Gastroesophageal reflux disease (GERD), commonly manifested by heartburn or regurgitation, is a chronic, progressive condition in which failed sphincter function allows the contents of the stomach to reflux into the esophagus, the airways and the mouth. Chronic GERD affects 10% of western society. The majority of patients receive adequate relief from proton pump inhibitors, but up to 40% have incomplete relief of symptoms that cannot be addressed by increasing the dose of medications. The laparoscopic Nissen fundoplication is the surgical gold standard; however, the level of technical difficulty and its side effects have limited its use to less than 1% of the GERD population. These factors have contributed to the propensity of patients to persist with medical therapy, even when inadequate to control symptoms and complications of the disease. Consequently, a significant gap in the treatment continuum for GERD remains evident in current clinical practice. The LINX™ Reflux Management System (Torax Medical) is designed to provide a permanent solution to GERD by augmenting the physiologic function of the sphincter barrier with a simple and reproducible laparoscopic procedure that does not alter gastric anatomy and can be easily reversed if necessary.

**Keywords:** adenocarcinoma • Barrett’s • fundoplication • esophagitis • gastroesophageal junction • gastroesophageal reflux disease • lower esophageal sphincter • magnetic sphincter augmentation • PPI • Nissen • LINX™ Reflux Management System • regurgitation

Gastroesophageal reflux disease (GERD), commonly manifested by heartburn or regurgitation, is a chronic, progressive condition in which failed sphincter function allows the contents of the stomach to reflux into the esophagus, the airways and the mouth. Chronic GERD affects 10% of western society. The majority of patients receive adequate relief from proton pump inhibitors, but up to 40% have incomplete relief of symptoms that cannot be addressed by increasing the dose of medications. The laparoscopic Nissen fundoplication is the surgical gold standard; however, the level of technical difficulty and its side effects have limited its use to less than 1% of the GERD population. These factors have contributed to the propensity of patients to persist with medical therapy, even when inadequate to control symptoms and complications of the disease. Consequently, a significant gap in the treatment continuum for GERD remains evident in current clinical practice. The LINX™ Reflux Management System (Torax Medical) is designed to provide a permanent solution to GERD by augmenting the physiologic function of the sphincter barrier with a simple and reproducible laparoscopic procedure that does not alter gastric anatomy and can be easily reversed if necessary.

**Keywords:** adenocarcinoma • Barrett’s • fundoplication • esophagitis • gastroesophageal junction • gastroesophageal reflux disease • lower esophageal sphincter • magnetic sphincter augmentation • PPI • Nissen • LINX™ Reflux Management System • regurgitation

Gastroesophageal reflux disease (GERD), commonly manifested by heartburn or regurgitation, is a chronic, progressive condition in which failed sphincter function allows the contents of the stomach to reflux into the esophagus, the airways and the mouth. Chronic GERD affects 10% of western society. The majority of patients receive adequate relief from proton pump inhibitors, but up to 40% have incomplete relief of symptoms that cannot be addressed by increasing the dose of medications. The laparoscopic Nissen fundoplication is the surgical gold standard; however, the level of technical difficulty and its side effects have limited its use to less than 1% of the GERD population. These factors have contributed to the propensity of patients to persist with medical therapy, even when inadequate to control symptoms and complications of the disease. Consequently, a significant gap in the treatment continuum for GERD remains evident in current clinical practice. The LINX™ Reflux Management System (Torax Medical) is designed to provide a permanent solution to GERD by augmenting the physiologic function of the sphincter barrier with a simple and reproducible laparoscopic procedure that does not alter gastric anatomy and can be easily reversed if necessary.

**Keywords:** adenocarcinoma • Barrett’s • fundoplication • esophagitis • gastroesophageal junction • gastroesophageal reflux disease • lower esophageal sphincter • magnetic sphincter augmentation • PPI • Nissen • LINX™ Reflux Management System • regurgitation
regurgitation with aspiration and Barrett’s metaplasia, a precursor to adenocarcinoma [7–9]. Recent literature has also indicated that chronic acid suppression may inhibit absorption of certain medications and critical nutrients [10,11], increase the risk of *Clostridium difficile* infection [12], and may be associated with an increased incidence of gastric cancer [13].

