgery from 1995 to 2003 were recruited into these trials. Two trials compared anterior 90° partial versus Nissen fundoplication<sup>9,10</sup> and 2 compared anterior 180° partial versus Nissen fundoplication.<sup>11,12</sup> Five-year outcome data for 2 of the trials has been reported previously.<sup>13,14</sup>

All trials used a common methodology. Procedures were standardized across all centers, follow-up was undertaken in a blinded fashion, and common standardized symptom and outcome scores were used in all studies. All enrolled patients had objective evidence of gastroesophageal reflux disease at either 24-hour pH monitoring (pH < 4 for more than 7% of time) or upper endoscopy (ulcerative esophagitis).<sup>9–12</sup> Three hundred ninety-three patients underwent laparoscopic fundoplication in either Adelaide, South Australia,<sup>9–11</sup> or in Cape Town, South Africa.<sup>12</sup> Sixty-eight patients underwent surgery elsewhere in Australia or New Zealand within a multicentre trial of anterior 90° versus Nissen fundoplication, which was coordinated from Adelaide.<sup>9</sup> The lead clinician in the South African study worked in Adelaide in 1995 and participated in the development of the first anterior 180° partial versus Nissen fundoplication trial undertaken in Adelaide.<sup>11</sup> He applied the same surgical techniques, clinical outcome scores, and follow-up methodology in the South African trial.

Exclusion criteria were age less than 18 years or more than 75 years, esophageal motility disorders that precluded Nissen fundoplication, contemporaneous abdominal procedures, and previous gastric or esophagogastric junction surgery. Data for preoperative work-up, perioperative care and follow-up was collected prospectively and entered into computerized databases. Follow-up was undertaken yearly by “blinded” research nurses. The human research ethics committees of the hospitals in which surgery was undertaken approved the protocols of all trials.

**Surgical Procedures**

In each trial, patients were randomized 1:1 to undergo either anterior (90° or 180°) partial or Nissen fundoplication. All procedures were commenced laparoscopically. The surgical techniques have been described in detail elsewhere.<sup>9–12</sup> The initial steps for all 3 types of fundoplication were identical: hiatal dissection with minimal use of diathermy, preservation of the hepatic branch of the vagus nerve, mobilization of the distal esophagus and routine posterior hiatal repair. Short gastric blood vessels were not routinely divided, except in patients undergoing Nissen fundoplication in one of the 4 trials.<sup>9</sup>

Laparoscopic anterior 90° partial fundoplication was fashioned by first stabilizing the intra-abdominal esophagus with a posterior esophagopexy suture. The angle of His was then accentuated by placing 2 sutures between the left side of the esophagus and the adjacent gastric fundus—the upper suture also incorporating the hiatal rim. Next, the gastric fundus was sutured loosely over the left side and the front of the esophagus using an apical suture that anchored the

fundus to the anterior esophagus and the apex of the hiatal rim in the midline. The inferior edge of the fundal fold was also sutured to the anterior esophagus in the midline.<sup>9,10</sup> Laparoscopic anterior 180° partial fundoplication was constructed by suturing the anterior fundal wall to the right and left hiatal pillars and the apex of the hiatal rim using 5 to 6 sutures.<sup>11,12</sup> The key difference between the 2 anterior partial fundoplication techniques was that the fundus was anchored to the right hiatal pillar during anterior 180° fundoplication, but not during anterior 90° fundoplication. Laparoscopic Nissen fundoplication entailed construction of a loose 1- and 2-cm long 360° fundoplication with a 52 to 60 Fr intraesophageal bougie present to help ensure a tension-free wrap.<sup>9–12,15</sup> Three sutures were used to secure the wrap.<sup>9–12,15</sup>

