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NEW TECHNOLOGY

Small bowel magnetic compression anastomosis creation for bypass procedures in a porcine model

Oscar A. Olavarria[1] · Karan R. Chhabra[2] · Shoshana T. Levi[3] · Erik B. Wilson[1] · Matthew M. Hutter[2]

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Abstract

Background Stapled and hand-sewn techniques dominate gastrointestinal anastomotic procedures. These techniques are effective but not without flaws. Retained foreign bodies, pathways from mucosa to serosa, and increased scar tissue are some of the drawbacks, and can lead to postoperative complications. The GI Windows Flexagon™ system utilizes self-forming magnets (SFM's) to create anastomoses by compression, sealing serosa to serosa, leaving no foreign bodies. Combining the Flexagon™ SFM with the OTOLoc™ device (implant with a central lumen which provides radial support to the enterotomies), enables immediate flow through the anastomosis and facilitates creation of enteral bypass procedures unique to this technology. We sought to compare the safety and efficacy of the GI Windows Flexagon™ and OTOLoc™ technologies against conventional stapling.

Methods A preclinical study was conducted on 14 Yorkshire swine to compare laparoscopic magnetic and stapled duodenoileostomies and jejunojejunostomies. Study endpoints included: adverse or serious adverse events, anastomotic burst pressure, adhesions, histopathology, and bacterial ingress. A Likert scale was used to assess the usability of the devices.

Results All procedures were successfully completed via laparoscopic approach; no adverse or serious adverse events were observed at the 42-day endpoint. All SFM's were expelled in less than 20 days. Average anastomotic burst pressure was 129.2 mmHg for SFM compared to 79.4 mmHg in stapled controls. Adhesion scores were similar between groups. Histopathology revealed that magnetic anastomoses have less intestinal wall distortion, fewer signs of chronic inflammation, and no bacterial ingress. The usability of all devices was reported as "Easy" or "Very Easy."

Conclusion GI Windows magnetic compression anastomoses creation in this porcine model revealed an overall ease of use, all while demonstrating procedural feasibility, safety, and clinical effectiveness. Surprisingly, in nearly all results assessed, SFM anastomoses were found to be comparable to the control stapled anastomoses in regard to structural, physiological, and histological endpoints.

Keywords Magnetic anastomosis · Magnetic compression device · Self-forming magnets · Sutureless anastomosis · Small bowel anastomosis · Staple free anastomosis

Introduction

In modern surgery, broadly adopted techniques for the creation of anastomoses in the gastrointestinal tract include either stapled or hand-sewn approaches. When compared to hand-sewn, stapled anastomoses are recognized for their efficiency in reducing operating room time, yet, several randomized controlled studies have found similar anastomotic leak rates related to both techniques across different clinical settings [1–3].

Due to their permanent nature, staples and suture materials elicit a chronic localized inflammatory response, disorganized collagen deposition and fibrosis which can

✉ Oscar A. Olavarria
oolavarriak@gmail.com; oscar.a.olavarria@uth.tmc.edu

[1] Department of Surgery, McGovern Medical School, The University of Texas Health Science Center Houston, 6431 Fannin St, MSB 4.162B, Houston, TX 77030, USA

[2] Department of Surgery, Massachusetts General Hospital, Harvard Medical School, Boston, USA

[3] Department of Surgical Oncology, MD Anderson Cancer Center, The University of Texas Health Science Center Houston, Houston, USA

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contribute to postoperative complications, including anastomotic leaks or strictures [4, 5]. Also, staples and sutures penetrate through the intestinal wall layers, resulting in transmural bacterial pathways. Moreover, hand-sewn intracorporeal anastomoses are technically demanding and often require advanced training.

Magnetic technologies address these challenges by atraumatically approximating serosal surfaces, exerting compressive forces of the interposed tissue. This creates a controlled area of tissue ischemia, which is followed by revascularization, organized collagen formation and fusion of serosal surfaces, ultimately resulting in a functional anastomosis. Furthermore, magnetic technologies enable minimally invasive surgical approaches. They very well could aid surgeons with less operative experience, particularly in stapled or sutured bowel anastomoses, to safely and consistently create intracorporeal gastrointestinal anastomoses in a standardized fashion with good results.

GI Windows, Inc (Westwood, MA) has developed the Flexagon™ Self-Forming Magnet (SFM) and OTOLoc™ device as a "staple free" and "suture free" innovative compression anastomotic system. The Flexagon™ SFM consists of a linear chain of multiple neodymium magnets, coated with nitinol sleeves, that upon deployment in a straight configuration inside of the bowel lumen, it will self-form into an octagonal ring. Once two octagonal rings are coupled, the magnets apply pressure to the tissue in between, resulting in ischemia, tissue fusion, and, ultimately, the creation of the anastomosis. These SFM's are designed to incur full circumferential serosa-to-serosa contact, thus creating a seal, preventing transmural bacterial migration. The OTOLoc™ device is an implant with a central lumen designed to be delivered laparoscopically into, and provide radial support for, a previously made enterotomy. It facilitates the insertion of the Flexagon™ into the bowel through its lumen and remains in situ after the magnets are coupled, allowing immediate communication between lumen segments, and enables the creation of end-to-end intestinal bypass procedures that cannot be performed with other magnetic or compression anastomosis technologies. Once the anastomosis is completely formed, the SFM's and the OTOLoc™ implants pass naturally through the gastrointestinal tract and are expelled through the anus along with stool, leaving no foreign body behind [6–8].

