



# Sutureless Duodeno-Ileal Anastomosis with Self-Assembling Magnets: Safety and Feasibility of a Novel Metabolic Procedure

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## Abstract

**Background** Less invasive and safer anastomotic techniques are desirable. We aimed to determine technical feasibility and safety of sutureless duodeno-ileal side-to-side anastomosis in obese patients using self-assembling magnets.

**Methods** This was an open-label, prospective, and single-arm study including obese patients (BMI 30–50 kg/m<sup>2</sup>) with type II diabetes. The ileal magnet was deployed laparoscopically, and the duodenal magnet was deployed endoscopically. Both magnets were coupled under laparoscopic and fluoroscopic guidance. The primary endpoints were technical feasibility and safety. The secondary endpoints were patency of the anastomosis, HbA1c reduction, and weight loss 12 months after the procedure.

**Results** A total of 8 patients were enrolled in the study; median age was 51.5 years (range: 34–65), and median BMI was 38.8 kg/m<sup>2</sup> (range: 35–47.9). The mean procedural duration was 63.5 min (range: 41–95). No intraoperative complications were recorded, and no major postoperative morbidity related to the procedure occurred. Magnets were expelled at a median of 29.5 days after the procedure with no associated complications. Upper endoscopy at 12 months confirmed patent anastomoses with healthy-appearing mucosa in all patients. HbA1c reduced below 7.0% in 6 out of 8 (75%) patients, and greater than 5% of total body weight loss was observed in 7 out of 8 (87.5%) patients at 12 months.

**Conclusions** Sutureless duodeno-ileal side-to-side anastomosis using self-assembling magnets is feasible and safe in obese patients, and a dual-path enteral diversion with large-caliber and durable anastomosis can be achieved.

**Keywords** Obesity · Diabetes · Magnets · Duodeno-ileal anastomosis

## Key Points

- Sutureless duodeno-ileal side-to-side anastomosis using self-assembling magnets is feasible and safe in obese patients.
- Once the anastomosis has formed, the mated magnet complex breaks free into the enteral flow and is excreted in the patient's stool.
- The procedure creates a dual-path enteral diversion in which both the diversion and “native” routes remain patent.

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## Introduction

Obesity prevalence has risen dramatically over the last decades, and it is estimated that one third of the world's population is overweight or obese [1]. In the USA, obesity is the second most preventable cause of mortality, and forecasts show that by 2030, 50% of the American population will be obese [2–4]. Obese patients undergoing bariatric surgery have a greater likelihood of remission of obesity-related comorbidities, as compared to those receiving medical treatment [5].

Currently, bariatric operations with intestinal bypasses are created using sutures or surgical staplers [6–8]. A third approach based on endoscopic magnetic compression anastomosis has also been described in both animal and human studies [9–12]. Compression anastomosis was first described in 1826 by Felix-Nicholas Denans, long before the advent of mechanical staplers [13]. Since then, multiple compression anastomosis devices, including most recently the compression

anastomosis ring (CAR) [14, 15], have been used safely and effectively, but mostly for colorectal anastomoses, and have required surgical placement. Theoretical advantages of using magnets include its ease of delivery, greater strength, dynamic slow compression of tissue, lack of foreign material left within the anastomosis long term, and operator independency [16]. However, a significant historical disadvantage of compression anastomoses has been the size of the magnet limiting the size of the anastomosis, which ultimately jeopardizes its long-term patency [17, 18].

Our study group has developed a novel and minimally invasive method to create an intestinal anastomosis that is ideally suited for use in the duodenum. Self-assembling magnetic octagons using minimally invasive techniques (endoscopy and laparoscopy) were used to create a dual-path enteral diversion, side-to-side anastomosis in which both the diversion and “native” routes remain patent. The self-assembling magnetic device is a system of self-pairing magnets with endoscopic and laparoscopic delivery systems. After the magnetic octagons couple, they create a diversion over several days through a process called compression anastomosis whereby the body remodels in response to a constant compressive force across two approximated viscera. The tissues between the two segments of the intestine heal as the tissue within the magnet necroses. Once the anastomosis has formed, the mated magnet complex breaks free into the enteral flow and is excreted in the patient’s stool.

This system represents the first type of compression anastomosis device for use in the intestinal tract that is capable of forming a permanent and large-caliber (25-mm internal diameter) anastomosis using a device that can be delivered through the working channel of a flexible endoscope or through a 5-mm laparoscopic port.

The aim of this study was to determine technical feasibility, safety, and effectiveness of sutureless duodeno-ileal anastomosis in obese patients with type II diabetes using self-assembling magnets in a Sutureless Neodymium Anastomosis Procedure (SNAP).

