Surg Endosc (2012) 26:413–422
DOI 10.1007/s00464-011-1889-5

Laparoscopic Nissen versus Toupet fundoplication: objective and subjective results of a prospective randomized trial

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Received: 22 March 2011 / Accepted: 4 August 2011 / Published online: 5 September 2011

Abstract
Background Although symptom outcomes following laparoscopic fundoplication have been adequately evaluated in the past, comparative subjective data of laparoscopic Nissen and Toupet fundoplications are scarce. Multichannel intraluminal impedance monitoring (MII) has not been used so far for comparison of objective data.
Methods One hundred patients with documented chronic gastroesophageal reflux disease (GERD) were randomly allocated to either floppy Nissen fundoplication (group I, $n = 50$) or Toupet fundoplication (group II, $n = 50$). Gastrointestinal Quality of Life Index (GIQLI), symptom grading, esophageal manometry, and MII data were documented preoperatively and 3 months after surgery. Subjective and objective outcome data were compared to those of healthy individuals.
Results Symptom intensity was significantly more severe and GIQLI showed impairment in the examined patient population compared to healthy controls. Both procedures resulted in a significant improvement in GIQLI and GERD symptoms ($p < 0.01$). Dysphagia improved significantly only in group II, while cough, asthma, and distortion of taste improved significantly in both groups. Hoarseness symptoms showed some degree of improvement in both groups but reached statistical significance only in group I. Postoperatively, bowel symptoms partly increased and the ability to belch decreased in both groups ($p < 0.05$). Comparison of postoperative GIQLI and symptom scores showed no significant difference between the two groups, except for the ability to belch, which was more impaired after Nissen fundoplication. Both procedures resulted in a significant improvement in lower esophageal sphincter (LES) pressure; however, the improvement was greater in group I than in group II. MII data showed more reflux control after Nissen, but the differences between the procedures were not significant.
Conclusions Both procedures equally improve quality of life and GERD symptoms. Bowel symptoms may increase after both procedures at the 3-month follow-up. Manometry and MII data favor Nissen fundoplication, but dysphagia and the inability to belch are more common compared to Toupet fundoplication.

Keywords Laparoscopic antireflux surgery · GERD quality of life · Nissen · Toupet

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Laparoscopic antireflux surgery (LARS) is the standard procedure with proven success in the surgical treatment of gastroesophageal reflux disease (GERD). Long-term follow-up has demonstrated a good to excellent outcome after LARS in most patients [1–3]. However, the potential benefits of surgery must be weighed against potential side effects, including epigastric pain, gas bloat (ability to belch or fullness), and bowel dysfunction (obstipation, flatulence, and diarrhea) [4].

The most common antireflux procedure worldwide is laparoscopic Nissen fundoplication. Toupet fundoplication has been recommended to avoid some of the postoperative side effects of a total fundoplication. The choice of surgical technique to provide optimal reflux control while minimizing side effects such as dysphagia remains controversial. Many centers

have used the so-called "tailored approach" for years. It was assumed that Toupet fundoplication would offer less resistance in patients with reduced esophageal motility, thus lowering the dysphagia rate. Some surgeons favor the Toupet fundoplication, arguing that a partial fundoplication is more physiological, allowing air to vent from the stomach and therefore reducing the rate of side effects [5, 6].

A recent systematic review and meta-analysis of laparoscopic Nissen versus Toupet fundoplication favored Toupet fundoplication because of less postoperative dysphagia, lower reoperation rate, lower prevalence of the inability to belch, and less gas bloat [7]. However, the numbers of patients in the available studies diverge and patients were excluded or stratified by esophageal motility. In the meantime, it has been proven that both Nissen and Toupet can be applied independent of motility. This enables the comparison of the two techniques where patients can be randomized irrespective of preoperative esophageal motility [8].

Classical outcomes for the evaluation of surgical procedures usually are perioperative mortality, morbidity, recurrence rate, and long-term survival. However, from the patient's point of view, the so-called heuristic end points such as symptom resolution, duration of convalescence, patient satisfaction, well-being, and quality of life (QoL) are at least as important as the "classical" outcomes [9]. These subjective outcomes are particularly relevant in LARS for GERD because one of the goals of the procedure is to improve the patient's GERD symptoms and QoL, providing subjective satisfaction with the treatment [10]. In previous studies, objective surgical outcome after LARS was evaluated by esophageal manometry and 24-h pH monitoring. In this study a multichannel intraluminal impedance–pH-monitoring system was used for assessment of objective data.

The aim of this study was to compare subjective and objective outcomes and surgical side effects of Nissen and Toupet fundoplications performed in a single institution by only two surgeons and to compare pre- and postoperative findings to healthy individuals.

