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Pilot study of an endoluminal-suturing device as a treatment for patients with gastroesophageal reflux disease

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ABSTRACT

Background and study aims Endoscopic therapy is a promising option for patients with gastroesophageal reflux disease (GERD). The aim of this study was to assess safety and feasibility of the Endomina suturing platform as a treatment for GERD.

Patients and methods This was a two-center study of patients with chronic GERD symptoms that responded at least partially to proton pump inhibitors (PPIs). Primary endpoints were to assess the safety of the procedure and persistence of the sutures. Secondary endpoints were to assess esophageal pH-impedance and manometry parameters changes at 6 months, as well as GERD symptoms and PPI use up to 12 months of follow-up.

Results Fourteen patients were treated (13 males, mean of 43±12 years), with a mean number of three plications per patient. Thirteen, 10, and nine patients were analyzed at 3, 6, and 12 months of follow-up, respectively. One device-related adverse event occurred (loss of needle tip requiring endoscopic retrieval 1 week later). A mean of two plications persisted at 3 and 12 months. A decrease in median acid exposure time and reflux episodes was observed after the procedure. Mean Reflux Symptom Index and GERD-Health-Related Quality of Life scores decreased during follow-up visits and 90% of the patients discontinued PPI use at 1 year.

Conclusions Endoscopic full-thickness suturing of the esophagogastric junction with the Endomina suturing platform is feasible, allowing persistence of two-thirds of the plications, with promising results for decreasing reflux and improving GERD symptoms.

Introduction

Gastroesophageal reflux disease (GERD) is a common problem affecting 10% to 20% of the population in the Western World [1]. Proton pump inhibitors (PPIs) heal esophagitis and improve GERD symptoms in many patients. However, acid suppressive therapy does not correct the underlying pathophysiology of esophagogastric junction (EGJ) dysfunction in GERD, and hence, symptoms of reflux due to weakly acidic or non-acid reflux persist in a significant of patients with GERD [2, 3].

Laparoscopic antireflux surgery restores the EGJ barrier function against reflux of the gastric content, is effective in reducing both reflux and GERD symptoms and is a therapeutic option in patients with severe GERD, with persisting symptoms due to reflux, or who are unwilling to take PPIs [4, 5]. However, concerns remain regarding postoperative adverse events (AEs) and durability of the surgical procedure [6, 7]. For these reasons, minimally-invasive endoscopic techniques have been developed during the last two decades [8, 9, 10].

Endomina v2 is a CE-marked device that can be attached to an endoscope inside the body, allowing manipulation of angulated tools during a peroral intervention and offering the possibility to perform transoral surgical full-thickness sutures. Transoral endoscopic gastroplasty has been shown to be safe and effective at mid-term follow-up in obese patients using the Endomina device [11, 12]. The ability to perform endoscopic full-thickness plications with Endomina v2, therefore, was used in a pilot study to assess safety and feasibility of the procedure in patients with persistent GERD symptoms despite daily PPI use.

Patients and methods

Study design and objective

This was a two-center, prospective open-label pilot study that was designed to evaluate the feasibility and the safety of the Endomina suturing platform as a treatment for GERD in subjects with chronic GERD symptoms responding at least partially to PPIs, requiring daily PPI use, and who continued to have symptoms despite maximal medical therapy. During a screening period, upper gastrointestinal endoscopy (if not performed within the last 12 months), high-resolution esophageal manometry and ambulatory esophageal pH-impedance monitoring were performed. Twenty-four-hour ambulatory esophageal pH-impedance monitoring was performed using a multi-channel intraluminal impedance system (Diversatek, Colorado, United States). The combined pH-impedance catheter was placed transnasally, with the pH-electrode positioned 5 cm above the upper border of the manometrically defined EGJ, and the impedance segments positioned 3, 5, 7, 9, 15, and 17 cm above the proximal border of the EGJ. The use of PPIs was discontinued 7 days before. Automated analysis of the pH-impedance study was performed, followed by a manual review of the tracing.

GERD Health-Related Quality of Life (GERD-HRQL) and Reflux Symptom Index (RSI) questionnaires were completed by the patients. Eligible patients were given clear information about the endoscopic procedure and the assessments required by the study, and gave their informed consent. Follow-up visits were scheduled at 1, 3, 6 and 12 months after the procedure for safety, symptoms, quality of life and PPI use assessment. Upper gastrointestinal endoscopy was performed at 3 and 12 months, and high-resolution esophageal manometry and ambulatory esophageal pH-impedance monitoring at 6 months.