## Methods

### Study Design and Patients

This was an open-label, prospective, and single-arm study conducted at one institution, approved by the Institutional Review Board and the National Health Regulatory Authority.

Eligible participants should fulfill the following inclusion criteria: age 18–65 years, body mass index (BMI) 30–50 kg/m<sup>2</sup>, and type II diabetes (diagnosis for more than 6 months and less than 10 years, taking at least one oral antidiabetic medication with fasting glucose < 200 mg/dl, and HbA1c 6.5–10% at the time of enrollment). In addition, any other comorbidity

(if present) should be adequately controlled with medication, and smoking should be ceased during the study.

Key exclusion criteria included type I diabetes, titanium and/or nickel allergy, insulin requirement, pregnancy, current malignant disease, presence of a pacemaker or implantable cardioverter defibrillator, and coagulopathy.

### Enrollment

Individuals who met the inclusion and exclusion criteria were screened by behavioral, nutritional, and medical evaluations. After all evaluations were completed, a consent form explaining the procedure, required follow-up, risks, and potential benefits was signed by all participants.

### Procedural Technique

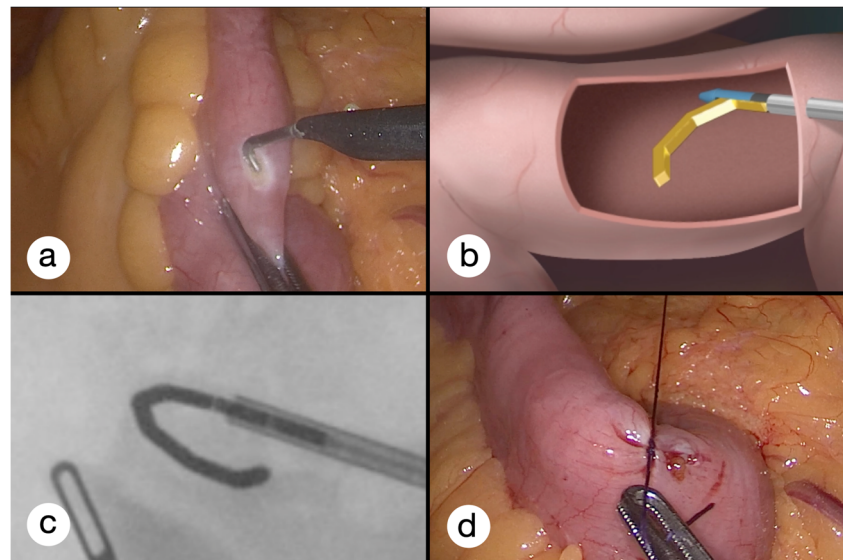
After induction of general endotracheal anesthesia, the patient was positioned supine in a low lithotomy position with the lower extremities extended on stirrups with pneumatic compression stockings, and knees flexed 20–30°. Both arms were left abducted and secured on a board with adequate padding. The Veress needle was placed at Palmer’s point, and pneumoperitoneum was established at 12 mmHg. Five ports were used for the procedure. The ileocecal valve (ICV) was identified, and an ileum loop 300 cm away from the ICV was grasped. A 5-mm ileotomy was created, and the magnet was delivered with a laparoscopic deployment tool under fluoroscopic guidance. The enterotomy was then closed with a single stitch of an absorbable suture (i.e., polyglactin 3.0) (Fig. 1).

An upper endoscopy was then performed, delivering the magnet in the duodenum (2 cm distal to the pylorus) with an endoscopic deployment tool (Fig. 2). The ileum loop with the inserted magnet was then approximated towards the duodenum, and both magnets were coupled under laparoscopic and fluoroscopic guidance (Fig. 3). Instruments and trocars were then removed from the abdomen under direct vision.

### Postoperative Care

Patients were extubated immediately after completion of the procedure. Patients were fed the morning after the operation with clear liquids and usually discharged after 24 h, with instructions to continue with liquid/soft diet for the first 2 weeks, with no specific dietary restrictions thereafter. An abdominal X-ray was performed at 2 and 4 weeks after the procedure to determine the localization and/or expulsion of the magnets (in case the patient did not notice the magnets in the toilet). Follow-up endoscopies were performed at 2 and 12 months after device placement to confirm patency of the anastomosis.