In this preclinical porcine study, we sought to assess the safety, feasibility, and usability of magnetic compression anastomoses utilizing the GI Windows Flexagon™ and OTOLoc™ technologies for laparoscopic enteral bypass procedures.

Materials and methods

GI Windows conducted a preclinical porcine study adhering to the Food and Drug Administration Good Laboratory Practices (GLP) to compare the safety and efficacy of magnetic compression small bowel anastomoses using self-forming magnets with stapled anastomoses created with a standard stapler (Endo GIA™ 60 mm tan [Vascular Medium, 2–3 mm] load. Medtronic, Minneapolis, MN) in an in vivo model developed to recreate two commonly performed laparoscopic anastomosis procedures. The study was approved by an independent Institutional Animal Care and Use Committee to assure compliance with ethical standards for research involving animals.

The Flexagon™ SFM system consists of two self-assembling octagonal magnetic rings which have an "A" and "B" configuration. These configurations consist of differing magnetic pole faces that allow the magnets to rotationally lock together. Self-assembly of the octagonal ring occurs once the Flexagon is deployed intraluminal (Fig. 1). After deployment into adjacent hollow organs

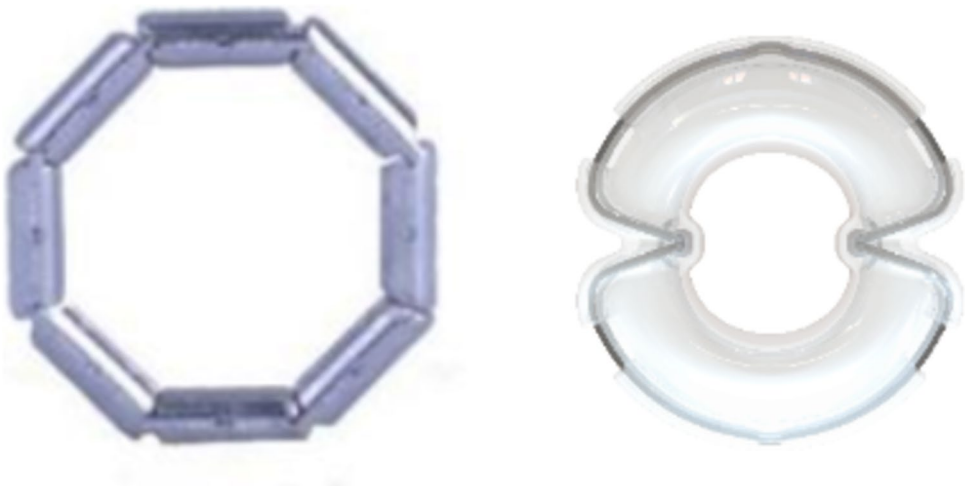

Fig. 1 Fully formed Flexagon™ self-forming magnet (left) and OTOLoc™ implant (right)

the magnets are coupled together. Once coupled they then function by compressing the interposed tissue resulting in transmural ischemia, necrosis, and fusion of the tissue, creating a full-thickness bowel anastomosis within days. The OTOLoc™ is an implantable device which provides radial support to the previously made enterotomy, facilitating luminal access for SFM delivery and allowing for immediate patency of the lumen until the magnetic anastomosis is fully mature. Both of these devices have the capability to be deployed laparoscopically and unlike conventional anastomoses created with sutures or staples, they are expelled through the anus into the stool leaving no foreign bodies behind.

Animals were housed a minimum of 7 days in the facility prior to treatment to ensure they remained healthy and were acclimated to the conditions. Five days before surgery, the animals were transitioned to a liquid diet, followed by a 24-h fasting period to ensure cleaning of the gastrointestinal tract prior to surgery. The animals were placed under general anesthesia and all surgeries were performed laparoscopically under sterile techniques. Animals were randomly divided into two groups:

- Test Group; $n = 8$ total. Four (4) underwent a Single Anastomosis Duodenal Ileostomy (SADI) bypass procedure using SFM with no gastric resection, and four (4) underwent a jejunojejunostomy using SFM to recreate the distal anastomosis conducted in a Roux-en-Y Gastric Bypass procedure.
- Control group; $n = 6$ total. Three (3) underwent a SADI bypass procedure using 60 mm linear laparoscopic staple loads and three (3) underwent a jejunojejunostomy using 60 mm linear laparoscopic staple loads.