The Nissen fundoplication is the current surgical standard of care and a treatment option typically reserved for GERD patients who have failed medical therapy or desire to be free from dependence on medical therapy. It is an effective and durable surgical procedure if performed in specialized and high-volume centers [14–16].

Patients undergoing a Nissen fundoplication are at risk for potential side effects of the procedure such as the gas–bloat syndrome, the inability to belch and vomit, and the occurrence of chronic dysphagia. This is one of the reasons why gastroenterologists tend to limit their referrals for fundoplication only to patients with severe disease. On the other hand, studies on the cost–effectiveness of Nissen fundoplication versus PPIs are largely inconclusive [17].

The limitations of medical therapy and fundoplication create a considerable ‘therapy gap’ in the patient care continuum (Figure 1), leaving many patients and clinicians to choose between either tolerating a lifetime dependence on a medication even though they experience incomplete symptom relief, or risk a surgical procedure that permanently restructures their anatomy and may have considerable side effects. Eventually, fewer than 30,000 Nissen fundoplication procedures are performed annually in the USA, corresponding to less than 1% of the GERD population [18]; this explains why there is a large proportion of patients with incomplete relief of symptoms who could benefit from a simple sphincter augmentation procedure rather than an anatomic altering fundoplication.

The LINX™ Reflux Management System (LINX System; Torax Medical) was developed to address this ‘therapy gap’ through a simple laparoscopic procedure that preserves gastric anatomy, augments the physiologic barrier to reflux and can be reversed if necessary, thereby preserving the option of fundoplication or other therapies in the future. Importantly, the procedure is also designed to limit technical variability, and can be performed safely using standard laparoscopic techniques and instruments.

The LINX System uses magnetic force to augment the natural barrier function of the LES, thus, for reflux to occur, gastric pressures must overcome both the patient’s native LES pressure and the magnetic bonds of the device, by this means creating a resistance to opening. Importantly, the device, while augmenting the LES, also allows for expansion to accommodate a swallowed bolus or the escape of elevated gastric pressure associated with belching or vomiting, thus inhibiting reflux without compromising the physiologic function of the LES (Figure 2) [19].

The LINX System device consists of a series of titanium beads with magnetic cores hermetically sealed inside. This series of beads is interlinked with independent titanium wires to form a flexible ring. The strength of the magnetic core contained in each bead is calibrated by mass to provide a resisting force that precisely augments the sphincter’s function. This attractive force between closed beads is approximately 40 g; this decreases exponentially with distance so the attractive force at full separation is approximately 7 g. The device is manufactured in different sizes from ten to 18 beads and is capable of nearly doubling its diameter when all beads are separated. The magnetic attraction force to

**Figure 1. Depiction of the ‘therapy gap’ concept.** A large proportion of patients with GERD receive incomplete relief of symptoms from PPIs; on the other hand, a fundoplication that significantly alter gastroesophageal anatomy may not be the ideal surgical procedure in individuals with early, uncomplicated disease. GERD: Gastroesophageal reflux disease; PPI: Proton pump inhibitor.

**Figure 2. The LINX™ Reflux Management System (Torax Medical) device is implanted at the gastroesophageal junction.** (A) The magnetic bonds of the device augment the resistance of the lower esophageal sphincter and impede reflux; (B) upon swallowing, the magnetic force between the beads is reduced to accommodate the bolus. Reproduced with permission from [21].

doi:10.1586/EGH.12.47
be counteracted to allow bead separation is independent of the number of beads contained in the device.

The LINX System device is implanted laparoscopically under general anesthesia, typically using five ports. Once access to the abdominal cavity is gained, dissection begins by dividing the peritoneum on the anterior surface of the gastroesophageal junction below the insertion of the inferior leaf of the phrenoesophageal ligament and above the junction of the hepatic branch to the anterior vagus nerve (Figure 3).