**Fig. 1** Laparoscopic delivery of the magnet into the ileum (**a** enterotomy; **b** delivery of magnet into the ileum; **c** fluoroscopy during delivery of magnet into the ileum; and **d** closure of enterotomy)



### Main Outcomes and Measures

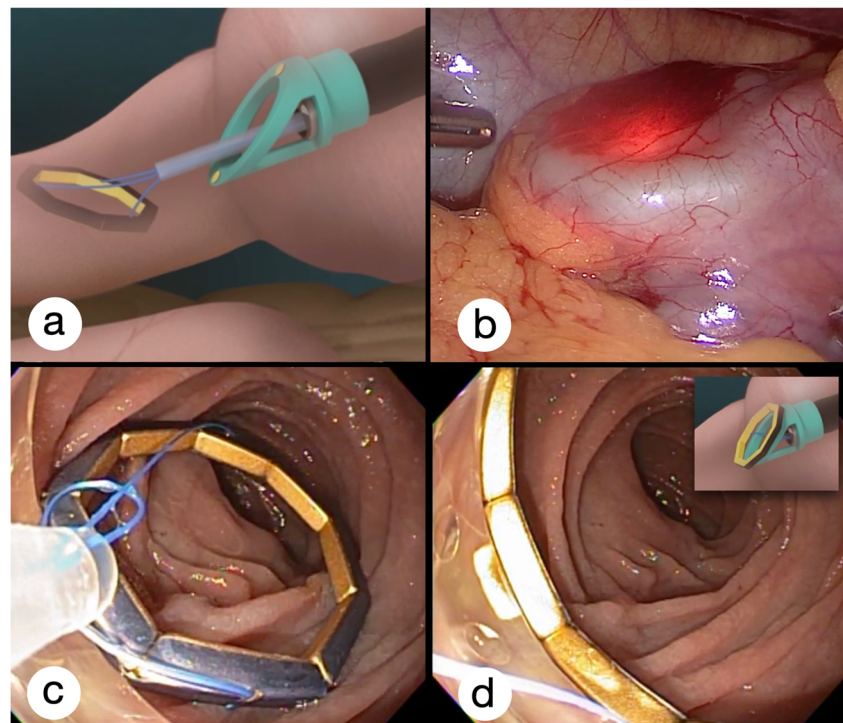
The primary endpoints of the study were technical feasibility and safety: magnet deployment through the laparoscopic port and endoscope channel, engagement of the magnets, and device-related adverse events (30-day morbidity using Clavien-Dindo classification). The secondary endpoints include patency of the anastomosis, HbA1c reduction, and weight loss at 12 months after the procedure.

### Results

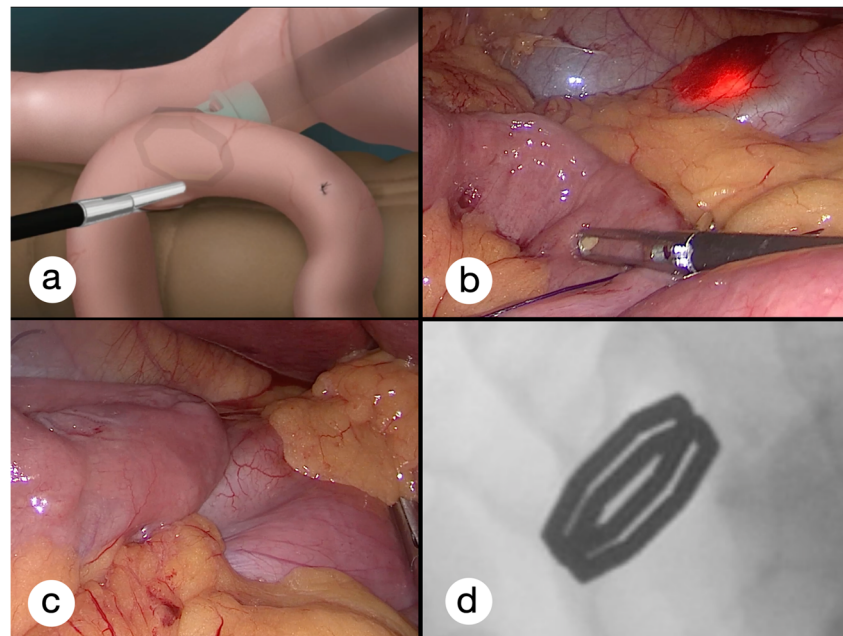
A total of 8 patients were enrolled in the study; 4 (50%) were male patients, the median age was 51.5 years (range: 34–65) years, and median BMI was 38.8 kg/m<sup>2</sup> (range: 35–47.9). Patient demographics are summarized in Table 1.