For animals undergoing laparoscopic SADI with SFM and OTOLoc™, the surgeons began performing a diagnostic laparoscopy, identified the stomach, and transected the duodenum with a laparoscopic linear stapler (60 mm tan load) distal to the pylorus and proximal to the common bile duct. The surgeon then made an enterotomy in duodenum and deployed the OTOLoc™ through the enterotomy with the use of the laparoscopic delivery device. Following this, the Flexagon™ SFM was introduced through the channel of the previously deployed OTOLoc™ into the bowel lumen. These steps were then repeated on the ileum and the magnets were then coupled to complete the anastomosis with the OTOLoc™ devices remaining in situ (Fig. 2). For those animals assigned to the laparoscopic stapled anastomosis, the bowel was initially transected using a stapler, enterotomies were created at the corners of the transected bowel ends, then the stapler was introduced through the enterotomies and subsequently fired to create the anastomosis. After creation of the anastomosis the common channel was closed with another staple load. For animals assigned to the creation of a jejunojejunostomy, a similar technique was utilized as described above for the SFM and staple anastomoses, respectively.

Post-procedure, all animals were kept on a liquid/gelatin diet for a minimum of three days, transitioning to mash and then returned to their normal diet on day 7, or earlier if fecal expulsion of SFM occurred. Animals assigned to SFM underwent serial fluoroscopic evaluation under sedation to verify the location of the device until expulsion of the SFM found through fecal output monitoring. Animals assigned to stapler also were subjected to fluoroscopic evaluation under sedation to ensure that all animals received the same treatment during the interim period. Animals underwent daily

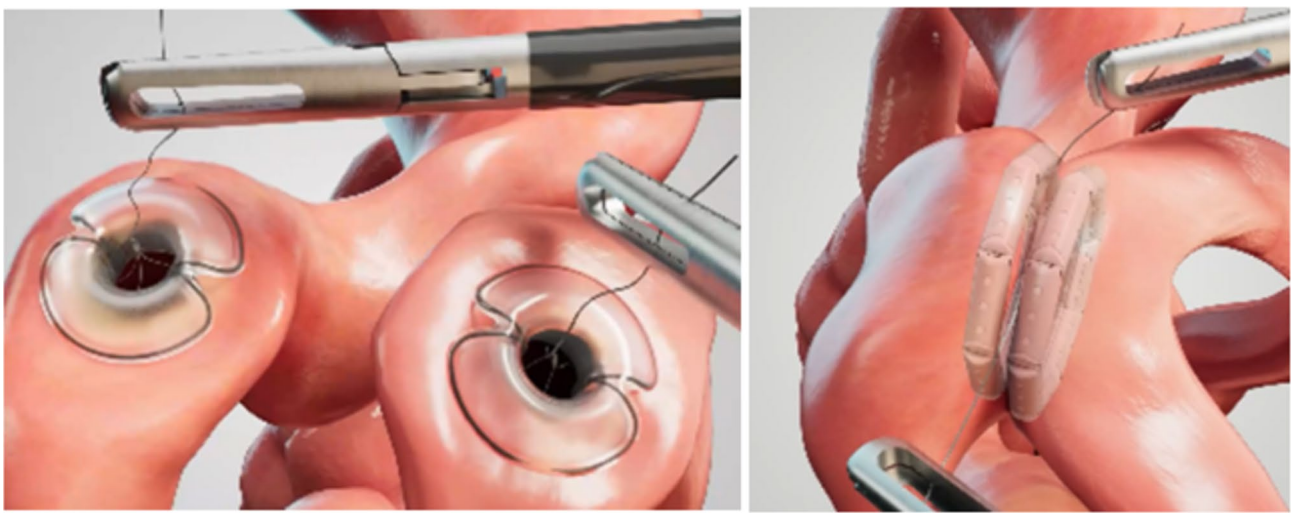

Fig. 2 OTOLoc's deployed transmurally in the duodenum and ileum, with Flexagon™ deployed intraluminally (left). Coupled Flexagon™ self-forming magnets, the luminal wall is transparent for illustrative purposes (right)

health evaluation and periodic weight and blood chemistry assessment by veterinarians. The animals were euthanized on day 42 (6 weeks) and necropsies were performed with gross visual assessment of the internal organs and adhesion grading. Six weeks was selected as the endpoint given the initial phases of wound healing including inflammation, proliferation, and early remodeling are complete. This allows researchers to also conduct a thorough histological and functional evaluation, and capture potential chronic responses such as strictures, adhesions, or anastomotic failures. All anastomoses were excised for either burst testing to evaluate robustness of the anastomosis or microscopic histopathology evaluations to assess for treatment effects, such as thrombosis, necrosis, inflammation, fibrosis, and bacterial infiltration. Endpoint tissue assignment for testing was defined a priori and can be found in Supplemental Table 1.

Primary study endpoints included: animal survival, serious adverse events or adverse events, percent weight change (as a measure of overall health and procedure tolerance), anastomotic burst pressure, and histopathology revealing presence of necrotic tissue, scarring, inflammation or strictures.