Material and methods

Between October 2007 and April 2010, a total of 100 consecutive chronic GERD patients entered the trial. Patients were randomized to undergo a laparoscopic floppy Nissen fundoplication (group I, $n = 50$) or a Toupet fundoplication (group II, $n = 50$). Before surgery, all patients were required to provide a detailed evaluation of GERD-related symptoms and quality of life and undergo an esophagogastroduodenoscopy with biopsy and histological examination, barium radiography, multichannel intraluminal impedance monitoring (MII), and esophageal manometry.

Indication for surgery in all patients was a long history of GERD symptoms, persistent or recurrent symptoms despite optimal medical treatment, persistent or recurrent complications of GERD, reduced QoL as a result of increasing esophageal exposure to gastric juice, and pathological values in the preoperatively evaluated functional parameters.

None of the patients had previously undergone an antireflux procedure. All patients were admitted to the study only after being instructed properly about the trial and signing the appropriate informed consent form. Randomization to undergo Nissen or Toupet fundoplication was performed via a random sampling number picked immediately before surgery by an independent member of the team.

Surgical technique

All patients underwent laparoscopic fundoplication in a standardized way by two experienced laparoscopic surgeons. Irrespective of preoperative manometric findings and depending on the preoperative randomization, a laparoscopic 360° "floppy" Nissen fundoplication or a 270° Toupet fundoplication was fashioned. Our technique of laparoscopic fundoplication has been described previously in detail [11].

Quality-of-life evaluation

Quality of life (QoL) was evaluated by means of the German Gastrointestinal Quality of Life Index (GIQLI) [12]. This questionnaire is well established [13–15] and has been validated and recommended by the European Study Group for Antireflux Surgery [16]. The GIQLI includes 36 items and the general response to it is graded from 0 to 144 points. The GIQLI is divided into five subdimensions: gastrointestinal symptoms (0–76 points), emotional status (0–20 points), physical functions (0–28 points), social functions (0–16 points), and a single item for stress of medical treatment (0–4 points). Higher scores indicate a better QoL.

Symptoms and surgical side effects evaluation

Symptoms and postoperative side effects evaluation was carried out in a standardized way using a written questionnaire, the so-called Symptom Check List (SCL). The SCL is an instrument of our house used to assess the dimensions of the patients' GERD and possible postoperative side effects. It is similar to the symptom score evaluation used by the Anvari group [17]. The questionnaire was administered to all patients by an independent observer. No patient was taking antireflux medication at the time

the questionnaire was administered. The patients had either stopped medication 7 days before diagnostic testing or had undergone surgery and were no longer taking antireflux medication.

The SCL asks about 14 specific symptoms, namely, heartburn, regurgitation, epigastric pain, cough, hoarseness, asthma, dysphagia, fullness, diarrhea, flatulence, constipation, belching, bloatedness, and distortion of taste. All symptoms were scored as a product of severity (0–4) and frequency (0–4). For each symptom, the patients were asked two questions: "How much does this problem bother you?" and "How often do you have this problem?" The severity was classified from 0 (not at all) to 4 (very severe). The frequency was classified as 0 if the symptoms were absent, 1 if symptoms occurred once a week, 2 if symptoms occurred several times a week, 3 if symptoms occurred daily, and 4 if symptoms were permanent. To get the final result, the frequency of each symptom is multiplied by its degree, resulting in scores from 0 to 16 for each symptom, with a total maximum score of 224 and a minimum score of 0. Higher scores indicated more severe symptoms.

To enable a comparison of the SCL scores between patients with GERD and healthy individuals, the SCL was handed out to 50 healthy people who did not take antireflux medication.

Esophageal manometry

All patients were studied in the supine position after an overnight fast. Manometry was performed using a conventional 4.5-mm, nasoesophageal, 8-lumen polyethylene catheter, continuously water-perfused (0.5 ml/min) by a low-compliance pneumohydraulic capillary infusion pump system. Five channels with exit ports located at 5-cm intervals along the length of the catheter and oriented radially around the circumference of the catheter were linked to a transducer, and the pressures were recorded on a computerized polygraph and analyzed on a PC [18, 19]. Lower esophageal sphincter (LES) resting pressure, overall length, and abdominal length were obtained as arithmetic mean values from each of the five radial side holes during a standard station pull-through. LES resting pressure was measured as the mid-respiratory resting pressure (mmHg) in the high-pressure zone using mid-respiratory gastric pressure as zero reference.