The study was approved by the local Ethics committees and was registered in ClinicalTrials.gov (Identifier: NCT03999502).

Patients

Inclusion criteria were as follows: adult patients aged 21 to 70 with chronic symptoms of GERD (heartburn and/or regurgitations for longer than 12 months), under daily PPI therapy for at least 6 months and responding at least partially to PPIs (worse heartburn and/or regurgitations when patients stopped taking their PPI), with documented GERD efined with at least two of the following criteria: previous demonstration of reflux esophagitis grade A, B or C (Los Angeles classification), an acid exposure time ≥ 4 % during esophageal pH-impedance monitoring performed after at least 7 days off PPIs, a positive association between GERD symptoms and reflux episodes (symptom association probability ≥ 95%).

Exclusion criteria comprised a previous esophageal or gastric laparoscopic or endoluminal surgery, a hiatal hernia > 3 cm, Barret's esophagus, history of grade D esophagitis, gastroparesis diagnosed by gastric emptying scintigraphy in case of symptoms compatible with gastroparesis and after exclusion of a mechanical obstruction, a major esophageal motility disorder, esophageal or gastric varices, a history of malignancy, a body mass index > 35 kg/m^2, and type I or uncontrolled type II diabetes.

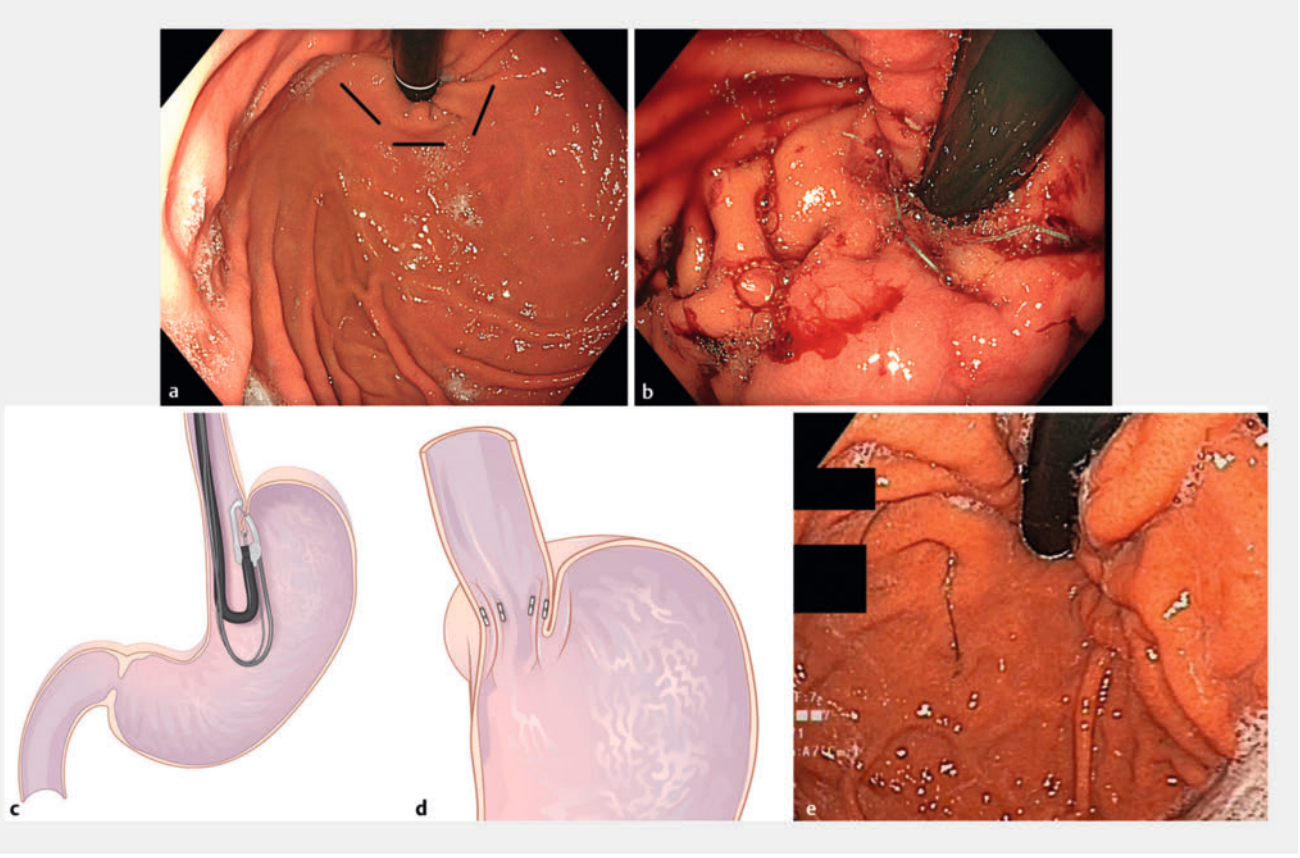
Endoluminal procedure and postoperative course