Serious adverse events were defined as early death or any clinical event requiring intervention. Adverse events were defined as: anastomotic bleeding requiring transfusion or intervention, anastomotic leak, obstruction, fistula, wound dehiscence or infection, anastomotic ulcer, internal hernia resulting in bowel ischemia, or implant retention requiring retrieval.

Secondary endpoints included: (1) capability of delivering the devices laparoscopically without complications and without the use of fluoroscopy, (2) average procedure time from bowel transection to anastomosis completion, (3) rate of device expulsion within 42 days, (4) adhesions greater than grade 2 on adhesions scale, (5) burst pressure testing, and (6) histopathology assessment. Adhesions were graded independently by the veterinarian in both test and control groups using an adhesion scale (0 = no adhesion, 1 = flimsy thickness and avascular, 2 = moderate thickness with limited vascularity, and 3 = dense thickness with vascularization). Burst testing was conducted on anastomoses harvested from both test and control groups, along with a segment of untreated tissue from each animal ("native"). Tissue sections were examined for effects associated with treatment, such as thrombosis, necrosis, inflammation, and fibrosis and were graded based on histopathology scoring criteria (0 = no observable changes, 1 = Minimal—a nearly imperceptible change in the tissues, 2 = Mild/moderate—an easily identifiable and/or notable change in the tissues, 3 = Marked/severe—prominent to overwhelming change in the tissues). Total operative time defined as time elapsed between first trocar placement and last suture placement, was recorded for each procedure. Time to completion of anastomosis was also captured and was defined as time elapsed between first stapled bowel transection and coupling of magnets or closure of common channel. Usability of both SFM and stapled anastomosis devices / procedures was assessed. At the conclusion of each procedure the physician conducting the procedure was asked to rank a series of usability attributes using a Likert scale (1 = very difficult, 2 = difficult, 3 = neutral, 4 = easy, 5 = very easy).

Averages, ranges, and standard deviations were reported for outcome measures. Given the low number of subjects in each group, no further statistical analyses were performed.

Results

A total of $n = 14$ female Yorkshire swine were included. All procedures were successfully completed laparoscopically as planned (Test group: $n = 4$ SADI with SFM, $n = 4$ jejunojejunostomies with SFM; Control group: $n = 3$ SADI with linear stapler, $n = 3$ jejunojejunostomies with linear stapler). All animals survived without any serious adverse events or adverse events until the assigned endpoint of 42 days. Average procedure time from bowel transection to anastomosis completion was 16 min in the SFM group versus 17 min in the control group. All animals expelled both the SFM and the OTOLoc™ devices within 20 days. All SFM were expelled with an average transit time of 15.8 ± 3.0 days for SADI and 13.3 ± 2.9 days for jejunojejunostomies. OTOLoc™ device average transit time was 12.0 ± 4.8 days for SADI and 9.8 ± 1.2 days for jejunojejunostomies.

No animals experienced clinical signs of anastomotic leak, bleeding, obstruction or fistula.

Blood samples were collected for analysis and animal weights were measured at days 0, 5, 14, 28, and 42. No concerning abnormalities were found in the blood chemistry throughout the in vivo portion of the study. Between Days 0 and 5, weight change was minimal across both test and control, with the SFM group having an average percent change of 0.0% ($n = 8$, range = [− 2.9 to 2.8%]) and the stapled group having an average percent change of 0.8% ($n = 6$, range = [− 3.0 to 3.5%]). At all subsequent follow-ups the animal weights in both test and control groups steadily increased, with the test group having an overall percent change of 26.0% ($n = 8$, range = [20.0 to 35.7%]) and the control group having an overall percent change of 29.5% ($n = 6$, range = [22.4 to 40.7%]) on day 42. There was no acute weight loss exceeding 20% in any animal, indicating that interventions were overall well tolerated.

Generally, anastomoses with SFM were noted to be smooth on necropsy with very little visual indication of the anastomosis, while the staple controls were readily apparent and easily located due to the thickened tissue from inflammation and presence of staples and sutures (Fig. 3).