Esophageal body motor function was assessed by recording pressures from side holes located at 3, 8, 13, 18, and 23 cm above the upper margin of the LES during ten wet swallows (5 ml each) at 20–30-s intervals. Esophageal amplitude was calculated from the mean intraesophageal baseline to the peak of the wave and presented in mmHg. Each wave was classified as normal, hypotensive (<30 mm in one of the two distal channels), or defective (interrupted or dropped, i.e., <15 mm in one of the two distal channels, or simultaneous over a 5-cm segment, i.e., beginning within 0.25 s of each other).

24-h ambulatory multichannel intraluminal impedance monitoring (MII)

All patients had discontinued antisecretory therapy at least 1 week before testing and were encouraged to maintain their normal activities and mealtimes and to remain upright during the day except for one short nap allowed. We used an ambulatory Sleuth® multichannel intraluminal impedance–pH-monitoring system (Sandhill Scientific, Highland Ranch, CO). A 2.1-mm nasogastric probe was inserted with two antimony pH electrodes located 5 cm above the manometrically located LES and 15 cm distal below the LES and with eight impedance electrodes which are used to measure intraluminal impedance in six segments at 3, 5, 7, 9, 15, and 17 cm above the LES. Data were recorded to the flash card of a portable datalogger at 50 samples per second. Patients were asked to report meal periods, posture changes, and symptoms by pressing one of three different event buttons on the data recorder. Reportable symptoms were heartburn, regurgitation, cough, or other, if troublesome to the patient. Meal periods were excluded from the analysis. The recorded tracings were preanalyzed on a PC using an autoscan algorithm (BioVIEW™, Sandhill Scientific) and visually revised by an expert reader in 3-min intervals. Analysis included identification, enumeration, and classification of liquid and mixed (liquid/gas) reflux events and measurement of acid and volume clearance times. A retrograde drop in impedance, starting in the distal esophagus and propagating at least to the next two impedance-measuring segments, defined liquid reflux and mixed reflux if superimposed by rapid increases in impedance, typically above 5,000 ohm occurring simultaneously or immediately before. Reflux events were classified by esophageal pH as acid (nadir pH < 4) or nonacid, proximal (reaching the proximal esophagus at 15 cm above the LES) or distal, and upright or recumbent. Recording time was at least 21 h, and the number of reflux events was converted to correlate to 24 h of total time, 24 h of recumbent time, and 24 h of upright time. A composite pH score according to DeMeester [20] but modified in the way that episodes with an esophageal pH < 4 only were included in the analysis, if started during retrograde bolus movement, was calculated by the software. Symptom analysis was done separately for each of the predominant symptom presentations determined for each subject. We used the Symptom Index (SI), which is the number of symptoms associated with reflux events based on a 5-min time window divided by the total number of symptoms. SI was declared positive if it was more than 50% [21].

GERD was diagnosed if the total number of reflux events in 24 h exceeded 73 [22, 23], if an abnormal esophageal acid exposition was found, when the reflux-related composite pH score according to DeMeester exceeded 14.7, or if SI was positive for symptoms reported at least three times.

Follow-up

The GIQLI questionnaire and the Symptom Check List were answered before surgery. Both GIQLI and SCL were handed out at the same time. Patients were seen 3 months after surgery to obtain manometry and MII measurements and to answer the GIQLI and SCL again.

Statistics

Statistical analysis was performed using SPSS statistical analysis software (SPSS Inc., Chicago, IL, USA). All data were tested for normal distribution by the Kolmogorov-Smirnov test. Comparison of pre- and postprocedural data was done using a paired *t*-test and the Wilcoxon signed-rank test, respectively, on a per-subject basis. Comparison between data sets was done using an independent *t*-test or the Mann-Whitney *U* test. All data were presented as median, 25th–75th quartile range, and 95th percentile. If normally distributed, the data were additionally presented as mean and standard deviation (SD). $p < 0.05$ was regarded as a significant change, and $p < 0.01$ was regarded as highly significant. In some cases, descriptive statistics were used.

Results

The mean age of the patients at the time of surgery was 49.61 (±11.76) years. There were 41 female and 59 male patients. The complete demographic data of all patients subdivided into the two surgical groups are shown in Table 1.

Comparison between the two groups before surgery

There were no significant differences between the groups regarding demographic data such as age, gender, or BMI (Table 1).

Quality of life

Preoperatively, the mean general GIQLI of the patients in group I was 92.2 (±22.19) points and in group II 97.0 (±16.74) points. There was no significant difference between the two groups except for social functions (more impaired in group I) in the five domains measured in the QoL tool used in this study. Compared to healthy individuals (122.6 ± 8.5 points), the mean GIQLI score showed significant impairment ($p < 0.01$) in both groups.