The Endomina v2 is a triangulation platform used with a flexible endoscope and a dedicated needle (TAPES, Endo Tools Therapeutics SA, Gosselies, Belgium) to create gastrointestinal sutures. The devices are currently CE-marked for endoscopic gastroplasty and were used in this study as a pre-market indication, i. e., the treatment of GERD. In the Endomina family, there are two platforms that were used in this study: the Endomina v2 and the Endomina v2-mini. The Endomina v2 has a therapeutic channel that can be bent perpendicularly to the axis of vision allowing piercing under visual control. The Endomina v2-mini has a pre-angled therapeutic channel allowing tissue appositions in narrower spaces, e. g., the esophagus.

The platform is inserted over one rigid guidewire into the stomach and can then be opened and tightened around the endoscope. This feature obviates the need to use an overtube and allows the endoscopist to assemble/detach the system when needed without having to withdraw the device. The Endomina comprises additional channel(s**)** that can be used for instrument insertion or flushing, leaving the endoscope channel free for instrumentation.

Grasping forceps were used through the endoscope channel to pull the gastric tissue inside the Endomina platform, and a dedicated needle (TAPES) was then used for tissue piercing. Each TAPES was loaded with two anchors connected by surgical suture, allowing creation of single or double plications (interrupted stitches). The anchors were then pulled toward each other using a snare until the formation of a tight serosa-to-serosa apposition.

Sutures were placed in retroflexion at the EGJ. Two to four sutures (depending on the space available in retroflexion) were placed in a step-by-step approach from the gastric fundus to the esophageal lumen over 240 degrees (leaving the smaller



▶ **Fig. 1** **a** Esophagogastric junction seen in retroflexion. Black marker shows where the sutures will be placed. **b** After the placement, a thread can be seen between tags. **c** Illustration of the technique with the Endomina v2 device in place. **d** Illustration of the final result. **e** Esophagogastric junction seen in retroflexion after 12 months after the procedure. Threads are still visible on the left and right part of the endoscope.

curvature intact) (▶ **Fig. 1**). This generated a narrowing of the EGJ and a "bump" in the gastric fundus distal to the EGJ. Procedures were done using the Endomina v2 and the Endomina v2-mini at the operator's discretion. All procedures were performed under general anesthesia with orotracheal intubation. Patients were kept overnight per protocol. Patients received antispasmodic and antiemetic drugs for 10 days and were asked to continue on their daily PPI for 3 months. They were kept on a liquid diet for 3 days after the procedure and then returned to solid food within 10 days.

Study endpoints

Primary endpoints of the study were feasibility defined as persistence of sutures at endoscopy at 3 and 12 months of follow-up, and safety characterized by the incidence of adverse device effects assessed at each follow-up visit, according to the Clavien-Dindo classification.

Secondary endpoints were as follows: change from baseline to 6 months esophageal acid exposure time (AET), number of distal and proximal reflux episodes, DeMeester score, lower esophageal sphincter (LES) pressure, and the 4-second integrated relaxation pressure (IRP4 s) of LES pressure (IRP4 s); change from baseline PPI use at 6- and 12-months follow-up; change from baseline to the 3-, 6- and 12-month follow-up visit of the mean RSI and GERD-HRQL scores (it appeared afterwards that questions 10 to 14 of the GERD-HRQL were not available for the Portuguese patients).