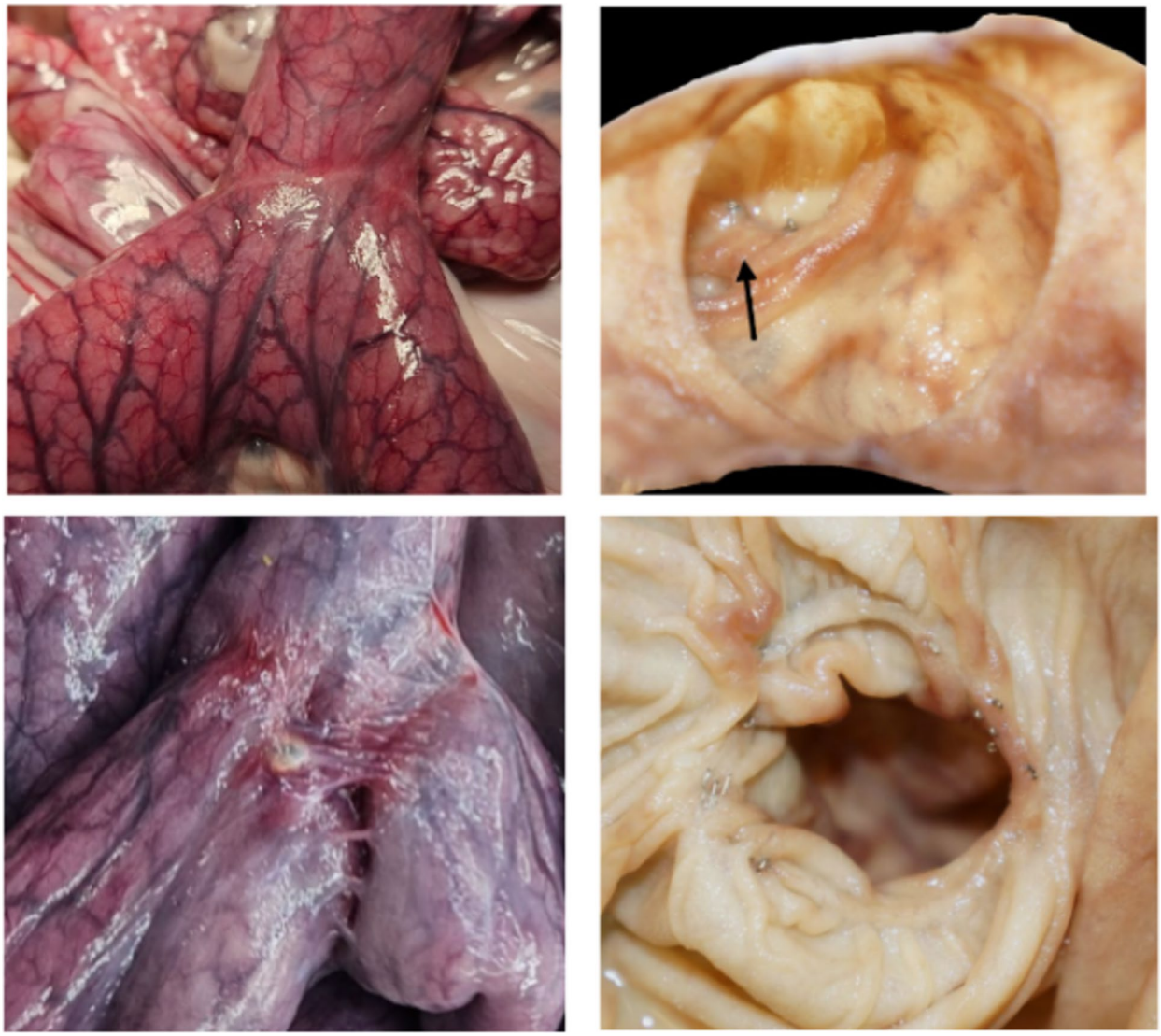

Fig. 3 Gross necropsy of anastomoses created using Flexagon™ self-forming magnets (top) and 60 mm linear staples (bottom)

At necropsy, the average diameter for the SFM anastomoses group was 20.7 mm ($n=8$, range = [17.8 to 25.5]) while the average diameter for the stapled anastomoses group was 21.6 mm ($n=6$, range [19.1 to 24.2]) (Table 1).

The mean adhesion score for the SFM group was 1.25 ($n=8$, range = [0 to 3]), whereas the control group score was 1.67 ($n=6$, range = [0 to 3]) (Supplemental Table 2). There were no noted adhesions between the anastomotic sites and any of the adjacent organs or the peritoneum in any of the animals assigned to SFM. One animal in the control group had a grade 2 adhesion from the staple line to the ventral peritoneum. Most adhesions were between the stapled end of the afferent duodenal limb and the serosa of the efferent small bowel. None of the observed adhesions had any impact on the health of the animals or the overall outcomes of the study.

The average burst pressure for the test samples was 129.2 mmHg ($n=4$, range = [115.3 to 141.7]) compared to the average values of the control samples of 79.4 mmHg ($n=2$, range = [70.3 to 88.4]) and the native tissue samples of 158.8 ($n=6$, range = [123.1 to 216.7]). The average test article anastomosis burst pressure also exceeded average staple control anastomosis burst pressure by 49.8 mmHg or 63%, indicating a stronger tissue bond for the SFM anastomoses (Fig. 4).