Dissection of the gastrohepatic ligament is made above and below the hepatic branch to facilitate retroesophageal dissection along the anterior border of the right crus just cephalad to the decussation of the crura. The same dissection is repeated along the left crus. If a hiatal hernia is present, it can be repaired at the discretion of the surgeon. The decision as to proceed with a posterior crural repair depends on the size of the hernia that is found intraoperatively; a sliding hernia up to 3 cm in size can be effectively repaired by approximating the crura with a few interrupted stitches and then the device can safely be implanted.

Gentle dissection from the right side opens a retroesophageal window and a tunnel is formed between the posterior esophageal wall and the posterior vagus nerve to accommodate the LINX System device.

A 6-mm Penrose drain is passed through the posterior tunnel and encircles the esophagus to maintain access and facilitate passage of the LINX System. A special sizing tool is used to precisely measure the outer diameter of the esophagus and indicate the size of the LINX System device to be implanted. No bougie is required. The sizing tool is a laparoscopic instrument with a soft, circular, curved tip actuated by coaxial tubes through a handset. The handle set contains a numerical indicator that corresponds with the size range of the LINX System device. The sizing tool is brought into the surgical field through the right laparoscopic port; it is placed around the esophagus in the dissected space between the posterior esophageal wall and the posterior vagus nerve bundle.

Once the appropriate device has been selected, it is introduced through the posterior tunnel. The opposing ends are then brought to the anterior surface of the esophagus, approximated and secured; this completes the implant process (Figure 4).

Operative time is approximately 30 min. Patients are discharged on the day of surgery or on the first postoperative day under direction to return to a normal diet as tolerated and discontinue use of acid suppression medication.

Patients typically return to normal physical activity in less than a week. The most common complaint following the LINX System procedure is mild dysphagia, which is easily tolerated and requires only temporary diet adjustments.

Clinical use of the LINX System device started in 2007 within the context of a feasibility multicenter trial. In Europe, use of the device continued within a registry for antireflux surgery after the trial ended. At the authors’ center in Milan, Italy, so far, a total of 117 patients have been implanted. Two prospective, multicenter, controlled clinical studies have been conducted under an US FDA investigational device exemption to evaluate the LINX System.

Figure 3. The minimal surgical dissection required for the operation. A tunnel is created between the posterior vagus nerve and the esophageal wall to accommodate the LINX™ Reflux Management System (Torax Medical) device.

The first study evaluated 44 patients implanted with the LINX System between February 2007 and October 2008 [20]; the 2- and 4-year results of this study have been previously published and are presented below [21,22]. Data from the first study was submitted for CE mark approval and was determined to have a positive risk-to-benefit ratio.

The second study evaluated 100 patients implanted between January and September 2009. This data has not yet been published. No significant differences were seen between the studies in terms of effectiveness and safety. A registry of antireflux surgery is currently enrolling patients in Europe to include treatment with the either the LINX System or fundoplication [23].

The LINX System has been recently reviewed by the Gastroenterology and Urology Advisory Panel of the FDA. This Panel voted unanimously that there was reasonable assurance of safety and effectiveness, and that the benefits of treatment...
outweighed the risks. This information is in the public domain and available on the FDA website.

Summary of published clinical experience with the LINX system

Patient population

Between February 2007 and October 2008, 44 patients underwent implantation of the LINX system through a laparoscopic approach. The primary criteria for inclusion in the trial were: >18 and <85 years of age, typical reflux symptoms at least partially responsive to PPI therapy, abnormal esophageal acid exposure, and normal contractile amplitude and wave form in the esophageal body. The primary criteria for exclusion from the trial were: a history of dysphagia, previous upper abdominal surgery, previous endoluminal antireflux procedures, sliding hiatal hernia that are >3 cm in size, esophagitis that is >grade A, and/or the presence of histologically documented Barrett’s esophagus. Patients with abnormal manometric findings (distal esophageal motility less than 35 mmHg peristaltic amplitude on wet swallows or <70% propulsive peristaltic sequences) were also excluded from the study.