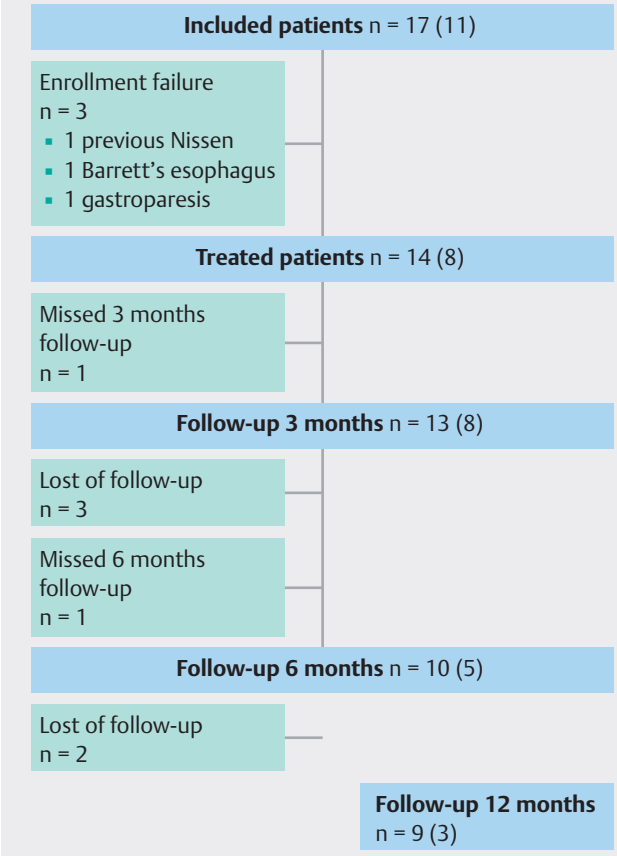
Statistical analysis

We planned to enroll 15 patients in this pilot study. Descriptive analysis was performed using mean and standard variation (SD) or median and interquartile range depending normality of the data for numeric parameters. Count and percentages were presented in each category of the categorical variables.

To evaluate the change between times of esophageal AET, number of distal and proximal reflux episodes, DeMeester score, LES pressure, and the 4-second integrated relaxation pressure (IRP4 s) of LES pressure (IRP4 s), medians of delta (difference between baseline and 6-month follow-up) with Confidence intervals at 95% were calculated with SAS Enterprise guide 8.3.

Results

From September 2018 to December 2021, 17 patients with GERD were enrolled (▶ **Fig. 2**). General characteristics of the patients are given in ▶ **Table 1**. Patients were on chronic daily PPI treatment (15 to 80 mg per day, mean duration 8.5 years,



▶ **Fig. 2** Flow diagram of the study. In the right part of the diagram, n = total number of patients from Brussels and Lisbon, n in brackets = number of patients from Brussels.

esomeprazole [5 patients] lansoprazole [3 patients], omeprazole [3 patients], pantoprazole [2 patients] and rabeprazole [1 patient]).

All patients had their heartburn score worsen 7 days after stopping PPI and had persistent regurgitation under PPI. Three patients had no esophagitis under PPI treatment, 11 patients had esophagitis (7 grade A, 3 grade B and 2 grade C). Eight of the 14 patients had an AET > 6%, five patients with an AET < 6% had a symptom association probability > 95% as a marker of GERD.

Three patients were considered enrollment failures: one patient with Barrett's esophagus, one patient with a previous Nissen fundoplication, and one patient with gastric food retention at endoscopy, due to non-previously diagnosed gastroparesis. Fourteen patients were treated with the endoluminal procedure (8 in Brussels and 6 in Lisbon). Five patients were lost to follow-up after 3 or 6 months, of whom two later opted for a surgical fundoplication. Two patients missed their 3- or 6-month follow-up, respectively, but completed the other follow-up visits.

All procedures were performed by experienced endoscopists (VH, JD and RRT) with a technical success rate of 100%. Mean procedure time was 1 hour 7 minutes±13 minutes. Five patients had four sutures performed, three patients had three sutures and six patients had two sutures. Eight of 14 patients (57%) complained of transient mild epigastric pain and/or dyspeptic symptoms (early satiety, belching) post procedure, which did not require medication and resolved within 4 weeks.

Primary endpoints

One AE related to the suturing procedure was recorded in one patient, (graded 3b according to the Clavien-Dindo classification), as the tip of one TAPES detached from the device and required endoscopic retrieval one week later. Corrective actions

▶ **Table 1** Baseline characteristics of study population (14 patients).