**Clinical Outcomes**

Preoperative, perioperative, and follow-up data were collected prospectively. Follow-up entailed the application of a standardized set of questions, administered each year by either postal questionnaire or telephone interview, 5-year follow-up data was analyzed. Other events during the follow-up period, such as endoscopic dilatation for dysphagia or surgical reoperation, were also identified prospectively and recorded. Visual analog scores were used to assess symptoms. Heartburn was evaluated using an analog score (0 = no heartburn; 10 = severe heartburn) and by determining the use of antisecretory medications. The presence of dysphagia (yes/no question) and analog scores for solids and liquids (0 = no dysphagia; 10 = severe dysphagia) were recorded. A validated 0 to 45 dysphagia score<sup>16</sup> was used to quantify the ability to swallow 9 types of liquids and solids (0 = no dysphagia; 45 = severe dysphagia).<sup>17</sup> Patients were also asked whether they were able to eat a normal diet. Gas-related symptoms were assessed by yes/no questions, which determined the ability to belch, presence of abdominal bloating symptoms, ability to relieve bloating by belching, and increased flatulence. Patient satisfaction was scored using an analog score (0 = dissatisfied; 10 = satisfied) and a Visick score (1 = no symptoms; 2 = mild symptoms; 3 = moderate symptoms; 4 = moderate symptoms interfering with life; 5 = symptoms as bad or worse after surgery).<sup>17</sup> Patients were also asked whether they still regarded their initial decision to undergo surgery to be correct.

**Statistical Analysis**

Statistical analysis was performed using SPSS version 17.0 (SPSS inc, Chicago, IL). Data were analyzed according to the intention-to-treat principle. Continuous variables were expressed as mean ± standard deviation [SD], and groups were compared using the Mann-Whitney *U* test. Ordinal variables were expressed as percentages, and differences between groups were analyzed using the  $\chi^2$  test. Differences in the number of patients undergoing endoscopic

dilatation for dysphagia or reoperation were determined using Kaplan-Meier survival curves with log-rank tests.

## RESULTS

A total of 461 patients were enrolled in the 4 randomized controlled trials and underwent either laparoscopic anterior partial fundoplication ( $n = 233$ ) or laparoscopic Nissen fundoplication ( $n = 228$ ) for gastroesophageal reflux. A 5-year outcome was available for 434 (94.1%). Nine (2.0%) patients died during follow-up, and clinical outcome scores were available for 425 (92.2%) patients 5 years after surgery—anterior partial ( $n = 211$ ), Nissen fundoplication ( $n = 214$ ). Full details of patient follow-up are summarized in Figure 1. Data were available from a subset of 172 patients for comparison of anterior 90° partial ( $n = 90$ ) versus Nissen fundoplication ( $n = 82$ ), and from 253 patients for comparison of anterior 180° partial ( $n = 121$ ) versus Nissen fundoplication ( $n = 132$ ). Baseline patient characteristics were similar for the anterior partial and fundoplication Nissen groups (Table 1).

## Anterior 90° Partial Versus Nissen Fundoplication

Outcomes at 5 years for anterior 90° partial versus Nissen fundoplication are summarized in Table 2. Heartburn scores were higher after anterior 90° partial fundoplication, and the use of anti-secretory medication was more common. However, dysphagia was less common, more patients were able to eat a normal diet, the mean analog score for dysphagia for solid food was lower, and the mean 0 to 45 dysphagia score was lower after anterior 90° partial fundoplication. Gas-related symptoms were less common after anterior 90° partial fundoplication, with better preserved ability to belch, and less flatulence. All measures of overall satisfaction with the outcome of surgery were similar for the 2 procedures.

There were no significant differences in the number of endoscopic dilations performed for dysphagia (2.0% vs 6.0%;  $P = 0.202$ ) or the overall number of reoperations (10.0% vs 4.9%;  $P = 0.212$ ) undertaken within the 5-year follow-up period (Fig. 2). In the group that underwent anterior 90° partial fundoplication, most reoperations were performed for recurrent reflux (6.7%), whereas in the Nissen fundoplication group, most reoperations were for dysphagia (3.7%).