Symptoms

The mean general SCL score in group I was 46.21 (±32.31) points and in group II 37.62 (±18.20) points. Compared to the normative data of healthy individuals [6.12 (±5.15) points], the mean general SCL showed significant impairment ($p < 0.01$) in both groups. Comparison between the two groups showed no significant difference for all symptoms asked about in the SCL. Highly significant differences were found for all items asked about, except for constipation, between the GERD patients and the healthy individuals (Table 2).

Objective data

In group I, the mean preoperative LES pressure was 8.86 (±4.40) mmHg, mean number of refluxes was 95.43 (±45.55), and the mean DeMeester score was 22.69 (±17.0). In group II, the mean preoperative LES pressure was 7.80 (±3.99) mmHg, mean number of refluxes was 100.22 (±49.64), and the mean DeMeester score was 22.19 (±19.37). The total baseline reflux episodes detected by MII are given in Tables 3 and 4. The differences between the two groups were not statistically significant.

Table 1 |Patient demographics

Variable	Group I Nissen (n = 50)	Group II Toupet (n = 50)	p Group I/Group II
Women	20	16	ns
Men	30	34	ns
Age [mean (range)] (years)	49.70 (20–76)	52.36 (25–78)	ns
BMI [mean (range)]	28.59 (19.47–41.80)	27.60 (21.55–35.86)	ns

BMI body mass index, *ns* not significant

Table 2 Comparison between the two groups before surgery

SCL	Healthy	Nissen	*p* Healthy/Nissen	Toupet	*p* Healthy/Toupet
SCL score	6.48 (±5.35)	53.20 (±32.31)	<0.000	43.44 (±21.20)	<0.000
Heartburn score	0.24 (±0.63)	9.13 (± 4.74)	<0.000	7.34 (±4.52)	<0.000
Regurgitation score	0.06 (±0.31)	4.42 (±4.67)	<0.000	3.60 (±3.70)	<0.000
Belching score	0.88 (±1.69)	5.57 (±4.54)	<0.000	6.47 (±4.74)	<0.000
Bloatedness score	0.98 (±1.27)	5.09 (±4.62)	<0.000	4.46 (±4.00)	<0.000
Flatulence score	1.92 (±1.87)	5.51 (±3.81)	<0.000	4.64 (±3.27)	<0.000
Fullness score	1.10 (±1.58)	6.23 (±4.85)	<0.000	4.57 (±3.67)	<0.000
Constipation score	0.52 (±1.36)	1.42 (±3.19)	ns	0.93 (±2.36)	ns
Diarrhea score	0.24 (±0.59)	1.18 (±2.16)	<0.010	1.26 (±2.71)	<0.005
Epigastric pain score	0.14 (±0.61)	3.53 (±4.27)	<0.000	2.43 (±3.02)	<0.000
Dysphagia score	0.04 (±0.28)	1.91 (±3.70)	<0.000	1.98 (±3.62)	<0.000
Distortion of taste score	0.00 (±0.00)	0.72 (±1.93)	<0.001	0.77 (±1.98)	<0.001
Asthma score	0.06 (±0.42)	0.67 (±2.03)	<0.006	1.08 (±2.94)	<0.007
Hoarseness score	0.04 (±0.20)	2.47 (±4.54)	<0.000	1.43 (±2.88)	<0.000
Cough score	0.26 (±0.69)	3.13(±3.97)	<0.000	2.54 (±3.44)	<0.000

SCL symptom check list, *ns* not significant

Comparison between the two groups after surgery

All procedures could be completed successfully laparoscopically with no intraoperative complications in either surgical group.

Follow-up

Three months after surgery 46/50 (92%) patients in group I and 48/50 (96%) patients in group II were available for follow-up. Reasons for loss of follow-up were reoperation or incomplete questionnaires.

Quality of life

After 3 months the QoL significantly improved in both groups (Table 5). There was no detectable difference between the two groups in any of the five domains measured in the QoL tool used in this study 3 months after the operation.

Symptoms and side effects

Three months after surgery there was a significant decrease in the typical GERD symptoms such as regurgitation, epigastric pain, and heartburn, with the scores for both

Table 3 Reflux episodes detected by MII before and after Nissen procedure

Reflux episodes	Total in 24 h		Acid in 24 h		Proximal in 24 h		Upright in 24 h		Recumbent in 24 h	
	Baseline	3 months	Baseline	3 months	Baseline	3 months	Baseline	3 months	Baseline	3 months
Mean	95.43	14.20	70.35	6.40	64.52	6.40	158.2	24.73	35.74	4.82
SD	45.55	14.48	33.44	11.41	28.59	7.49	75.85	25.83	47.63	8.49
Min.	25	0	11	0	14	0	40	0	0	0
Max.	231	61	166	49	157	31	435	99	309	46
Percentile										
25th	65.75	2.50	48.25	0.00	46.75	1.00	116.8	4.50	12.50	0.00
Med.	86.50	10.00	62.50	1.00	60.50	3.00	140.5	16.00	22.50	2.00
75th	106.3	25.00	88.00	8.50	75.50	10.00	178.0	42.00	40.50	5.00
95th	220.8	47.60	139.6	39.70	134.9	23.90	372.0	84.10	95.95	27.30
Significance	$p < 0.000$		$p < 0.000$		$p < 0.000$		$p < 0.000$		$p < 0.010$	