Age (years)	**Mean ± SD**	**43±12**
Sex	Female/male (n)	1/13
Weight (kg)	Mean ± SD	78.7±16.1
BMI (kg/m²)	Mean ± SD	25.6±3.8
Heartburn GERD-HRQL (Q1–6) on/off PPI	Mean ± SD	15.3±7.4 /23.5±3.7
Regurgitation GERD-HRQL (Q10 to Q13) on/off PPI	Mean ± SD	11.2±2.4/13.9±3.0
Esophagitis (LA grade 0/A/B/C)	% patients	14/50/22/14
PPI dose (half/single/double)	% patients	22/50/28
pH-impedance monitoring results		
▪ Acid exposure time (%)	Median [IQR]	6.0 [3.5–9.5]
▪ Number of reflux episodes	Median [IQR]	78 [62]–[96]

Heartburn and regurgitation GERD-HRQL scores were recorded on PPI medication and off PPI (7 days after PPI stopping). Regurgitation scores are data from patients treated in Brussels (n = 8).
SD, standard deviation; BMI, body mass index; GERD-HRQL, Gastroesphageal Reflux Disease Health-Related Quality of Life; PPI, proton pump inhibitor; IQR, interquartile range.

▶ **Table 2** Therapeutic outcomes of the study.

	Baseline	Intervention	3 months of follow-up	6 months of follow-up	12 months of follow-up	Median of delta (IC95%)
Mean number of stitches		3±1	2±1		2±1	
Acid exposure time (%)	6.0 [3.5–9.5]			2.6 [2.2–10]		–1.7 (–5.9; 7.8)
Number of reflux episodes	78 [62–96]			40 [37–66]		–28 (–50; 29)
Number of proximal reflux episodes	55 [46–61]			34 [26–46]		–14 (–36; 5)
DeMeester score	19.7 [16.2–29]			10.5 [7.3–29.7]		–7.3 (–22.6; 16.1)
Basal LES pressure (mmHg)	10 [8–19]			16 [10–19]		2 (–4; 10)
IRP4s	3.9 [1.0–5.8]			6.1 [4.0–8.1]		1.5 (–1.63; 3.5)
RSI	16.5±9.1		6.7±9.7	7.9±8.2	6.1±8.4	
GERD-HRQL (Q1 to Q9)	24.0±7.4		8.0±10.6	10.2±13.9	6.3±7.7	
Regurgitation GERD-HRQL (Q10 to Q13)	14.1±2.6		6.9±6.7	8.5±8.3	3.3±2.9	
Number of patients under PPI (%)	14 (100)			5 (50)	1 (11)	
Dose of PPI (mg, min.-max.)	15–80			10–40	7.5–7.5	
Weight (kg)	76 [72–90]			75 [68–84]	77 [68–80]	

Regurgitation GERD-HRQL scores are data from patients treated in Brussels. Values followed by brackets indicate Median and interquartile range. Values followed by plus/minus indicate mean and standard deviation. pH-impedance results at baseline and at 6-months follow-up were obtained after 7 days off PPI.
LES, lower esophageal sphincter; IRP4, 4-second integrated relaxation pressure; RSI, Reflux Symptom Index; GERD-HRQL, Gastroesophageal Reflux Disease Health-Related Quality of Life; PPI, proton pump inhibitor.

were thereafter implemented on the device and no recurrence was reported for subsequent patients. No AEs were recorded during follow-up visits.

Persistence of the sutures was evaluated at endoscopy 3 and 12 months after the treatment. A mean number of two plications persisted at 3 and 12 months, compared to a mean number of three plications performed during the treatment procedure (▶ **Table 2**). At 3-month follow-up, six patients had all sutures remaining, four patients had one suture lost and three patients had two sutures lost. At 12-month follow-up, six patients had all sutures remaining, one patient had one suture lost and two patients had two sutures lost.

Secondary endpoints

Analysis of reflux parameters showed that mean esophageal acid exposure, DeMeester score, distal and proximal number of reflux episodes were all reduced 6 months after the Endomina procedure (▶ **Table 2**). Of the eight patients with an abnormal AET before the procedure, three normalized their AET, while two did not.

As a marker of LES augmentation, an increase in basal LES pressure as well as IRP4 s, was observed at 6 months.