**TABLE 1.** Baseline Characteristics of Patients According to Treatment Group

	Anterior 90° vs Nissen Fundoplication		Anterior 180° vs Nissen Fundoplication	
	Anterior 90°	Nissen	Anterior 180°	Nissen
Patients (n)	90	82	121	132
Age (yr)	46.5 (22–76)	47.7 (22–72)	44.9 (20–74)	44.7 (16–71)
Male/female sex	52/38	48/34	72/49	82/50
Body mass index (kg/m <sup>2</sup> )*	29.5 [5.1]	30.0 [5.7]	27.7 [4.3]	30.0 [6.6]
Follow-up interval (mo)*	64.7 [9.6]	63.2 [8.2]	67.7 [10.1]	67.4 [9.6]

\*Values are given as mean [SD].

**TABLE 2.** Symptomatic Outcome at 5 Years After Anterior 90° and Nissen Fundoplication

	Anterior 90°	Nissen	P-value
Reflux symptoms			
Analog heartburn score*	2.2 [2.5] (n = 78)	1.6 [2.5] (n = 73)	0.043
Use of antiseecretory drugs	29/84 [34.5%]	9/76 [11.8%]	0.001
Dysphagia			
Dysphagia	26/84 [30.9%]	38/76 [50.0%]	0.014
Analog score for dysphagia for liquids*	0.7 [1.6] (n = 90)	1.2 [2.5] (n = 82)	0.399
Analog score for dysphagia for solids*	1.6 [2.4] (n = 89)	2.9 [3.0] (n = 81)	0.001
0–45 Dysphagia score*	6.4 [8.3] (n = 90)	10.8 [11.0] (n = 82)	0.007
Normal diet	83/87 [95.4%]	68/82 [82.9%]	0.009
Dilatation for dysphagia	2/90 [2.2%]	5/82 [6.1%]	0.202
Gas-related symptoms			
Inability to belch	3/87 [3.4%]	29/82 [35.4%]	<0.001
Gas bloating	48/89 [53.9%]	47/82 [57.3%]	0.656
Inability to relieve bloating	32/64 [50.0%]	26/61 [42.6%]	0.408
Increased flatulence	36/88 [40.9%]	55/82 [67.1%]	0.001
Patient satisfaction			
Analog score for satisfaction*	7.3 [3.3] (n = 90)	7.5 [3.0] (n = 82)	0.975
Correct decision for surgery?	72/87 [82.8%]	68/81 [84.0%]	0.836
Visick score			0.404
1 (no symptoms)	24 [27.6%]	17 [20.7%]	
2 (mild symptoms)	36 [41.4%]	37 [45.1%]	
3 (moderate symptoms)	7 [8.0%]	7 [8.5%]	
4 (symptoms interfering with life)	8 [9.2%]	14 [17.1%]	
5 (symptoms not improved)	12 [13.8%]	7 [8.5%]	
Visick 1 and 2 (no or mild symptoms)	60/87 [69.0%]	54/82 [65.9%]	0.666

\*Values are given as mean [SD].

### Anterior 180° Partial Versus Nissen Fundoplication

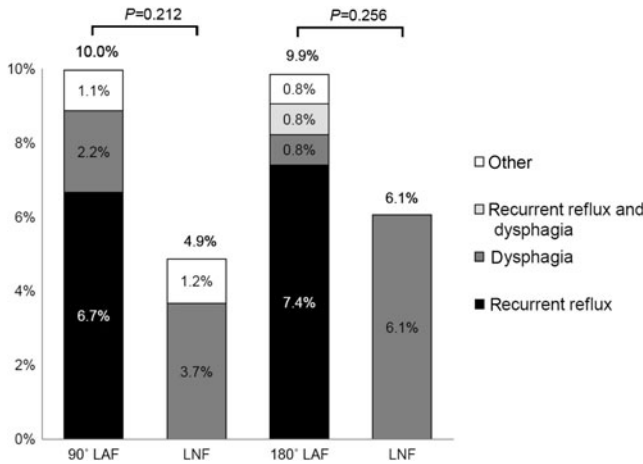
The outcomes at 5 years for anterior 180° partial versus Nissen fundoplication are summarized in Table 3. Heartburn scores and the use of antisecretory medication were similar for the 2 procedures. Dysphagia was less common after anterior 180° partial fundoplication, the mean analog scores for dysphagia for solids and liquids was lower, and the mean 0 to 45 dysphagia score was lower after anterior 180° partial fundoplication. Gas-related symptoms were also less common after anterior 180° partial fundoplication, belching ability and the ability to relieve bloating were better preserved, and flatulence

was less troublesome. All measures of overall satisfaction with the outcome of surgery were similar for the 2 procedures.