Table 4 Reflux episodes detected by MII before and after Toupet procedure

Reflux episodes	Total in 24 h		Acid in 24 h		Proximal in 24 h		Upright in 24 h		Recumbent in 24 h	
	Baseline	3 months	Baseline	3 months	Baseline	3 months	Baseline	3 months	Baseline	3 months
Mean	100.22	19.00	71.85	6.69	64.20	9.36	167.9	33.98	34.02	5.91
SD	49.64	22.67	39.40	12.05	34.16	11.82	86.74	42.82	31.02	11.74
Min.	10	0	2	0	5	0	16	0	0	0
Max.	245	105	165	56	152	52	403	245	144	70
Percentile										
25th	70.50	6.00	42.50	0.00	40.75	1.00	118.5	10.00	10.50	0.00
Med.	85.50	10.00	62.00	2.00	59.00	5.00	149.5	20.00	27.00	2.00
75th	125.0	23.00	96.00	7.00	84.25	13.00	191.5	40.00	52.75	6.00
95th	192.85	83.80	158.8	40.00	141.6	35.80	359.9	119.8	98.65	28.40
Significance	$p < 0.000$		$p < 0.000$		$p < 0.000$		$p < 0.000$		$p < 0.000$	

MII multichannel intraluminal impedance

Table 5 Comparison of GIQLI before and after Nissen/Toupet fundoplication

	Nissen		*p*	Toupet		*p*
	Before surgery	3 months after surgery	pre/post Nissen	Before surgery	3 months after surgery	pre/post Toupet
General (healthy: 122.6)	92.22 (±22.19)	113.26 (±16.70)	<0.000	97.08 (±16.74)	114.94 (±14.28)	<0.000
Symptoms (healthy: 62.9)	48.57 (±10.92)	58.42 (±9.72)	<0.000	50.22 (±7.96)	60.27 (±7.81)	<0.000
Emotional (healthy: 18.5)	12.34 (±4.13)	16.64 (±2.80)	<0.000	13.16 (±3.74)	16.89 (±2.69)	<0.000
Physical (healthy: 23.5)	15.94 (±6.01)	21.13 (±4.49)	<0.000	16.92 (±5.34)	20.15 (±4.86)	<0.000
Social (healthy: 14.8)	12.51 (±2.91)	13.65 (±2.89)	ns	13.67 (±2.31)	14.02 (±2.40)	ns
Medical treatment (healthy: 3.8)	2.82 (±1.13)	3.43 (±0.81)	<0.008	3.12 (±1.14)	3.67 (±0.66)	<0.001

ns not significant

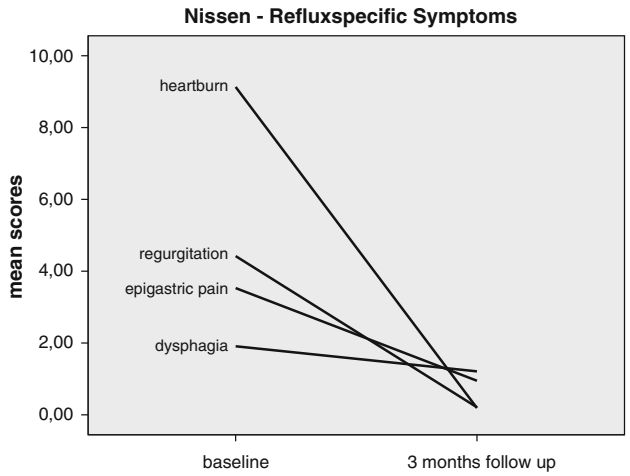

Fig. 1 Typical GERD symptoms after Nissen fundoplication

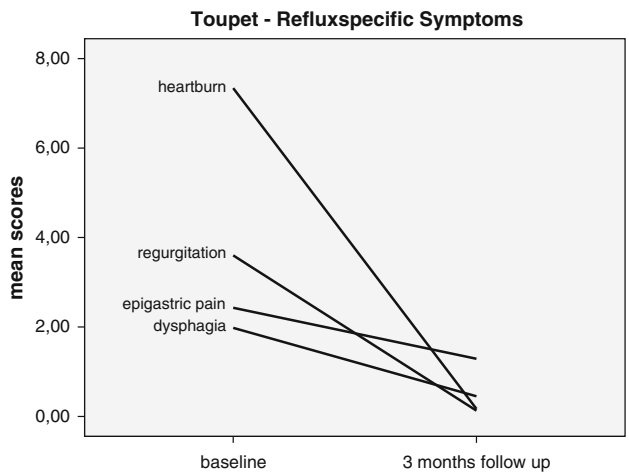

Fig. 2 Typical GERD symptoms after Toupet fundoplication

groups comparable to that of healthy individuals. The symptom of dysphagia decreased in both groups. In the Toupet group the decrease in dysphagia was significant compared to preoperative data (Figs. 1, 2).