Laparoscopic and endoscopic delivery of the magnets into the desired segments of the bowel (ileum and duodenum) was successfully accomplished in all patients. Engagement of the magnets was also achieved in all patients. The mean procedural

**Fig. 2** Endoscopic delivery of the magnet in the duodenum, 2 cm distal to the pylorus (**a** magnetic octagon delivered through the biopsy channel of a flexible endoscope; **b** laparoscopic view of the magnet against the anterior duodenal wall; **c** magnet deployed inside the duodenum; **d** magnet attached to the cap)



**Fig. 3** Both magnets are coupled under laparoscopic and fluoroscopic guidance (**a** schematic image showing how both magnets should be coupled; **b** the ileum loop containing the magnet is moved towards the duodenum; **c** laparoscopic view of the engagement of both magnets; **d** fluoroscopic confirmation that both magnets are coupled correctly)



duration (trocar in–trocar out) was 63.5 min. The mean enterotomy creation to magnet coupling procedural duration was 52.3 min in the first 3 procedures and 36.3 min in the last 3 procedures. No intraoperative complications were recorded.

All patients were discharged on postoperative day (POD) 1; 30-day morbidity occurred in 6 (75%) patients (5 Clavien-Dindo grade I and 1 Clavien-Dindo grade IV). Two (25%) patients were readmitted at 3 weeks post-device implant: one for abdominal pain requiring intravenous analgesia for 24 h (abdominal CT without pathologic findings) which was identified as constipation and the other one with diabetic ketoacidosis due to poor medical therapy compliance. This patient required intravenous insulin therapy and was hospitalized for 3 days (Clavien-Dindo grade IV because the patient was admitted to the ICU for 24 h for strict blood glucose monitoring).

**Table 1** Demographics of patients included in the study

	<i>n</i> = 8
Male gender	50%
Median age, years (range)	51.5 (34–65)
Median weight, kg (range)	100.55 (94–159)
Median BMI, kg/m <sup>2</sup> (range)	38.78 (35.58–47.48)
Median HbA1c % (range)	8.2 (7.4–9.6)
Comorbidities	
Diabetes	100%
Hypertension	50%
Dyslipidemia	25%
Hypothyroid	20%
Obstructive sleep apnea	0%
Smoking	50%

No anastomotic bleeding or leaks were observed in any of the patients. Magnets were expelled in the patients' stool at a median of 29.5 days (range: 15–45) after the procedure. Mild abdominal pain was present in 3 (35.5%) and 1 (12.5%) patients at POD 30 and 60, respectively. Nausea was present in 4 (50%) and no patients at POD 30 and 60, respectively. Diarrhea affected 2 (25%) and 1 (12.5%) patients at POD 30 and 60, respectively (Table 2).

Upper endoscopy at 12 months confirmed patent anastomoses with healthy-appearing mucosa in all patients (Fig. 4). HbA1c (baseline: 7.4–9.6) was reduced below 7.0% in 6 out of 8 (75%) patients, and greater than 5% of total body weight loss was observed in 7 out of 8 (87.5%) patients at 12 months.

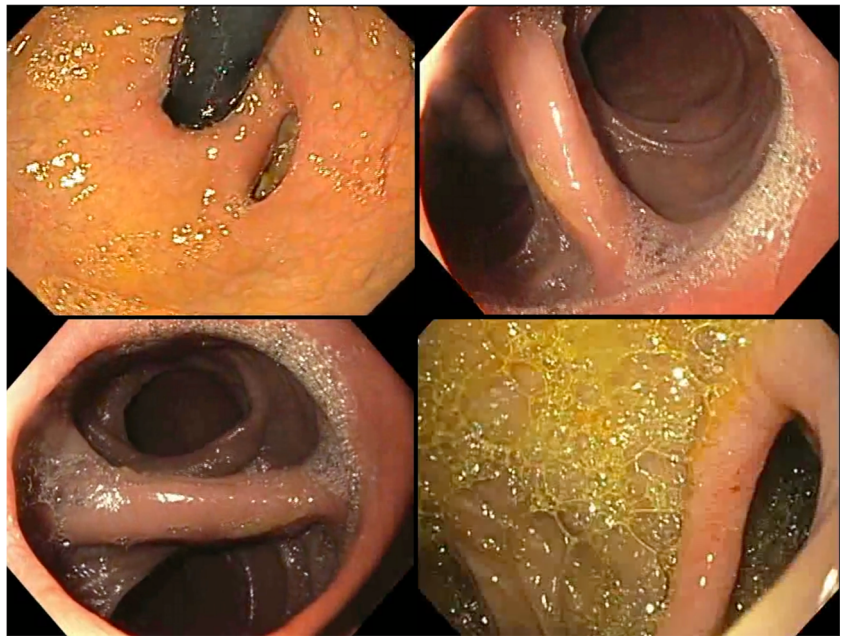
## Discussion

The primary aim of this study was to evaluate technical feasibility and safety of sutureless duodeno-ileal anastomosis with self-assembling magnets in obese patients with type II