There were no significant differences in the number of endoscopic dilations performed for dysphagia (2.0% vs 5.0%;  $P = 0.191$ ) or the overall number of reoperations (9.9% vs 6.1%;  $P = 0.256$ ) undertaken (Fig. 2). In the group that underwent anterior 180° partial fundoplication most reoperations were performed for recurrent reflux (7.4%), whereas in the Nissen fundoplication group most reoperations were for dysphagia (6.1%).

### DISCUSSION

Antireflux surgery aims to provide durable reflux control with minimal postfundoplication side effects. In general, for most patients this is achieved, although some are troubled by side effects. To minimize the risk of side effects, routine use of a partial fundoplication has been proposed. However, the perception that there is a paucity of long-term follow-up data for antireflux surgery has recently led to published American guidelines for the surgical treatment of reflux recommending “controlled studies with long-term follow-up” to determine the surgical therapy of choice.<sup>7</sup> Long-term follow-up data is available in many relevant randomized controlled trials,<sup>13,14,18,19</sup> and excellent outcomes have been demonstrated for anterior partial fundoplication variants in randomized controlled trials at 5 and 10 years follow-up.<sup>13,14,18</sup> In contrast, the 5-year outcomes of another trial has suggested inferior reflux control after anterior partial fundoplication.<sup>19</sup> In our current study, we provide further analysis of long-term outcome data from 4 randomized controlled trials, and by combining the 5-year outcome data sets for further analysis of the original data we have accessed the largest randomized controlled data set, which evaluates anterior partial versus Nissen fundoplication. The American guidelines for antireflux surgery correctly conclude that differences in outcome between anterior 90° and 180° partial fundoplication have not been investigated.<sup>7</sup> To identify potential differences in outcome between the anterior fundoplication subtypes,



**FIGURE 2.** Reoperation rate and indications for reoperation at 5 years after anterior 90° partial (90° LAF) versus Nissen fundoplication (LNF), and anterior 180° partial (180° LAF) versus Nissen fundoplication (LNF).

**TABLE 3.** Symptomatic Outcome at 5 Years After Anterior 180° and Nissen Fundoplication

	Anterior 180°	Nissen	P
Reflux symptoms			
Analog heartburn score*	1.8 [2.7] (n = 120)	1.6 [2.7] (n = 132)	0.316
Use of antisecretory drugs	2/51 [3.9%]	4/52 [7.7%]	0.414
Dysphagia			
Dysphagia	8/38 [21.1%]	19/33 [57.6%]	0.002
Analog score for dysphagia for liquids*	0.5 [1.4] (n = 121)	1.2 [1.8] (n = 132)	<0.001
Analog score for dysphagia for solids*	1.3 [2.1] (n = 121)	2.5 [2.8] (n = 131)	<0.001
0–45 Dysphagia score*	5.3 [7.3] (n = 120)	8.8 [9.5] (n = 132)	0.003
Normal diet	106/119 [89.1%]	114/131 [87.0%]	0.618
Dilatation for dysphagia	2/121 [1.7%]	6/132 [4.5%]	0.191
Gas-related symptoms			
Inability to belch	19/120 [15.8%]	46/132 [34.8%]	0.001
Gas bloating	63/120 [52.5%]	77/132 [58.3%]	0.352
Inability to relieve bloating	30/100 [30.0%]	55/123 [44.7%]	0.024
Increased flatulence	57/110 [51.8%]	79/119 [66.4%]	0.025
Patient satisfaction			
Analog score for satisfaction*	8.5 [2.2] (n = 119)	8.2 [2.8] (n = 130)	0.643
Correct decision for surgery?	107/116 [92.2%]	111/124 [89.5%]	0.465
Visick score			0.254
1 (no symptoms)	55 [47.4%]	51 [39.5%]	
2 (mild symptoms)	41 [35.3%]	54 [41.9%]	
3 (moderate symptoms)	13 [11.2%]	10 [7.8%]	
4 (symptoms interfering with life)	5 [4.3%]	6 [4.7%]	
5 (symptoms not improved)	2 [1.7%]	8 [6.2%]	
Visick 1 and 2 (no or mild symptoms)	96/116 [82.8%]	105/129 [81.4%]	0.781