Extraesophageal symptoms like cough, asthma, and distortion of taste improved significantly in both groups 3 months after surgery. Hoarseness also decreased in both groups; in group I the decrease was significant.

Postoperative side effects in the sense of enhancement of symptoms occurred, with a significant increase of flatulence in both groups, an increase of diarrhea in both groups which was significant after Nissen, and an increase in constipation, and bloatedness in group II. Belching was reduced significantly in both groups; however, it was still greater than that in healthy individuals. Comparison of all mean symptom scores evaluated showed a significant difference between the two groups for belching 3 months after surgery. No other significant differences were found between the two groups (Table 6 and Figs. 3, 4, 5).

Objective data

In both groups the mean LES pressure significantly improved to 12.54 (±3.40) mmHg in group I and 9.56 (±3.64) mmHg in group II; the improvement was significantly better after Nissen than after Toupet fundoplication. The mean number of refluxes decreased to 14.20 (±14.49) in group I and 19.00 (±22.67) in group II, and the mean DeMeester score decreased to 1.70 (±3.00) in group I and 4.75 (±17.75) in group II. Total postoperative reflux episodes detected by MII are given in Tables 3 and 4. The differences between the two groups with respect to MII data were not statistically significant.

Reoperations

Two of 100 patients (2%) suffered from severe postoperative symptoms and a reoperation was necessary. In both cases the patients had undergone a Nissen fundoplication (2/50; 4%). Indication for reoperation was prolonged dysphagia. During reoperation a recurrent hiatal hernia with intrathoracic slipping of an intact wrap was found; this was the cause of the dysphagia. In both cases reoperation was performed 2 months after surgery. After laparoscopic reintervention and performance of a 270° Toupet hemifundoplication, both patients are currently free of symptoms.

Discussion

Many investigations have been performed to find out the best surgical alternative to medical management of patients with GERD [5, 6]. An ideal antireflux procedure should be safe, effective, and durable, and result in minimal complications. There is significant evidence that anterior fundoplication offers less effective long-term reflux control compared to Nissen or Toupet [6]. The Nissen fundoplication has been shown to be safe, effective, and durable, but side effects like dysphagia, gas bloat, and bowel syndrome are associated with it. The most frequently used alternative is the Toupet fundoplication. Both Nissen and Toupet have proven to provide relief of GERD symptoms in the majority of patients [24].

The choice of surgical technique to provide optimal reflux control while minimizing side effects is still controversial. This study demonstrates that both Nissen and Toupet fundoplications significantly improve a patient's quality of life and provide optimal control of typical GERD

Table 6 Symptoms before and after Nissen/Toupet fundoplication

SCL	Nissen			Toupet		
	Before surgery	3 months postop	*p*	Before surgery	3 months postop	*p*
SCL score	53.20 (±32.31)	23.03 (±18.03)	<0.000	43.44 (±21.21)	27.04 (±17.05)	<0.000
Heartburn score	9.13 (± 4.74)	0.19 (±0.69)	<0.000	7.34 (±4.52)	0.17 (±0.92)	<0.000
Regurgitation score	4.42 (±4.67)	0.21 (±0.68)	<0.000	3.60 (±3.70)	0.13 (±0.45)	<0.000
Belching score	5.57 (±4.55)	1.98 (±3.21)	<0.000	6.47 (±4.74)	2.98 (±2.83)	<0.000
Bloatedness score	5.09 (±4.62)	4.49 (±4.48)	ns	4.46 (±4.00)	5.45 (±4.79)	ns
Flatulence score	5.51 (±3.81)	7.24 (±4.73)	<0.042	4.64 (±3.28)	7.37 (±4.38)	<0.001
Fullness score	6.23 (±4.85)	2.76 (±3.43)	<0.000	4.57 (±3.68)	2.58 (±2.92)	<0.002
Constipation score	1.42 (±3.19)	0.84 (±2.06)	ns	0.93 (±2.37)	1.19 (±3.05)	ns
Diarrhea score	1.18 (±2.16)	1.83 (±3.02)	<0.042	1.26 (±2.71)	2.00 (±2.81)	ns
Epigastric pain score	3.53 (±4.27)	0.95 (±1.77)	<0.001	2.43 (±3.02)	1.29 (±2.92)	<0.011
Dysphagia score	1.91 (±3.70)	1.21 (±3.16)	ns	1.98 (±3.62)	0.45 (±1.04)	<0.002
Distortion of taste score	0.72 (±1.93)	0.02 (±0.15)	<0.004	0.77 (±1.98)	0.10 (±0.59)	<0.007
Asthma score	0.67 (±2.03)	0.07 (±0.34)	<0.016	1.08 (±2.94)	0.25 (±0.86)	<0.033
Hoarseness score	2.47 (±4.54)	0.71 (±2.09)	<0.010	1.43 (±2.88)	1.02 (±2.57)	ns
Cough score	3.13(±3.97)	0.74 (±1.99)	<0.001	2.54 (±3.45)	1.04 (±2.33)	<0.003