Concerning GERD symptoms, mean RSI and GERD-HRQL scores decreased during follow-up visits.

PPI could be stopped after 3 months in most of the followed patients: Only one of the nine patients followed at 12 months was still on a low dose of PPI.

Interestingly, although evaluation of esophagitis was not included as an endpoint in the study, endoscopic evaluation of patients at 1-year follow-up did not show esophagitis in most of the patients. Whereas Los Angeles esophagitis grade A, B or C was observed before the Endomina procedure in seven, three and two of the 14 patients, respectively, only two of the nine patients followed at 12 months had grade A esophagitis and no reflux esophagitis was observed in the seven other patients.

Discussion

We report the results of a pilot study evaluating the Endomina procedure as a treatment for patients with chronic GERD symptoms that persist under a daily PPI therapy. First, the study showed that the Endomina v2 device is safe and facilitated creation of sutures under the EGJ in all treated patients, and a mean number of two of the three sutures persisted at 3 and

12 months of follow-up. These results are in line with the fact that the Endomina platform allows performing full-thickness plications [11]. Previous studies using endoscopic suturing devices in GERD patients showed that only transmural, full-thickness sutures do not fall out and persist with time [13, 14]. In our study, the loss of one-third of the sutures after 3 months is probably due to the loss of loose or partial-thickness plications.

Second, the study provides objective data suggesting the efficacy of the device for treating GERD. We observed an increase in basal and relaxation LES pressures as markers of LES augmentation after suturing the EGJ junction, as well as a decrease in reflux parameters measured during ambulatory reflux monitoring. These changes should, of course, be confirmed in a study with a larger number of patients. In parallel, improvement of GERD symptoms was observed in most of the patients.

Most of the patients followed at 12 months had no esophagitis and were able to reduce or stop their PPI usage. Due to the small number of patients included, it is not possible to evaluate if the clinical efficacy of the procedure was linked to the number of sutures remaining at the EGJ. Those results on objective reflux parameters and GERD symptoms should be confirmed in a study with a larger number of patients.

During recent decades, several endoscopic suturing devices have been developed. The EndoCinch suturing device could be used for submucosal sutures that did not persist and, therefore, do not offer long-term efficacy on GERD [14]. More recently, transoral incisionless fundoplication (TIF), which has been the most evaluated procedure to date, the Medigus ultrasonic surgical endostapler (MUSE) and the GERDx procedure were evaluated in clinical trials with encouraging results [15, 16]. Some of these procedures and devices, however, limited by their size making their use sometimes difficult in retroflexion [13]. The Endomina platform has some advantages, such as ease of use, maneuverability, ability to attach/detach during the procedure, and atraumatic design (i. e., no need for an overtube). It can be used with all types of endoscopes without the need for specific materials. The design of the Endomina v2-mini is smaller in diameter, with a piercing angle of 35 degrees, rendering the device able to work in retroflexion more efficiently in small spaces. Future studies should also evaluate where to place the sutures to offer the best results in augmenting the antireflux barrier.

The limitations of the study are inherent to a pilot study without randomization and a sham arm, with a small number of patients included, and the COVID-19 pandemic occurring during the recruitment period. The majority of enrolled patients were men, which might be a bias. One could also argue that the inclusion criteria of GERD are not validated and the protocol of the study was written before the Lyon Consensus was published. Two patients missed their 3- or 6-month follow-up and five patients were lost to follow-up. Among these patients, two opted later for a surgical fundoplication, and one can argue that patients lost to follow-up were not satisfied and had persistent GERD symptoms. Questions on the GERD-HRQL about regurgitation were not included in the Portuguese version of the questionnaires, limiting the number of available data for this tool. Finally, 1-year follow-up is short for a chronic condition like GERD, and long-term results cannot be guaranteed with this new endoscopic approach.

The strength of the study lies in its prospective design with precise inclusion and exclusion criteria, and that it was performed at two sites.

Conclusions

In conclusion, current data show that endoscopic full-thickness suturing of the EGJ with the Endomina v2 device is a safe procedure, allowing long-term plication to augment LES, with encouraging results to decrease reflux and improve GERD symptoms. The procedure should be further evaluated in a larger prospective trial, to confirm its safety, the sustainability of the sutures, and the effects on both objective GERD measurements and symptoms.