\*Values are given as mean [SD].

we stratified and compared these subtypes separately with Nissen fundoplication in a randomized fashion.

At 5 years follow-up, control of heartburn symptoms were similar for anterior 180° partial versus Nissen fundoplication, but inferior for anterior 90° fundoplication versus Nissen fundoplication. The use of antisecretory medication after anterior 180° partial fundoplication was similar to Nissen fundoplication, but more common after anterior 90° partial fundoplication versus Nissen fundoplication. This supports the contention that anterior 90° partial fundoplication creates a less effective antireflux barrier than the Nissen fundoplication. It should be noted, however, that use of antisecretory medication does not imply that all patients using these medications have recurrent reflux. Earlier studies have demonstrated that only a small proportion of these patients have abnormal esophageal acid exposure on pH monitoring<sup>1,2,20</sup> or endoscopic evidence of fundoplication disruption.<sup>3</sup> Others have demonstrated that approximately two thirds of patients who take these medications after fundoplication, use them for atypical symptoms, unrelated to the original symptoms, or use medication in combination with nonsteroidal anti-inflammatory agents for gastric mucosal protection.<sup>1,20</sup> The use of antisecretory medications should therefore only be interpreted as a “relative” indicator of recurrent reflux.<sup>1,20</sup> Both anterior 90° and 180° partial fundoplications were associated with less dysphagia and gas-related symptoms compared with Nissen fundoplication, and the extent of the reduction in this problem was similar for both anterior partial fundoplication procedures. Consistent with these outcomes was a higher incidence of reoperation for recurrent reflux after anterior partial fundoplication, a higher incidence of reoperation for dysphagia after Nissen fundoplication, even though the overall number of operative revision procedures were not significantly different for all procedures. Measures of overall patient satisfaction were not significantly different for both types of anterior partial fundoplication and Nissen fundoplication. Overall, this suggests that the best clinical outcome at 5 years follow-up was achieved after anterior 180° partial fundoplication.

The long-term differences in postfundoplication symptoms between anterior and Nissen fundoplication are supported by studies that have evaluated physiological effects of fundoplication. Impaired lower esophageal sphincter relaxation correlates with postfundoplication dysphagia.<sup>21,22</sup> A recent meta-analysis suggested that lower esophageal sphincter relaxation is more likely to be incomplete after posterior than anterior partial fundoplication.<sup>8</sup> This is probably a consequence of placement of the stomach behind the intra-abdominal esophagus, and this mechanism probably contributes to the higher incidence of dysphagia after Nissen fundoplication. Furthermore, it is commonly assumed that impairment of the ventilation of swallowed air from the stomach (ie, inability to belch) causes gas bloating and flatulence after fundoplication.<sup>23</sup> A recent study by our group suggests that air venting from the stomach is easier after partial than Nissen fundoplication, and this could explain a reduced risk of gas bloat and flatulence.<sup>28</sup>