Preoperative assessment

Preoperative evaluation consisted of a symptom questionnaire, upper gastrointestinal endoscopy, a barium swallow, esophageal manometry and 24-h esophageal pH monitoring. The GERD Health-Related Quality-of-Life (GERD-HRQL) validated questionnaire [24] was administered prior to any diagnostic test and off PPI therapy. The questionnaire consists of six heartburn questions, two swallowing questions, one gas–bloat question and one question about medication use. The responses to these questions are scored on a scale of 0 (no symptoms) to 5 (incapacitating symptoms) (Table 1).

The presence of esophagitis was assessed by an upper gastrointestinal endoscopy using the Los Angeles or Savary–Miller classification. The length of hiatal hernia, if present, was measured as the distance between the gastroesophageal junction, defined by the proximal limit of the gastric folds and the crural impression.

The LES resting pressure and length were measured by esophageal manometry using a station pull-through technique. The percentage of LES relaxation and the LES residual pressure were assessed with five wet swallows. The amplitude of esophageal contractions was measured by averaging ten wet swallows of 5 ml each, taken 30 s apart. Abnormal motility was defined as a mean amplitude of less than 35 mmHg and/or a greater than 30% prevalence of simultaneous, dropped or interrupted waves.

Prolonged (24–48 h) esophageal pH monitoring was used to measure esophageal acid exposure off PPI therapy. The probe or Bravo capsule (Bravo™ pH Monitoring System, Given Imaging) was inserted 5 cm above the upper border of the LES as determined by manometry or 6 cm above the Z line determined by endoscopy.

Postoperative assessment

The initial position and function of the device were verified with a standard chest x-ray and a modified barium swallow study on postoperative day 1. The GERD-HRQL questionnaire, upper gastrointestinal endoscopy, modified barium esophagram and 24-h esophageal pH monitoring were obtained at 3, 12 and 24 months after surgery. Esophageal manometry was obtained at 3 and 12 months.

Clinical outcomes

All devices were successfully implanted through a laparoscopic approach. The median operative time was 40 min (range: 19–104). Patients were instructed to resume a regular diet on postoperative day 1 after radiological assessment of the esophageal transit. No postoperative complications occurred. Most patients were discharged within 48 h.

Two patients were explanted; one at 8 months because of persistent dysphagia and the other at 18 months because of the need for a MRI study. Two patients withdrew consent, with a normal symptom profile at the time of withdrawal; one subject was lost to follow-up.

The mean GERD-HRQL score decreased by 90% at 2 years (p < .0001) (Figure 5). Changes in each component of the GERD-HRQL score are shown in Table 2. At 2 years of follow-up, 86% of the patients were feeling well and did no longer assume PPI therapy. A post hoc analysis showed that all patients were able to belch and that four patients were able to vomit when it occurred. In total, 43% of patients complained of mild dysphagia during the postoperative period; in all individuals the symptom resolved by 90 days without treatment.

Table 1. Symptom score for the Gastroesophageal Reflux Disease Health-Related Quality-of-Life validated questionnaire.

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No symptoms</td>
</tr>
<tr>
<td>1</td>
<td>Symptoms noticeable, but not bothersome</td>
</tr>
<tr>
<td>2</td>
<td>Symptoms noticeable and bothersome, but not everyday</td>
</tr>
<tr>
<td>3</td>
<td>Symptoms bothersome everyday</td>
</tr>
<tr>
<td>4</td>
<td>Symptoms affect daily life</td>
</tr>
<tr>
<td>5</td>
<td>Symptoms are incapacitating – unable to do activities</td>
</tr>
</tbody>
</table>

Figure 5. Preoperative and postoperative mean total score from the Gastroesophageal Reflux Disease Health-Related Quality-of-Life questionnaire (p < 0.0001).

Reproduced with permission from [21].

doi:10.1586/EGH.12.47

Expert Rev. Gastroenterol. Hepatol. 6(6), (2012)
Endoscopy

The impression of the device was observed at the level of the Z line in all patients undergoing upper gastrointestinal endoscopy during the postoperative period. The passage of a standard 9-mm endoscope through the gastroesophageal junction was smooth and no increased resistance was felt at the gastroesophageal junction. No mucosal erosions of the device have been reported.