Conflict of Interest

Endo Tools Therapeutics S.A. (Gosselies, Belgium) provided a grant covering medical devices and data management. Drs. Huberty and Deviere are shareholders in Endotools SA, which was initially a startup of the Université Libre de Bruxelles where they have appointments. Loulia Leclercq is employee at Endo Tools Therapeutics S.A. Hubert Louis, Pauline Van Ouytsel, Mélina Houinsou Hans, and Ricardo Rio Tinto have no competing interest.

Clinical trial

Trial registry: ClinicalTrials.gov (http://www.clinicaltrials.gov/)
Registration number (trial ID): NCT03999502
Type of Study: Prospective

References

[1] Bredenoord AJ, Pandolfino JE, Smout AJ. Gastro-esophageal reflux disease. Lancet 2013; 381: 1933–1942 doi:10.1016/S0140-6736(12)62171-0

[2] Subramanian CR, Triadafilopoulos G. Refractory gastroesophageal reflux disease. Gastroenterol Rep (Oxf) 2015; 3: 41–53 doi:10.1093/gastro/gou061

[3] Herregods TV, Bredenoord AJ, Smout AJ. Pathophysiology of gastroesophageal reflux disease: new understanding in a new era. Neurogastroenterol Motil 2015; 27: 1202–1213 doi:10.1111/nmo.12611

[4] Oelschlager BK et al. Long-term outcomes after laparoscopic antireflux surgery. Am J Gastroenterol 2008; 103: 280–288 doi:10.1111/j.1572-0241.2007.01606.x

[5] Galmiche JP, Hatlebakk J, Attwood S et al. Laparoscopic antireflux surgery vs esomeprazole treatment for chronic GERD: the LOTUS randomized clinical trial. JAMA 2011; 305: 1969–1977 doi:10.1001/jama.2011.626

[6] Vakil N, Shaw M, Kirby R. Clinical effectiveness of laparoscopic fundoplication in a US community. Am J Med 2003; 114: 1–5 doi:10.1016/s0002-9343(02)01390-6

[7] Richter JE. Gastroesophageal reflux disease treatment: side effects and complications of fundoplication. Clin Gastroenterol Hepatol 2013; 11: 465–471 doi:10.1016/j.cgh.2012.12.006

[8] Rothstein R, Filipi C, Caca K et al. Endoscopic full-thickness plication for the treatment of gastroesophageal reflux disease: A randomized, sham-controlled trial. Gastroenterology 2006; 131: 704–712 doi:10.1053/j.gastro.2006.07.004

[9] Muls V, Eckardt AJ, Marchese M et al. Three-year results of a multicenter prospective study of transoral incisionless fundoplication. Surg Innov 2013; 20: 321–330 doi:10.1177/1553350612459275

[10] Witteman BP, Strijkers R, de Vries E et al. Transoral incisionless fundoplication for treatment of gastroesophageal reflux disease in clinical practice. Surg Endosc 2012; 26: 3307–3315 doi:10.1007/s00464-012-2324-2

[11] Huberty V, Ibrahim M, Hiernaux M et al. Safety and feasibility of an endoluminal-suturing device for endoscopic gastric reduction (with video). Gastrointest Endosc 2017; 85: 833–837

[12] Huberty V, Boskoski I, Bove V et al. Endoscopic sutured gastroplasty in addition to lifestyle modification: short-term efficacy in a controlled randomised trial. Gut 2020; 322026: doi:10.1136/gutjnl-2020-322026

[13] Raphael KL, Walsh P, Benias PC. Innovations in endoscopic therapy for gastroesophageal reflux disease. Gastrointest Endosc Clin N Am 2020; 30: 291–307 doi:10.1016/j.giec.2019.12.009

[14] Schiefke I, Zabel-Langhennig A, Neumann S et al. Long term failure of endoscopic gastroplication (EndoCinch). Gut 2005; 54: 752–758 doi:10.1136/gut.2004.058354

[15] ASGE Technology Committee. Thosani N, Goodman A et al. Endoscopic anti-reflux devices (with videos). Gastrointest Endosc 2017; 86: 931–948 doi:10.1016/j.gie.2016.01.007

[16] Kushner BS, Awad MM, Mikami DJ et al. Endoscopic treatments for GERD. Ann N Y Acad Sci 2020; 1482: 121–129 doi:10.1111/nyas.14511