A previous randomized controlled trial reported by Hagedorn et al demonstrated poorer reflux control 5 years after an anterior 120° partial fundoplication, compared with posterior partial fundoplication.<sup>19,24</sup> Might different types of anterior partial fundoplication have different outcomes? The key difference between the anterior 180° and the 90° and 120° variants is extent of anchorage of the fundoplication to the hiatal rim on the right side of the esophagus. In the anterior 180° partial fundoplication, the gastric fundus is sutured securely to the right hiatal pillar and to the esophageal wall with 3 to 4 sutures, whereas the stomach is not sutured to the right hiatal pillar in the 90° and 120° variants. When undertaking revision surgery for recurrent reflux, we have noted that an anterior 180° fundoplication always remains securely attached to the right hiatal pillar,

whereas with the lesser anterior 90° and 120° partial fundoplications, lack of anchorage on the right side can allow the fundoplication to unravel to some extent in some patients. This might account for differences in the rates of recurrent reflux. In general, posterior partial fundoplications are also anchored to the hiatal rim, and the Nissen fundoplication is constructed in a manner that does not allow it to “unwind.” Variation in construction probably accounts for different clinical outcomes between different wrap types at late follow-up, and we now believe that secure anchorage of a partial fundoplication to a rigid structure such as the hiatal rim during construction is a key step for achieving effective long-term control of reflux.

Strengths of our current study are the randomized design, common protocols across all trials, the large sample size ( $n = 461$ ), and the use of raw data sets for our current data analysis. Surgical techniques for construction of the fundoplication were identical, except that in one trial short gastric vessels were routinely divided in the Nissen fundoplication arm.<sup>9</sup> However, multiple randomized controlled trials have shown that division of the short gastric blood vessels during Nissen fundoplication provides no advantage.<sup>5</sup> Bias associated with incomplete follow-up<sup>25</sup> was limited by the high level of complete follow-up at 5 years across our combined data set (94.1%).

A potential limitation of our study is that 3 of the 4 trials were performed in Australia,<sup>9–11</sup> and 1 in South Africa.<sup>12</sup> However, the principal investigator of the South African trial worked with the Australian research group during the first trial, and then applied identical surgical techniques and questionnaires in the South African patient population.<sup>12</sup> The only difference in data collection was that the use of antisecretory medication was not assessed in the South African trial.<sup>12</sup> Another limitation is that we relied on clinical follow-up using validated questionnaires and we did not repeat pH monitoring, esophageal manometry, or endoscopy at 5 years. Objective studies were undertaken at early follow-up in each trial, and the results have been reported previously.<sup>9–11</sup> At early follow-up, there were no differences in endoscopic findings or normalization of acid exposure times between the different types of fundoplication.<sup>9–11</sup> Our previous experience with trying to obtain compliance with objective follow-up in otherwise well patients has shown that a high rate of compliance with studies such as manometry and pH monitoring at multiple points during clinical trials is not feasible in our communities.<sup>11,25</sup> Despite this, the clinical outcomes we have reported are still informative, and these clinical outcomes are arguably more relevant to day-to-day clinical practice, in which patients determine the success of antireflux surgery by the resolution of clinical symptoms, rather than the results of objective investigations.

Even though our data has demonstrated equivalence for reflux control, and less side effects for anterior 180° partial versus Nissen fundoplication, it remains possible that subgroups of patients might have different outcomes. For example, equivalence of reflux control might not be true for individuals with more severe gastroesophageal reflux, and a tailored approach to fundoplication might have some merit. Unfortunately, however, it is difficult to undertake meaningful subgroup analyses on smaller groups of patients without compromising the statistical validity of our current data analysis. Further appropriately designed studies are needed to specifically explore whether some clinical subgroups might do better after one or other type of fundoplication.

Recently published meta-analyses comparing posterior partial (Toupet) with Nissen fundoplication have also concluded that posterior partial fundoplication offers similar reflux control, but with fewer troublesome postfundoplication side effects compared with the Nissen procedure.<sup>4,26</sup> Our study demonstrates that anterior 180° partial fundoplication has the same advantages over Nissen fundoplication. Two randomized controlled trials of an anterior versus posterior partial fundoplication have been reported, and both suggest better reflux

control after posterior fundoplication, less side effects after anterior partial fundoplication, and equivalent overall satisfaction with the outcome of surgery.<sup>19,27</sup> However, as discussed above, Hagedorn et al evaluated an anterior 120° not a 180° partial fundoplication.<sup>19,24</sup> The trial reported by Khan et al did evaluate an anterior 180° partial fundoplication, but only reported 12 months follow-up, and this follow-up was incomplete, being available for only 57% of the enrolled patients at this early time point.<sup>27</sup> Hence, more trials are needed to address the relative advantages, if any, of anterior 180° versus posterior partial fundoplication for the surgical treatment for gastroesophageal reflux.