Esophageal pH monitoring

The esophageal acid exposure was normalized in 90% of the patients at 2 years (Figure 6). The mean percentage time pH was <4 decreased from a preoperative baseline of 11.9–2.4% at 2 years. All the other components of the 24-h pH test and the DeMeester composite score were significantly reduced compared with baseline at 2 years (Table 3).

Esophageal manometry

In total, 32 patients had both baseline and 1-year postoperative manometric testing. The LES resting pressure increased from 6.5 to 14.6 mmHg (p < .005) in the nine patients with a hypotensive (less than 10 mmHg) LES pressure. No significant changes in pressure occurred in the 23 patients with normal LES pressure at baseline. There were no statistically significant changes in the length of the LES. Similarly, there were no statistically significant changes in the amplitude of esophageal contractions.

As mentioned earlier, the primary therapies available for GERD are still acid suppression therapy by PPIs and surgical alteration of the gastric anatomy by fundoplication. Table 4 shows a perspective on the benefits and limitations of these therapies. The LINX System has been introduced to select centers in the EU under CE certification and has been recently approved in the USA by the FDA.

Updated clinical results

Safety and efficacy of the LINX System were confirmed at 4 years of follow-up [22]. The mean total GERD-HRQL score was 3.3 compared with the baseline score of 25.7 (p < 0.001); 87.5% of patients were satisfied with their present condition and 80% of them were free from daily PPI dependence. Normalization of the pH score was achieved in 80% of the patients.

Expert commentary

The primary therapies available for GERD are still acid suppression therapy by PPIs and surgical alteration of the gastric anatomy by fundoplication. Table 4 shows a perspective on the benefits and limitations of these therapies.

### Table 2. Changes in each component of the Gastroesophageal Reflux Disease Health-Related Quality-of-Life score at various time intervals.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Preimplant (n = 44)</th>
<th>3 months (n = 37)</th>
<th>1 year (n = 39)</th>
<th>2 years (n = 28)</th>
</tr>
</thead>
<tbody>
<tr>
<td>How bad is your heartburn?</td>
<td>3.7</td>
<td>0.6</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Heartburn when lying down?</td>
<td>3.1</td>
<td>0.3</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Heartburn when standing up?</td>
<td>3.3</td>
<td>0.4</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Heartburn after meals?</td>
<td>3.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Does heartburn change your diet?</td>
<td>3.1</td>
<td>0.5</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Does heartburn wake you from sleep?</td>
<td>2.5</td>
<td>0.0</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Do you have difficulty swallowing?</td>
<td>1.2</td>
<td>0.7</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Do you have bloating and gasy feelings?</td>
<td>2.9</td>
<td>0.8</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Do you have pain with swallowing?</td>
<td>0.6</td>
<td>0.4</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>If you take medication, does this affect your daily life?</td>
<td>2.0</td>
<td>0.2</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>How satisfied are you with your present condition?†</td>
<td>0%</td>
<td>84%</td>
<td>87.0%</td>
<td>86%</td>
</tr>
</tbody>
</table>

Mean preoperative and postoperative scores from Gastroesophageal Reflux Disease Health-Related Quality-of-Life questionnaire.

†Percentage of satisfied patients.

Reproduced with permission from [21].

Figure 6. Changes in the proportion of patients with normalized esophageal pH exposure at various time intervals.

Reproduced with permission from [21].
The limitations of current therapies for GERD have left a significant segment of the reflux patient population in an equivocal position: either to continue with a life-time dependence on a medication that does not provide complete relief of symptoms, or have a surgical procedure that requires significant alteration of gastric anatomy, may deteriorate over time and may have significant side effects. Based upon the clinical experience to date, the LINX System represents a third option that addresses the limitations of existing therapies and provides patients with a permanent, easily reversible and more physiologic solution to their reflux. Importantly, the LINX System can be broadly adopted by the clinical community as it requires no new diagnostic techniques and can be implanted with surgical techniques currently used routinely by laparoscopic surgeons.