SCL symptom check list, *ns* not significant

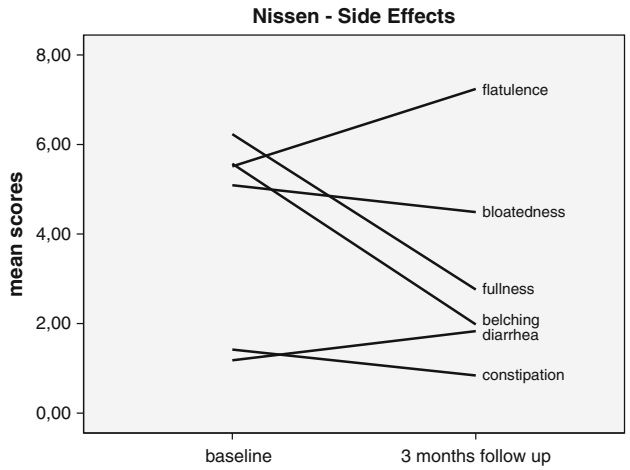

Fig. 3 Side effects (gas bloat and bowel symptoms) after Nissen fundoplication

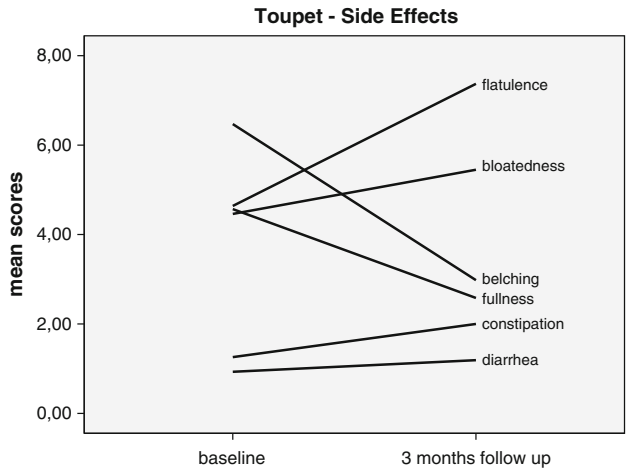

Fig. 4 Side effects (gas bloat and bowel symptoms) after Toupet fundoplication

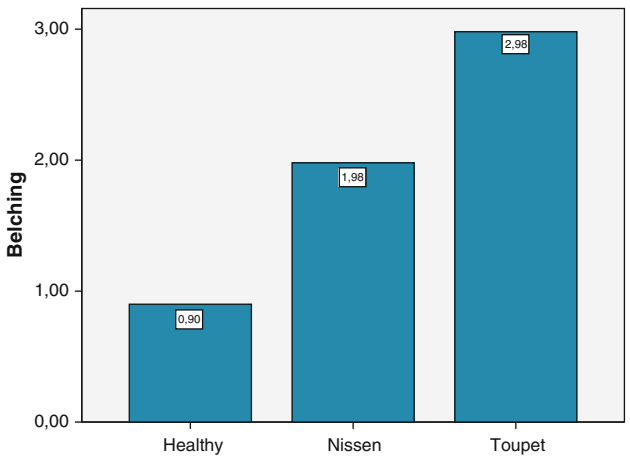

Fig. 5 Significant ($p < 0.008$) more patients are able to belch after Toupet fundoplication compared to Nissen

symptoms 3 months after surgery, irrespective of preoperative esophageal motility. In regard to dysphagia, this study shows that after LARS the rate of dysphagia is lower than before surgery. This is remarkable considering that dysphagia is supposed to be a postoperative side effect that occurs especially after Nissen fundoplication. However, the study clearly demonstrates that Toupet fundoplication is superior, with a significant reduction of preoperative dysphagia in group II 3 months after the operation. Preoperative dysphagia decreased in the Nissen group, but the reduction was not statistically significant. Furthermore, two patients from the Nissen group had to be reoperated on because of prolonged dysphagia. During redo surgery, it was found that there was intrathoracic "slipping" of the wrap and recurrence of hiatal hernia in both patients; thus, the reason for the dysphagia was not the wrap but a problem with the hiatal closure.