**Table 2** Postoperative adverse events

	Day 30	Day 60	Day 90
Abdominal distension	75% (6/8)	50% (4/8)	50% (4/8)
Abdominal/epigastric pain	35.5% (3/8)	12.5% (1/8)	12.5% (1/8)
Constipation	12.5% (1/8)	0/8	0/8
Diarrhea	25% (2/8)	12.5% (1/8)	12.5% (1/8)
Nausea	50% (4/8)	0/8	0/8
Vomiting	12.5% (1/8)	0/8	0/8

**Fig. 4** Upper endoscopy at 12 months confirming patency of the anastomosis and healthy-appearing mucosa



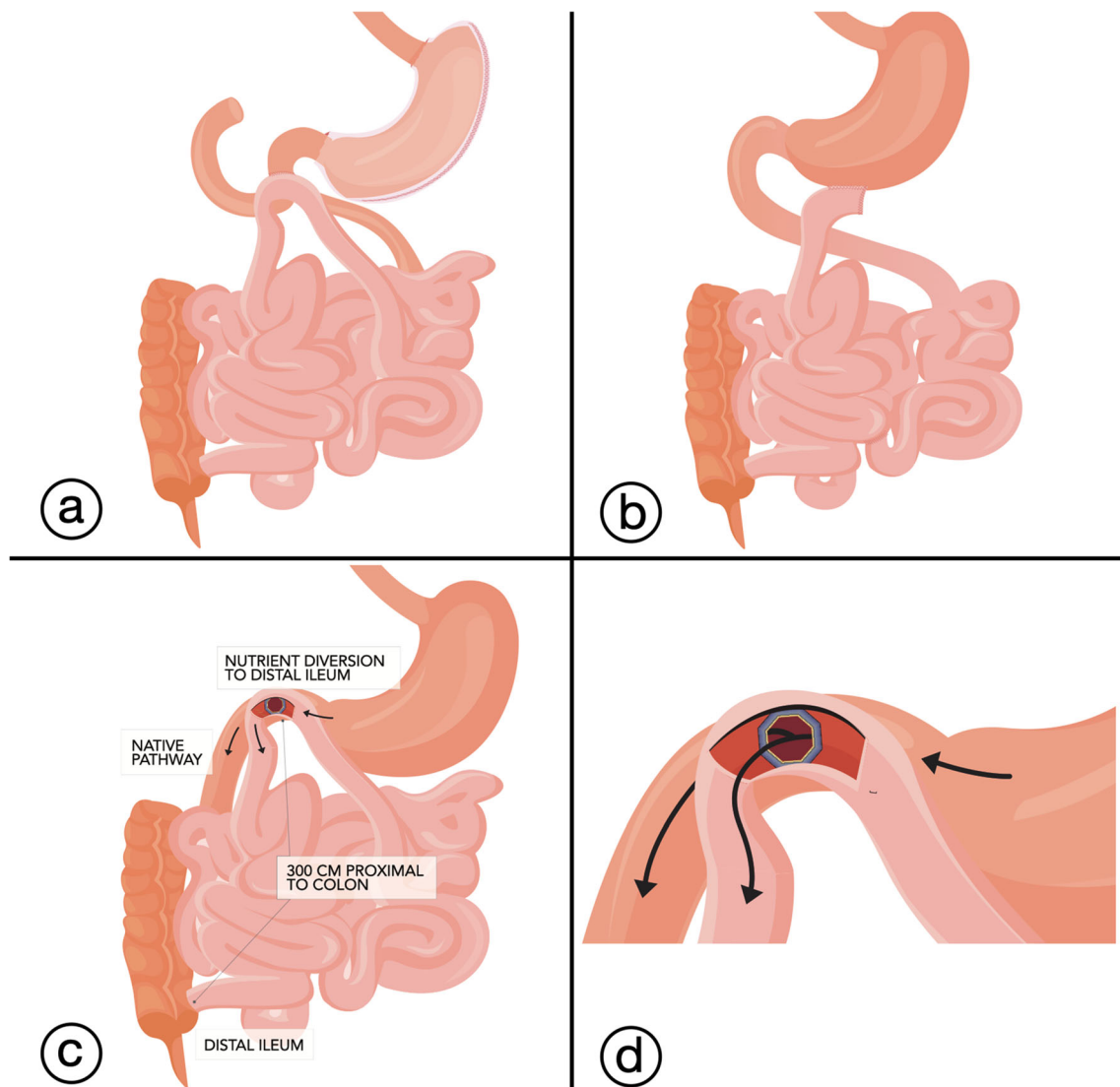
diabetes. We found that this novel metabolic procedure was feasible and safe, providing a durable intestinal diversion.