In conclusion, in this comparison of anterior 90° and anterior 180° versus Nissen fundoplication at 5 years follow-up, anterior 180° partial fundoplication achieved the best overall outcome, with equivalent reflux symptom control but less side effects compared with Nissen fundoplication. Reflux control after anterior 90° partial fundoplication appears less effective than after Nissen fundoplication, and overall this suggests that an anterior 180° partial fundoplication is an appropriate operation for the treatment of uncomplicated gastroesophageal reflux disease, and in our centers this is now the most commonly performed antireflux procedure.

### ACKNOWLEDGMENTS

The authors acknowledge the support of Dr Stephen Archer, Dr Justin Bessell, Dr Michael Booth, Dr Richard Cade, Dr Graham Cullingford, Professor David Fletcher, Dr James Hurley, Dr George Kiroff, Professor Christopher Martin, Dr Ian Martin, Professor Lesley Nathanson, and Professor John Windsor who contributed patients to a multicenter trial of anterior 90° partial versus Nissen fundoplication.<sup>10</sup> Dr Philip Game and Dr Robert Britten-Jones contributed patients to the trial of anterior 180° partial versus Nissen fundoplication undertaken in Adelaide, South Australia.<sup>11</sup>

J.A.B. was supported by a University Medical Center Utrecht Alexandre Suerman MD/PhD grant. The randomized controlled trials conducted in Australia were supported by research project grants from the National Health and Medical Research Council (NHMRC) of Australia (grant Nos 157986 & 480401). These trials were registered with the Australasian Clinical Trials Register (ACTRN12607000298415, ACTRN12607000303448 & ACTRN12607000304437).