One of our main goals of this study was to evaluate which procedure causes fewer postoperative side effects. The benefits of surgery are often negated by the risk of severe dysphagia, an inability to belch, and increased bowel symptoms (e.g., diarrhea, flatulence, bloating, abdominal pain, and constipation) [25]. Recent studies showed that postoperatively new bowel symptoms occurred in 36% of the patients and gas bloat syndrome was present in 30% of the patients [26, 27].

So far no randomized clinical trial has evaluated gas bloat and bowel syndrome after Nissen and Toupet fundoplications. In the evaluation of postoperative gastrointestinal side effects, a fundamental question is the extent to which the side effects seen after laparoscopic fundoplication are already present before surgery in patients with chronic GERD. Klaus et al. [28] noted that bowel syndromes are found in 35% of the patients preoperatively. Another study reported that as many as 66% of patients who underwent antireflux surgery had preexisting irritable bowel syndrome [29]. Strate et al. [8] reported that 50% of the patients complain about gas bloat preoperatively. These observations underscore the importance of the evaluation of gastrointestinal symptoms before surgery. Otherwise, postoperative side effects would be overestimated. We were surprised to find that patients with chronic GERD suffer with gastrointestinal symptoms before surgery to such a high degree. Patients with GERD showed significantly higher scores for all items asked about preoperatively, except for constipation, compared to healthy individuals. In a large epidemiologic study that evaluated 3,318 adult patients from general practice clinics, 72% of the GERD patients were found to have functional bowel disorders. The most commonly reported symptoms were gas and flatulence (81%), transit disorders (62%), and abdominal distension (58%) [26]. These facts led to the question of whether there are actually any side effects,

except for dysphagia, after an antireflux procedure, as the symptoms are already present before surgery. Probably the preexisting gastrointestinal symptoms come into focus for the patient after the operation.

In this study, 3 months after surgery flatulence had increased and belching had decreased significantly in both groups, and diarrhea had increased in both groups, but only significantly after the Nissen procedure. No other significant side effects were detected. The increase in the constipation and bloatedness scores for group II was not statistically significant compared to the preoperative scores. Comparison between the two groups after surgery showed that belching is significantly more impaired after Nissen. No other significant differences between the two procedures were found. It was interesting to find that although the decrease in belching was significant in both groups, the mean scores were still higher compared to healthy individuals. Do patients who subjectively report belching really belch or are we talking about two different things? The role of belching, supragastric belching, and aerophagy pre- and postoperatively in GERD patients should be matter of further research.

The objective data of this study using MII show that both procedures provide excellent reflux control: Nissen slightly better but not significantly so compared to Toupet. The only significant difference was that Nissen led to a higher postoperative LES pressure. To date, it is assumed that a high postoperative LES pressure assures a good outcome for the patient. However, the results of this study give rise to the suspicion that the higher LES pressure after Nissen compared to Toupet could be the reason for the smaller reduction of dysphagia and the lower ability to belch. Long-term follow-up will be necessary to prove this theory.

Several studies demonstrated that the most common complication after LARS is intrathoracic herniation of the wrap into the chest, which is caused by inadequate closure of the crura or disruption of the crural closure [30–32]. Although the technique of hiatal closure was the same in both surgical groups in this study, symptomatic slipping and recurrent hiatal hernia occurred only after the Nissen procedure. Recent studies also reported a higher rate of reoperation after laparoscopic Nissen fundoplication compared to Toupet fundoplication [7, 8].

In conclusion, irrespective of preoperative esophageal motility, both procedures equally improve QoL and reduce typical GERD symptoms. Manometry and MII data favor Nissen fundoplication, but reoperations, dysphagia, and the inability to belch are more common after Nissen compared to Toupet fundoplication. Postoperatively, both methods lead to an increase of bowel symptoms. This study confirms that patients with GERD in general suffer more gastrointestinal symptoms. Whether this coincidence is one disease or an overlap of two disorders will be matter of further research. In summary, there is no distinct difference between the outcomes of the two procedures 3 months after surgery.

Disclosure Oliver Owen Koch, Adolf Kaindlstorfer, Stavros A. Antoniou, Kai Uwe Asche, Frank Alexander Granderath, and Rudolph Pointner have no conflicts of interest or financial ties to disclose.

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