Tissue sections examined for histopathology revealed that magnetic anastomoses have far less distortion of the intestinal wall compared to the staple anastomoses (Fig. 5). In staple anastomoses, the most obvious change was displacement of myofibers of the tunica muscularis into the superficial submucosa but collagen patterns in the serosa and submucosa were altered as well. In magnetic anastomoses,

Table 1 Summary of anastomosis measurements taken at necropsy and pathology and the resulting calculated diameters

	Anastomosis size (measured at necropsy)		
	Flat measurement (mm)	Calculated diameter (mm)	Average
Magnet Group	33	21.0	20.7
	33	21.0	
	40	25.5	
	31	19.7	
	28	17.8	
	29	18.5	
	32	20.4	
	34	21.6	
Staple Group	32	20.4	21.6
	33	21.0	
	30	19.1	
	38	24.2	
	38	24.2	
	33	21.0	

the only distortion was mild disorganization and occasional isolation of myofibers in the tunica muscularis. The mean histopathology score in the SFM arm was 1 ($n=4$, range = [1 to 1]), while the mean score was 2.5 ($n=4$, range = [2 to 3]) for those assigned to linear stapler (Table 2). Intestinal wall thickness of the anastomoses with SFM was more consistent with the native tissue compared to the staple technique. Staple anastomoses average 2.7 mm ($n=4$, range = [2.3 to 3.3]) in wall thickness compared to average adjacent native tissue thickness of 1.3 mm ($n=4$, range = [1.1 to 1.3]). This resulted in an average difference in wall thickness of 1.4 mm ($n=4$, range = [1.0 to 2.2]) between the native tissue and stapled anastomosis tissue. Magnetic anastomoses average 1.3 mm ($n=4$, range = [1.2 to 1.4]) in wall thickness compared to average adjacent native tissue thickness of 1.3 mm ($n=4$, range = [1.2 to 1.4]). This resulted in an average difference in wall thickness of 0.03 mm ($n=4$, range = [0.0 to 0.1]) between the native tissue and magnetic anastomosis tissue. (Supplemental Table 3). Also of note, the histopathologist found evidence of bacterial infiltration in tissue samples from 3 out of 4 of the stapled control anastomoses (75%), whereas no signs of bacterial infiltration were found in any of the magnetic anastomoses (0%).

Mean total operative time was similar between groups: SFM = 32 min ($n=8$, range = 25 to 46) versus staple controls = 33 min ($n=6$, range = [24 to 42]). There was also no significant difference in average time to completion of anastomosis: SFM = 16 min ($n=8$, range = 11 to 23) versus staple controls = 17 min ($n=6$, range = [12 to 27]). Overall, across several predefined usability criteria, anastomoses created with SFM and their delivery devices were rated more positively (overall average = 4.9 / 5) than the linear staplers used in the control group (overall average = 4.4 / 5) (Supplemental Tables 4 and 5).

Discussion

The concept of compression gastrointestinal anastomosis, ranging from anastomotic rings to compression clips, has been available for many years and has been extensively documented in the literature, yet, it has not become widely adopted [9–15]. Wullstein et al. published a study on 442 colorectal anastomoses performed with compression devices in both elective and emergent settings, proving it to be safe with low rates of anastomotic complications [16]. Among compression devices, magnetic anastomoses have gained popularity, partially due to the fact that they address the