The LINX System has been introduced to select centers in the EU under CE certification and has been recently approved in the USA by the FDA. The results of our feasibility trial have shown that magnetic augmentation of the gastroesophageal junction barrier is highly effective in reducing symptoms and esophageal acid exposure, and improves patients’ quality of life. Although the published data refer to a 4-year follow-up only, and are not randomized, the results appear quite similar to those reported for partial fundoplication procedures in terms of less side effects, similar reflux control and fewer reoperation rate [25,26]. Two distinct advantages of the LINX System procedure are the simple and standardized technique for insertion and the easy reversibility in the absence of significant periesophageal fibrosis. The potential limitations of the new technique are the lack of long-term results, the untested efficacy in the presence of sliding or paraesophageal herniation, short esophagus and Barrett’s esophagus, the current contraindication to undergo MRI, the patient’s acceptance, and long-term consequences of the permanent insertion of a foreign body.

Despite these limitations, the LINX System is a promising new technique that might overcome current GERD treatment limitations in the future. Until this is proven in large multi-institutional studies and randomized trials against the gold standard, the new technique should be dealt with caution in order to ensure patient safety. At the moment, laparoscopic fundoplication remains the gold-standard approach for surgical treatment and patients should be informed and consented accordingly.

**Table 3. Parameters of esophageal acid exposure and the composite DeMeester score (mean values) at 1 and 2 years after the LINX™ Reflux Management System (Torax Medical) implant.**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Baseline (n = 44)</th>
<th>1-year postimplantation (n = 39)</th>
<th>p-value</th>
<th>2-years or later postimplantation (n = 20)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total % time &lt;pH 4</td>
<td>11.9</td>
<td>3.1</td>
<td>&lt;0.0001</td>
<td>2.4</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Upright % time &lt;pH 4</td>
<td>13.6</td>
<td>3.2</td>
<td>&lt;0.0001</td>
<td>3.0</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Supine % time &lt;pH 4</td>
<td>8.3</td>
<td>2.8</td>
<td>0.0009</td>
<td>1.1</td>
<td>0.009</td>
</tr>
<tr>
<td>No. episodes</td>
<td>98.8</td>
<td>27.1</td>
<td>0.001</td>
<td>26.3</td>
<td>0.0004</td>
</tr>
<tr>
<td>No. episodes &gt;5 min</td>
<td>6.3</td>
<td>2.2</td>
<td>&lt;0.0001</td>
<td>1.2</td>
<td>0.0005</td>
</tr>
<tr>
<td>Longest episode, min</td>
<td>36.5</td>
<td>10.7</td>
<td>0.0002</td>
<td>8.9</td>
<td>0.0009</td>
</tr>
<tr>
<td>DeMeester score</td>
<td>42.3</td>
<td>11.9</td>
<td>&lt;0.0001</td>
<td>9.4</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Reproduced with permission from [21].

**Table 4. Comparison of benefits and limitations of current available treatments for patients with gastroesophageal reflux disease.**

**Surgery**

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective at preventing reflux</td>
<td>Requires anatomy to be altered</td>
</tr>
<tr>
<td>Effective at reducing esophagitis</td>
<td>Is not physiologic (impacts ability to belch vomit)</td>
</tr>
<tr>
<td>Can help with ‘secondary symptoms’</td>
<td>Very technique dependent</td>
</tr>
<tr>
<td>High level of gas–bloat, distention, dysphagia</td>
<td>Can lose efficacy over time</td>
</tr>
<tr>
<td>Can lose efficacy over time</td>
<td>Difficult to reverse few alternatives after failure</td>
</tr>
</tbody>
</table>