Our study group has previously demonstrated proof of concept of self-assembling magnets for entero-enteral anastomosis in both animal and human studies, showing critical features in the resulting anastomoses: absence of bleeding, absence of leaks, absence of residual foreign (i.e., sutures/staples) material, and long-term patency [19–21]. In these studies, however, a purely endoscopic procedure was performed with simultaneous enteroscopy and colonoscopy for jejunal-ileal diversion [19–21]. Although this endoluminal incisionless approach was indeed promising, we learned that the need for two highly trained endoscopists and the potential inadvertent capture of adjacent structures might limit the embracement of the procedure. Therefore, we decided to shift towards a laparo-endoscopic technique in the current trial focusing on a duodenal-ileal diversion, and we found that this approach is technically simpler, faster, and most likely safer. In all patients, the laparoscopic and endoscopic magnet delivery was uneventful, and the engagement of the magnets was rapidly accomplished under direct visualization.

A new intestinal bypass procedure was introduced in 2007; the single anastomosis duodenal-ileal (SADI) bypass procedure which provides good weight loss outcomes has less metabolic complications as the biliopancreatic diversion with duodenal switch or Roux-en-Y gastric bypass and is rarely associated with “dumping syndrome” because the procedure preserves the pylorus [22–25]. However, the SADI procedure is technically challenging using a conventional laparoscopic hand-sewn anastomosis technique because the duodenum is a fixed retroperitoneal structure and the duodenal dissection for a SADI involves close proximity to the portal triad. In

addition, this is also a difficult area in which we use surgical staplers to create an anastomosis. In fact, anastomosis leaks, strictures, abscess formation, and postoperative bleeding have been observed after SADI [26, 27]. These technical considerations and concerns over long-term malabsorptive complications are likely the rationale behind the limited number of surgeons adopting the SADI procedure as something that they routinely offer their patients. The proposed SNAP procedure offers an alternative to both concerns. Although our entero-enteral dual-path diversion SNAP procedure using self-assembling magnets partially resembles the SADI procedure, it differs in that there is no division of the duodenum, and some enteral flow through the duodenum is maintained. Therefore, the SNAP configuration resembles more the so-called transit bipartition operation [28, 29] (Fig. 5). As such, this procedure would offer less malabsorption and would likely be less effective than the SADI procedure. However, it also has significant potential advantages over the SADI including being much less technically challenging and potentially offering a lower risk of anastomotic leak or bleeding. The maintenance of duodenal enteral flow also potentially may lessen vitamin and mineral deficiencies while establishing new stimulation of distal K cells in the small intestine. In addition, such a procedure maintains access to the ampulla of the Vater biliary system for interventional gastrointestinal procedures if needed. Clearly, further clinical data are needed to determine the metabolic and relative complications of this procedure.

Some precautions should be followed due to the use of magnets. Intraoperatively, efforts should be made to minimize contact between the magnets and stainless-steel laparoscopic instruments, which may lead to procedure time delays. Postoperatively, patients cannot undergo magnetic resonance



**Fig. 5** **a** SADI-S procedure; **b** transit bipartition procedure; **c** Sutureless Neodymium Anastomosis Procedure (SNAP); and **d** magnified view of duodeno-ileal side-to-side anastomosis with self-assembling magnets

imaging until the expulsion of the magnets is confirmed. In our cohort, we had no intraoperative complications and no major postoperative morbidity. Although one patient was readmitted to the ICU due to diabetic ketoacidosis, this complication was most likely associated with poor patient compliance with prescribed medical therapy. In addition, the severity of the gastrointestinal adverse events observed in our trial was relatively mild and consistent with the altered anatomy. Most symptoms resolved upon diet correction, and only one patient persisted with diarrhea at the 2-month follow-up control.

Long-term patency of magnetic compression anastomosis is a common concern because small-diameter magnets are often passed endoscopically over a guidewire [30, 31]. For instance, a recent study analyzed the outcomes of 14 patients undergoing magnetic compression anastomosis for gastrointestinal obstruction. Anastomotic stenosis occurred in two (14%) patients, and one (7%) patient had an anastomotic

perforation due to balloon dilation to prevent stenosis (perforation with generalized peritonitis after the 8th balloon dilation) [31]. In our cohort of patients, endoscopic evaluation of the duodenal bulb 12 months after the procedure showed a widely patent dual-path diversion. Our “flexible” magnets progress through a linear configuration to the final octagonal configuration, allowing for the creation of a large-caliber anastomosis. The absence of residual foreign material (i.e., staples or sutures) in the anastomosis avoids ongoing inflammation and fibrosis, which may potentially lead to anastomotic strictures. Additionally, the 360° compression force of the self-assembling magnets creates a complete hemostatic effect theoretically eliminating bleeding at the anastomosis site. All the patients included in this study had no prior bariatric procedure for weight loss, but the study group believes there may be a valuable use in patients that are regaining weight several years after a sleeve gastrectomy.