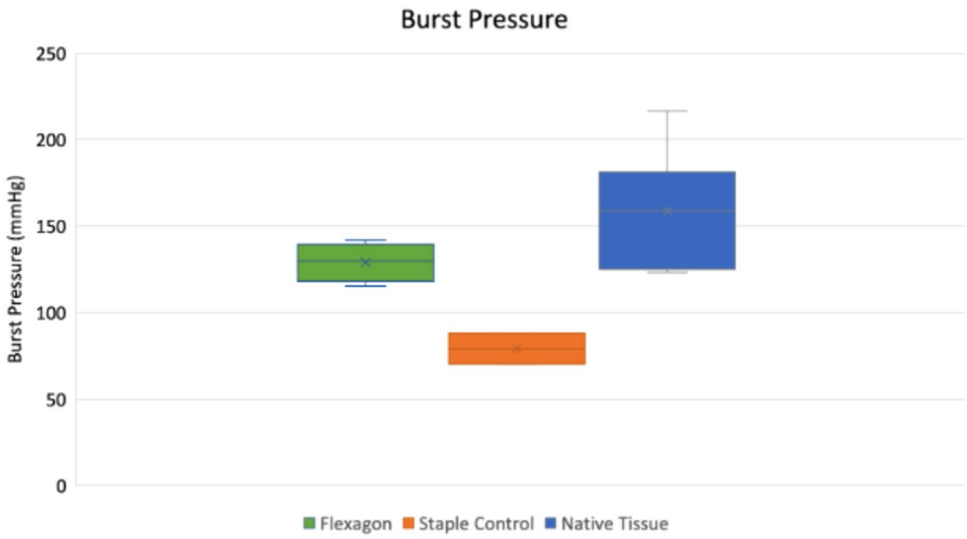

Fig. 4 Box and whisker plot of comparative burst test data

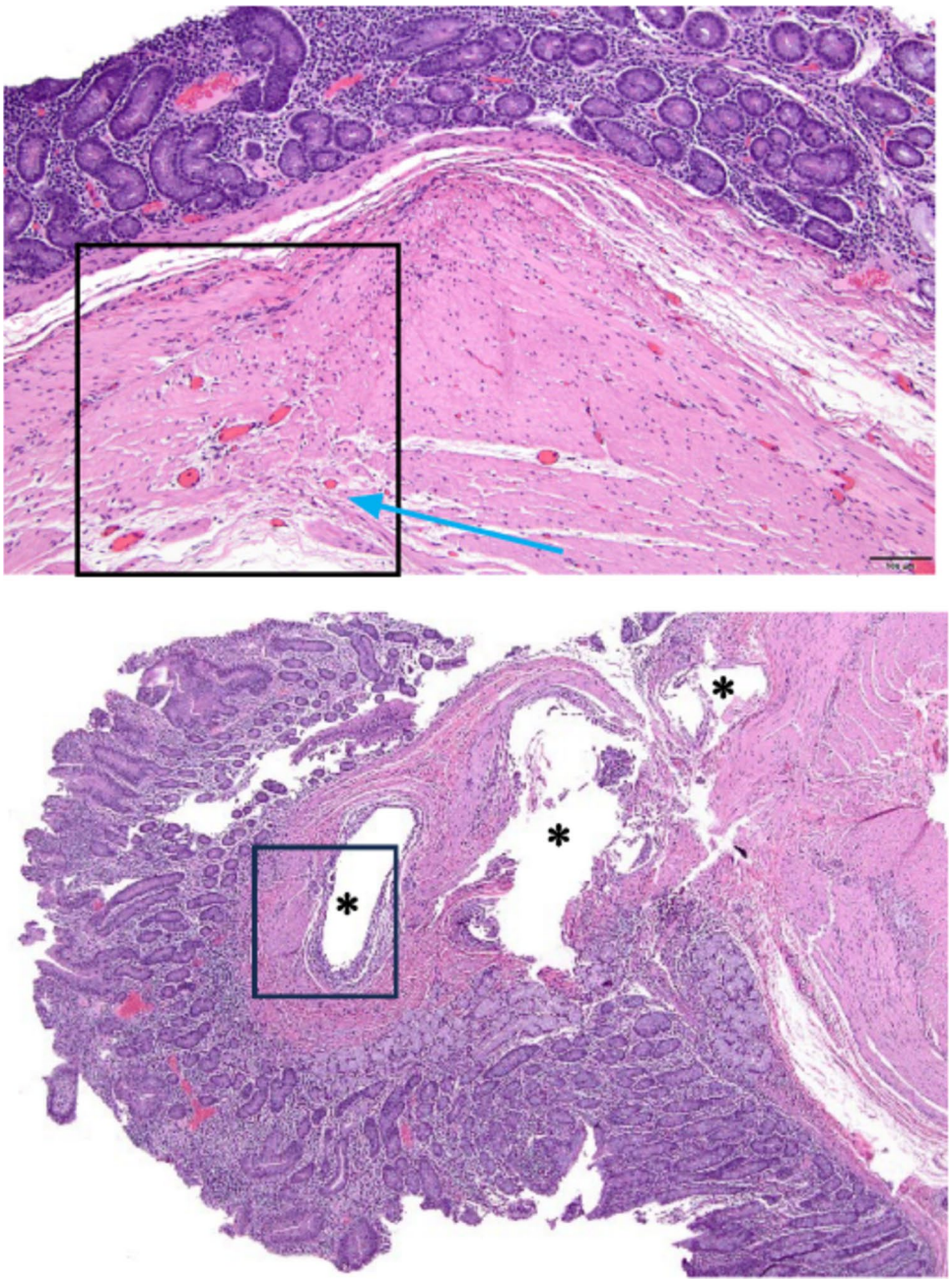

Fig. 5 Microscopic histopathologic evaluation of anastomosis: Flexagon™ self-forming magnetic anastomosis showing only mild tissue disorganization (top) (blue arrow shows the anastomotic line of compressive fusion). Stapled anastomosis have macrophages and neutrophils surround the staple cavities yielding disorganized regeneration of tunics (bottom) (staple cavities are denoted with " * " in the submucosa and muscularis) (Color figure online)

challenges associated with staples and sutures which act as foreign bodies in the gastrointestinal tract [17, 18]. Unlike conventional anastomoses created by sutures or staples, after the coupled magnets mature the anastomosis and are expelled, there is no long-term implant that can contribute to inflammation, scarring or stricture formation.

There has been a growing interest toward integrating magnetic anastomosis into the landscape of bariatric procedures. Through our preclinical porcine model study, we sought to replicate the creation of some of the anastomosis commonly performed during laparoscopic bariatric procedures. We found the GI Windows Flexagon™ + OTOLoc™ device to be safe and efficacious in creating durable single anastomosis duodenal ileostomies and jejunojejunostomies when compared to linear staplers, while at the same time having an effortless laparoscopic deployment. Its favorable usability profile potentially allows surgeons without advanced laparoscopic expertise to create consistent intracorporeal anastomoses through minimally invasive techniques. During this study, no animal experienced any serious adverse events including anastomotic leak, bleeding, or stricture formation during the course of our study. All magnets were expelled without erosions or separations. Moreover, anastomoses with SFM were associated with less adhesion

Table 2 Overall histopathology scores (0 = no observable changes, 1 = Minimal—a nearly imperceptible change in the tissues, 2 = Mild/moderate—an easily identifiable and/or notable change in the tissues, 3 = Marked/severe—prominent to overwhelming change in the tissues) and bacterial contamination

	Histopathology score		Evidence of bacterial contamination	
		Average		Total
Magnet Group	1	1	No	0 of 4
	1		No	
	1		No	
	1		No	
Staple Group	2	2.5	Yes	3 of 4
	3		No	
	2		Yes	
	3		Yes	

formation as well as stronger anastomosis on burst pressure testing while at the same time having less histopathological distortion and no signs of bacterial infiltration. In comparison to staples and sutures, the circumferential compression seal created by the magnets eliminates bacterial migration into the anastomotic region.