### REFERENCES

- Broeders JA, Rijnhart-de Jong HG, Draaisma WA, et al. Ten-year outcome of laparoscopic and conventional Nissen fundoplication: randomized clinical trial. *Ann Surg.* 2009;250:698–706.
- Draaisma WA, Rijnhart-de Jong HG, Broeders IA, et al. Five-year subjective and objective results of laparoscopic and conventional Nissen fundoplication: a randomized trial. *Ann Surg.* 2006;244:34–41.
- Salminen PT, Hiekkanen HI, Rantala AP, et al. Comparison of long-term outcome of laparoscopic and conventional Nissen fundoplication: a prospective randomized study with an 11-year follow-up. *Ann Surg.* 2007;246:201–206.
- Broeders JA, Mauritz FA, Ahmed AU, 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;97:1318–1330.
- Catarci M, Gentileschi P, Papi C, et al. Evidence-based appraisal of antireflux fundoplication. *Ann Surg.* 2004;239:325–337.
- Varin O, Velstra B, De SS, et al. Total vs partial fundoplication in the treatment of gastroesophageal reflux disease: a meta-analysis. *Arch Surg.* 2009;144:273–278.
- Stefanidis D, Hope WW, Kohn GP, et al. Guidelines for surgical treatment of gastroesophageal reflux disease. *Surg Endosc.* 2010;24:2647–2669.
- Broeders JA, Roks DJ, Ali UA, et al. Laparoscopic anterior versus posterior fundoplication for gastroesophageal reflux disease: systematic review and meta-analysis of randomized clinical trials. *Ann Surg.* 2011;254:39–47.
- Watson DI, Jamieson GG, Lally C, et al. Multicenter, prospective, double-blind, randomized trial of laparoscopic nissen vs anterior 90 degrees partial fundoplication. *Arch Surg.* 2004;139:1160–1167.
- Spence GM, Watson DI, Jamieson GG, et al. Single center prospective randomized trial of laparoscopic Nissen versus anterior 90 degrees fundoplication. *J Gastrointest Surg.* 2006;10:698–705.
- Watson DI, Jamieson GG, Pike GK, et al. Prospective randomized double-blind trial between laparoscopic Nissen fundoplication and anterior partial fundoplication. *Br J Surg.* 1999;86:123–130.
- Baigrie RJ, Cullis SN, Ndhluni AJ, et al. Randomized double-blind trial of laparoscopic Nissen fundoplication versus anterior partial fundoplication. *Br J Surg.* 2005;92:819–823.
- Ludemann R, Watson DI, Jamieson GG, et al. Five-year follow-up of a randomized clinical trial of laparoscopic total versus anterior 180 degrees fundoplication. *Br J Surg.* 2005;92:240–243.
- Nijjar R, Watson D, Jamieson G, et al. Five-year follow-up of a multicenter, double-blind randomized clinical trial of laparoscopic Nissen vs anterior 90 degrees partial fundoplication. *Arch Surg.* 2010;145:552–557.
- Jamieson GG, Watson DI, Britten-Jones R, et al. Laparoscopic Nissen fundoplication. *Ann Surg.* 1994;220:137–145.
- Dakkak M, Bennett JR. A new dysphagia score with objective validation. *J Clin Gastroenterol.* 1992;14:99–100.
- Watson DI, Pike GK, Baigrie RJ, et al. Prospective double-blind randomized trial of laparoscopic Nissen fundoplication with division and without division of short gastric vessels. *Ann Surg.* 1997;226:642–652.
- Cai W, Watson DI, Lally CJ, et al. Ten-year clinical outcome of a prospective randomized clinical trial of laparoscopic Nissen versus anterior 180(degrees) partial fundoplication. *Br J Surg.* 2008;95:1501–1505.
- Engström C, Lönroth H, Mardani J, et al. An anterior or posterior approach to partial fundoplication? Long-term results of a randomized trial. *World J Surg.* 2007;31:1221–1225.
- Wijnhoven BP, Lally CJ, Kelly JJ, et al. Use of antireflux medication after antireflux surgery. *J Gastrointest Surg.* 2008;12:510–517.
- Scheffer RC, Samsom M, Frakking TG, et al. Long-term effect of fundoplication on motility of the oesophagus and oesophagogastric junction. *Br J Surg.* 2004;91:1466–1472.
- Mathew G, Watson DI, Myers JC, et al. Oesophageal motility before and after laparoscopic Nissen fundoplication. *Br J Surg.* 1997;84:1465–1469.
- Woodward ER, Thomas HF, McAlhany JC. Comparison of crural repair and Nissen fundoplication in the treatment of esophageal hiatus hernia with peptic esophagitis. *Ann Surg.* 1971;173:782–792.
- Hagedorn C, Jonson C, Lonroth H, et al. Efficacy of an anterior as compared with a posterior laparoscopic partial fundoplication: results of a randomized, controlled clinical trial. *Ann Surg.* 2003;238:189–196.
- Ludemann R, Watson DI, Jamieson GG. Influence of follow-up methodology and completeness on apparent clinical outcome of fundoplication. *Am J Surg.* 2003;186:143–147.
- Shan CX, Zhang W, Zheng XM, et al. Evidence-based appraisal in laparoscopic Nissen and Toupet fundoplications for gastroesophageal reflux disease. *World J Gastroenterol.* 2010;16:3063–3071.
- Khan M, Smythe A, Globe J, et al. Randomized controlled trial of laparoscopic anterior versus posterior fundoplication for gastro-oesophageal reflux disease. *ANZ J Surg.* 2010;80:500–505.
- Broeders JA, Bredenoord AJ, Hazebroek EJ, Broeders IA, Gooszen HG, Smout AJ. Reflux and belching after 270 degree versus 360 degree laparoscopic posterior fundoplication. *Ann Surg.* 2012;255:59–65.