Metabolic surgery is evolving rapidly, and alternative endoscopic gastrointestinal bypass techniques might be also available in the near future. For instance, an anastomosis between the stomach and the intestinal limb using a transgastric approach with a two-channel endoscope with a novel stent was described in a porcine model [32]. Recently, an endoscopic ultrasonography-guided gastrojejunal anastomosis using a lumen-apposing metal stent was also reported in a patient with a duodenal stricture [33]. Overall, we believe that novel anastomotic techniques should be further explored and may become soon part of the armamentarium of metabolic surgery.

This study has several limitations. First, a small number of patients were enrolled in the trial. Second, all procedures were performed by the same surgical team, which limits the reproducibility of our results. Third, there was a lack of a control group. Finally, longer follow-up will be needed to demonstrate a more durable patency of the anastomosis and metabolic benefits.

## Conclusions

Sutureless duodeno-ileal anastomosis using self-assembling magnets is feasible and safe in obese patients with type II diabetes, and a dual-path enteral diversion with large-caliber and durable anastomosis can be achieved. Potential additional applications may include patients that had previous sleeve gastrectomy with inadequate weight loss. Further studies with longer follow-up are needed to determine if this procedure can serve as an effective treatment modality for obese patients with type II diabetes.

## Declarations

**Ethical Approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed Consent** Informed consent was obtained from all individual participants included in the study.

**Conflict of Interest** Francisco Schlottmann has no conflicts of interest or financial ties to disclose. Marvin Ryou has financial ties with GI Windows (consulting fees). David Lautz has financial ties with GI Windows (consulting fees and stock options). Christopher C. Thompson has financial ties with GI Windows (consulting fees and stock options). Rudolf Buxhoeveden has no conflicts of interest or financial ties to disclose.

## References

- Ng M, Fleming T, Robinson M, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*. 2014;384:766–78.
- Hill JO, Wyatt HR, Reed GW, et al. Obesity and the environment, where do we go from here? *Science*. 2003;299:853–5.
- Ogden CL, Carroll MD, Fryar CD, et al. Prevalence of obesity among adults and youth: United States, 2011–2014. *NCHS Data Brief*. 2015;219:1–8.
- Finkelstein EA, Khavjou OA, Thompson H, et al. Obesity and severe obesity forecasts through 2030. *Am J Prev Med*. 2012;42(6):563–70.
- Jakobsen GS, Smastuen MC, Sandbu R, et al. Association of bariatric surgery vs medical obesity treatment with long-term medical complications and obesity-related comorbidities. *JAMA*. 2018;319:291–301.
- Salminen P, Helmio M, Ovaska J, et al. Effect of laparoscopic sleeve gastrectomy vs laparoscopic Roux-en-Y gastric bypass on weight loss at 5 years among patients with morbid obesity: the SLEEVEPASS randomized clinical trial. *JAMA*. 2018;319(3):241–54.
- Peterli R, Wolnerhanssen BK, Peters T, et al. Effect of laparoscopic sleeve gastrectomy vs laparoscopic Roux-en-Y gastric bypass on weight loss in patients with morbid obesity: the SM-BOSS randomized clinical trial. *JAMA*. 2018;319(3):255–65.
- Yashkov Y, Bordan N, Torres A, et al. SADI-S 250 vs Roux-en-Y duodenal switch (RY-DS): results of 5-year observational study. *Obes Surg*. 2020;
- Pichakron KO, Jelin EB, Hirose S, et al. Magnamosis II: magnetic compression anastomosis for minimally invasive gastrojejunostomy and jejunojejunostomy. *J Am Coll Surg*. 2011;212(1):42–9.
- Gonzales KD, Douglas G, Pichakron KO, et al. Magnamosis III: delivery of a magnetic compression anastomosis device using minimally invasive endoscopic techniques. *J Pediatr Surg*. 2012;47(6):1291–5.
- Lebares CC, Graves CE, Lin MY, et al. Endoscopic magnetic compression anastomosis for small bowel bypass in a high operative risk setting. *Surg Laparosc Endosc Percutan Tech*. 2019;29(5):84–7.
- Kamada T, Ohdaira H, Takeuchi H, et al. Magnetic compression anastomosis for non-anastomotic stenosis of the proximal jejunum after total gastrectomy with Roux-en-Y reconstruction: a case report. *Surg Case Rep*. 2020;6(1):167.
- Kaidar-Person O, Rosenthal RJ, Wexner SD. Compression anastomosis: history and clinical considerations. *Am J Surg*. 2008;195:818–26.
- Khromov Y, Pliakos I, Ibrahim M, et al. A prospective multi-institutional study assessing clinical outcome with the NiTi compression anastomosis ring (Biodynamix ColonRing) in elective colorectal anastomoses. *Hepatogastroenterology*. 2013;60:522–7.
- Masoomi H, Luo R, Mills S, et al. Compression anastomosis ring device in colorectal anastomosis: a review of 1,180 patients. *Am J Surg*. 2013;205:447–51.
- Jamshidi R, Stephenson JT, Clay JG, et al. Magnamosis: magnetic compression anastomosis with comparison to suture and staple techniques. *J Pediatr Surg*. 2009;44(1):222–8.
- Cope C, Ginsberg GG. Long-term patency of experimental magnetic compression gastroenteric anastomoses achieved with covered stents. *Gastrointest Endosc*. 2001;53(7):780–4.
- Kawabata H, Sone D, Yamaguchi K, et al. Endoscopic gastrojejunostomy for superior mesenteric artery syndrome using magnetic compression anastomosis. *Gastroenterol Res*. 2019;12(6):320–3.
- Ryou M, Agoston AT, Thompson CC. Endoscopic intestinal bypass creation by using self-assembling magnets in a porcine model. *Gastrointest Endosc*. 2016;83(4):821–5.