**Pharmaceuticals**

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective at suppressing acid</td>
<td>Does not restore the sphincter barrier</td>
</tr>
<tr>
<td>Effective and healing esophagitis</td>
<td>Cannot prevent regurgitation/respiration</td>
</tr>
<tr>
<td>Requires no intervention</td>
<td>Efficacy can taper significantly over time</td>
</tr>
<tr>
<td>Can be taken ‘as needed’</td>
<td>Lifetime dependency</td>
</tr>
<tr>
<td>Absorption issues</td>
<td>May cause cancer</td>
</tr>
</tbody>
</table>

**Five-year view**

The publication of this review will coincide with the fifth anniversary of the pilot study. Since the first implants, a consistent performance of the LINX System was observed through use in multiple centers worldwide. The device has demonstrated a high level of efficacy and has met patient expectations, with few side effects or serious adverse events.
If this clinical performance is maintained over the course of the next 5 years, the LINX System will become a recognized and significant therapeutic advance in the GERD patient care continuum. The LINX device is intended to be used in patients with unsatisfactory response to medical therapy who would not usually be considered candidates for fundoplication procedures because they have early, uncomplicated disease. Considering the significant ‘therapy gap’ that is left between patients treated with medical and surgical therapy and the fact that less than 1% of the GERD population is treated by fundoplication, a less invasive surgical option seems desirable.

Importantly, the LINX System evaluated to date is first generation technology. In the coming years, there will be further opportunities to refine the device as well as the procedure. Specifically, the surgical technique required to implant the LINX System device lends itself to less invasive approaches including single incision and natural orifice techniques. Considering the efficacy, side effects and safety profile of the LINX System, there will probably be a direct correlation between the level of invasiveness and the number of patients who will choose this therapy as opposed to life-long pharmaceutical dependence or more invasive surgical alternatives.

In this time of constrained healthcare resources, the advancement and expanded use of the LINX System may have benefits well beyond clinical outcomes: providing an effective, minimally invasive and permanent solution for chronic GERD patients may help to significantly reduce the burden their treatment places on care providers and payers.

Financial & competing interests disclosure
The authors have received consulting fees from Torax Medical. The authors have no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript apart from those disclosed.

No writing assistance was utilized in the production of this manuscript.

Key issues

- Gastroesophageal reflux disease (GERD) results when the lower esophageal sphincter fails and gastric juices reflux into the esophagus, airways and mouth.
- GERD is commonly manifested by symptoms of heartburn and regurgitation; however, it can progress beyond quality-of-life impairments to more serious conditions such as Barrett’s esophagus and adenocarcinoma.
- GERD places a significant resource and cost burden on the healthcare system and the general economy:
  - GERD is the number one reason for a patient to visit an outpatient clinic;
  - Over US$5 billion was spent in 2010 on omeprazole;
  - That same year, 53 million prescriptions were written for the generic omeprazole;
  - Employees with GERD demonstrate significantly higher levels of absenteeism and significantly lower levels of productivity.
- Two primary treatment options exist for GERD:
  - Proton pump inhibitors (PPIs) are the first-line treatment;
  - Nissen fundoplication, the surgical gold standard for care, is reserved for patients with more advanced disease or significant anatomic defects.
- Each of these treatment options have limitations:
  - PPIs only suppress acid and do not prevent reflux. They require lifetime dependence, can become less effective with time and only achieve complete symptom relief in approximately 70% of patients;
  - Fundoplication procedures are effective. However, wide variability in outcomes, as well as a significant side-effect profile, have limited adoption.
- The ‘therapy gap’ between partially effective PPIs and fundoplication, with its inherent side effects, leaves a significant number of patients dissatisfied with their current treatment options.
- The LINX™ Reflux Management System (Torax Medical) was designed to provide a less invasive procedure that addresses this ‘gap’ by restoring normal physiologic function of the gastroesophageal junction.
- Two prospective, multicenter, controlled studies have demonstrated that patients receiving the LINX™ Reflux Management System device have significantly improved quality of life with normalization of reflux, low occurrence of significant adverse events and a dramatic reduction in PPI use.

References

Papers of special note have been highlighted as:

* of interest
** of considerable interest

Device profile
Bonavina, DeMeester & Ganz