The major drawback of linear solid magnetic anastomotic devices is the inability to provide a patent lumen at the time of the surgical intervention. This meant that the technology could only be utilized in a bipartition procedure, allowing the anastomosis to form in approximately 7 to 21 days while the native pathway remained open [19–24]. The advent of the GI Windows OTOLoc™ device allows the physician to circumvent this limitation by radially supporting both enterotomies and providing an immediate, patent lumen while the Flexagon™ SFM matures the anastomosis. This is of particular importance as it allows for the creation of a functional end-to-end anastomosis which would otherwise be impossible with the use of any configuration of linear solid magnets. Moreover, large solid magnets with holes require closure of the enterotomies made to introduce the magnets into the lumen of the intestine via large enterotomies following the coupling of the magnets. Some linear solid magnets avoid this step by providing an endoscopic platform for the delivery of both magnets transorally, yet still need to be laparoscopically manipulated through long lengths of varying thickness bowel into place before coupling. The GI Windows Flexagon™ self-forming magnets combined with OTOLoc technology overcome the need of closing the enterotomies, by including the enterotomies within the Flexagon™ SFMs and therefore within the anastomosis, creating an immediate flow pathway across the anastomosis.

Previous authors have published similar preclinical studies; one on the use of SFMs for open ileostomy takedown and another study on laparoscopic ileocolic anastomosis with SFMs combined with a transluminal capture device to allow for immediate bowel continuity [6, 25]. Both of these studies demonstrated that ileoileostomies and ileocolostomies can be safely and effectively created with the GI Windows SFMs and without the need for closing the enterotomies created to introduce the magnets. This highlights the versatility of the SFM in addressing a broad spectrum of clinical conditions, not limited to the small bowel. Moreover, growing interest exists for utilizing this technology in foregut and colorectal conditions.

Ensuring a proper technique during the creation of intestinal anastomoses is crucial for achieving favorable patient outcomes in minimally invasive metabolic and bariatric surgery. As innovation continues to generate disruptive surgical technologies, these should be carefully evaluated and studied prior to incorporation into practice to ensure their efficacy, safety, and compatibility with established surgical standards.

Some of the limitations of our study include a small sample size and the use of a porcine model. Nonetheless, our results suggest that intestinal anastomoses created with the GI Windows Flexagon™ SFM with OTOLoc™ are as safe and effective as those anastomoses created by traditional suture or staple techniques. We opted for porcine models for our preclinical study given the similarity in bowel size and structure to that of humans, therefore making them a suitable model for evaluating surgical devices designed for human-size applications [26]. Further clinical trials in humans with follow up are needed to validate our findings and to ensure a safe adoption and implementation of these technologies. Finally, our protocol was not designed to investigate trends in weight loss and nutritional parameters. Contrary to other published literature on SADI, we opted not to perform gastric resections, only bypass minimal amount of bowel and not restrict animals' diet as the primary objective of our study was to assess the safety and performance of the test device with respect to the creation and healing of small bowel to small bowel anastomoses. Creation of a gastric resection was not directly related to the execution or healing of the anastomosis and may have added additional risks to the animals, potentially confounding the outputs of the study. Animal weights were periodically monitored solely as a means of assessing the animals' health and overall procedure tolerance.

Conclusion

This preclinical study suggests that magnetic compression small bowel anastomoses using GI Windows Flexagon™ SFM along with the OTOLoc™ device, are safe, effective, and simple to perform. The favorable results in terms of clinical outcomes, adhesion formation, burst pressure,

histopathology, bacterial infiltration, and usability support the potential of the GI Windows platform of devices as an innovative and promising alternative anastomosis tool in gastrointestinal surgery.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00464-025-11575-x.

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Declarations

Disclosures Wilson EB: Johnson & Johnson (consulting), GORE (consulting), GI Windows (consulting), BSCI (consulting), Activ surgical (consulting), Medtronic (education, consulting and research), Intuitive (education and research), Olympus (consulting), Allurion (research), Lexion (research), Reshape (education). Hutter MM: GI windows (consultant), MarvelBiome (consultant), Vicarious Surgical (consultant), Aiomics (consultant), Hillrom (advisory panel). Olavarria OA, Chhabra KR, Levi ST have no conflict of interest or financial ties to disclose.

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