20. Ryou M, Aihara H, Thompson CC. Minimally invasive entero-enteral dual-path bypass using self-assembling magnets. *Surg Endosc.* 2016;30(10):4533–8.
21. Machytka E, Bužga M, Zonca P, et al. Partial jejunal diversion using an incisionless magnetic anastomosis system: 1-year interim results in patients with obesity and diabetes. *Gastrointest Endosc.* 2017;86(5):904–12.
22. Zaveri H, Surve A, Cottam D, et al. A multi-institutional study on the mid-term outcomes of single anastomosis duodeno-ileal bypass as a surgical revision option after sleeve gastrectomy. *Obes Surg.* 2019;29(10):3165–73.
23. Merz AE, Blackstone RB, Gagner M, et al. Duodenal switch in revisional bariatric surgery: conclusions from an expert consensus panel. *Surg Obes Relat Dis.* 2019;15:894–9.
24. Sánchez-Pernaute A, Herrera MA, Pérez-Aguirre ME, et al. Single anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADIS). One to three-year follow-up. *Obes Surg.* 2010;20(12):1720–6.
25. Sánchez-Pernaute A, Rubio MÁ, Pérez Aguirre E, et al. Single-anastomosis duodenoileal bypass with sleeve gastrectomy: metabolic improvement and weight loss in first 100 patients. *Surg Obes Relat Dis.* 2013;9(5):731–5.
26. Shoar S, Poliakin L, Rubenstein R, et al. Single anastomosis duodeno-ileal switch (SADIS): a systematic review of efficacy and safety. *Obes Surg.* 2018;28(1):104–13.
27. Cottam A, Cottam D, Roslin M, et al. A matched cohort analysis of sleeve gastrectomy with and without 300 cm loop duodenal switch with 18-month follow-up. *Obes Surg.* 2016;26(10):2363–9.
28. Topart P, Becouam G, Finel JB. Comparison of 2-year results of Roux-en-Y gastric bypass and transit bipartition with sleeve gastrectomy for superobesity. *Obes Surg.* 2020;30(9):3402–7.
29. Azevedo FR, Santoro S, Correa-Giannella ML, et al. A prospective randomized controlled trial of the metabolic effects of sleeve gastrectomy with transit bipartition. *Obes Surg.* 2018;28(10):3012–9.
30. Hu B, Ye LS. Endoscopic applications of magnets for the treatment of gastrointestinal diseases. *World J Gastrointest Endosc.* 2019;11(12):548–60.
31. Kamada T, Ohdaira H, Takeuchi H, Takahashi J, Ito E, Suzuki N, Narihiro S, Yoshida M, Yamanouchi E, Suzuki Y. New technique for magnetic compression anastomosis without incision for gastrointestinal obstruction. *J Am Coll Surg.* 2020.
32. Caiazzo R, Branche J, Daoudi M, et al. Increased postprandial glucagon-like peptide-1 (GLP-1) production after endoscopic gastrointestinal bypass using the Cousin lumen-apposing stent in a porcine model. *Endoscopy.* 2018;50(1):14–21.
33. Monino L, Gonzalez JM, Serrero M, et al. First case of endoscopic ultrasound-guided gastrojejunal anastomosis for duodenal stricture in refractory Crohn's disease: a bridge toward inflammation control. *Endoscopy.* 2020;52(6):E204–5.

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