BMC Gastroenterology

RESEARCH

Open Access

Magnet-assisted diverticuloplasty for treating the symptomatic esophageal diverticulum: a case series (with video)

Ruide Liu[1†], Xianhui Zeng[2†], Xianglei Yuan[1†], Wei Liu[1], Shuang Liu[1], Yinong Zhu[1] and Bing Hu[1*]

Abstract

Background The development of the magnetic compression technique (MCT) for the gastrointestinal (GI) tract has been widely applied in the treatment of biliary strictures, esophageal atresia, and GI anastomoses. Our team combined the MCT and minimally invasive endoscopic operation to propose a novel alternative procedure called magnet-assisted diverticuloplasty (MAD) for treating various esophageal diverticula. This case series aimed to report the effectiveness, safety, and our experience of MAD.

Methods This retrospective case series included patients with symptomatic esophageal diverticulum (SED) who underwent MAD between November 2017 and June 2022 in West China Hospital, Sichuan University. The patients' symptomatic scores were accessed by Eckardt symptomatic scores. The telephone follow-up period ended in March 2023. The primary outcome of the study was clinical success. Secondary outcomes included the technical success of MAD, procedure time, hospitalization, recurrence, and adverse events.

Results We reported 6 patients with SED who underwent MAD (3 with Zenker's, 1 with middle, and 2 with lower esophageal diverticulum). The technical success rate was 100% (6/6) and no adverse events were reported. The median procedural duration was 22.5 min (interquartile range (IQR) 18.5). The mean hospitalization was 2 days (range 1–3). The median time of follow-up endoscopy was on postoperative day 18 (IQR 31), revealing a shortened diverticular septum under endoscopic examination. After a median telephone follow-up of 23 months (IQR 36), the median total symptomatic score decreased significantly from 4.00 (IQR 3.25) to 1.00 (IQR 2.00) ($P=0.015$). The clinical success rate was 83.3% (5/6), and only one patient had recurrent symptoms two years after MAD.

Conclusion MAD provided a novel method for treating SED. Our limited experience suggested that MAD could be minimally invasive and effective. More extensive, multicenter prospective studies were needed to assess this technique further.

Keywords Esophageal diverticulum, Magnetic compression technique, Magnet-assisted diverticuloplasty, Symptomatic esophageal diverticulum, Peroral endoscopic myotomy

†Ruide Liu, Xianhui Zeng and Xianglei Yuan contributed equally to this work.

*Correspondence:
Bing Hu
hubing@wchscu.edu.cn

[1]Department of Gastroenterology and Hepatology, West China Hospital, Medical Engineering Integration Laboratory of Digestive Endoscopy, West China Hospital, Sichuan University, No.37, Guo Xue Alley, Wuhou district, Chengdu, Sichuan Province, China
[2]Department of Gastroenterology and Hepatology, West China School of Public Health and West China Fourth Hospital, Sichuan University, Chengdu, China

Introduction

Esophageal diverticulum was a rare disease characterized by the bulging of the esophageal wall. As the diverticulum enlarges, it easily leaded to food retention within the diverticular cavity, significantly impacting patients' quality of life. According to the anatomical location, esophageal diverticulum was categorized into three types: Zenker's, middle, and lower diverticulum. Zenker's diverticulum (ZD) was the most common type in Western countries, with an estimated overall prevalence of between 0.01% and 0.11% in the American population [1]. Approximately 37–63% of patients with esophageal diverticulum had symptoms, such as dysphagia, regurgitation, chest discomfort, and weight loss [2].

For small or asymptomatic esophageal diverticulum, follow-up observation should have been performed, while large or symptomatic esophageal diverticulum (SED) needed to perform surgery. Although open surgery could altogether remove the diverticulum, it was an atraumatic procedure with a high incidence of serious complications, such as bleeding, infection, esophageal fistula, and stenosis. Therefore, the endoscopic operation has gradually replaced traditional transthoracic surgery as the primary treatment option for the esophageal diverticulum. There were a series of novel endoscopic procedures for SED, such as flexible endoscopic septum division (FESD), Zenker's peroral endoscopic myotomy (Z-POEM) and diverticular-peroral endoscopic myotomy (D-POEM) [3–6]. The clinical success and recurrence rates of FESD were 91% and 10.5%, respectively. In two international multicenter studies, Z-POEM demonstrated high clinical success rates in treating ZD, particularly in relieving dysphagia [7, 8]. Another retrospective study showed that D-POEM had a 90% (9/10) clinical remission rate in patients [9]. The results of these studies suggested that these procedures were effective alternatives for treating esophageal diverticulum, but were all difficult procedures that required experienced endoscopists to perform. Similarly, these procedures carried the risk of perforation, bleeding and other complications.

Magnetic compression technique (MCT) was the application of magnetic attraction to reattach organs or compress tissue by placing two magnets on either side of the location to be clamped, aligning the serosa-to-serosa, and causing pressure necrosis through magnetic force, which resulted in an orifice connection [10, 11]. MCT has been widely adopted to treat biliary strictures, esophageal atresia, and gastrointestinal (GI) anastomoses [11–16]. Therefore, to reduce the possibility of adverse events and take advantages of minimally invasive endoscopic treatment, our team combined the MCT and endoscopic operation to propose a novel alternative procedure called magnet-assisted diverticuloplasty (MAD) in 2018 [17]. The brief principle of MAD was to destroy the pouch structure of the esophageal diverticulum, reducing food retention within the diverticulum and alleviating the patient's symptoms.

Here, we conducted this case series with the aim of reporting the effectiveness of MAD in treating SED patients regarding clinical symptom relief and our experience.

Methods

Study design

This retrospective study, conducted in a tertiary hospital (West China Hospital, Sichuan University, Chengdu, China), was approved by the Ethics Committee on Biomedical Research, West China Hospital of Sichuan University [Review (557) No. 2023]. The registration number of this study protocol was ChiCTR2300070901 in the Chinese Clinical Trial Registry (https://www.chictr.org.cn/). The Registration Date was April 26, 2023.

Patients

We retrospectively reviewed medical records and conducted telephone follow-up on patients with SED who underwent MAD at our hospital between November 2017 and June 2022. Patients with SED were defined as those with a total preoperative symptomatic score ≥ 3, or a single symptomatic score ≥ 2, or those who did not meet the symptomatic score requirements but experienced intolerable symptoms and requested endoscopic intervention. The symptomatic scores of patients were accessed by Eckardt symptomatic scores (Table 1), which focused on the symptoms of dysphagia, chest discomfort, regurgitation and weight loss [18]. The esophageal diverticulum was diagnosed preoperatively by barium meal radiography or computed tomography and confirmed by endoscopy. The exclusion criteria were as follows: (1) patients who underwent other surgical or endoscopic interventions for SED before MAD; (2) patients without complete information. All patients received a

Table 1 Criteria of Eckardt symptomatic scores [18]

	Symptom			
Score	**Dysphagia**	**Chest discomfort**	**Regurgitation**	**Weight loss**
0	None	None	None	None
1	Occasional	Occasional	Occasional	< 5 kg
2	Daily	Daily	Daily	5–10 kg
3	Each meal	Each meal	Each meal	> 10 kg

preoperative consultation with a detailed explanation of the advantages and disadvantages of different approaches including open surgery, FESD, Z-POEM, D-POEM and the novel MAD technique. Informed consent to undergo the MAD was obtained from all included patients.

Procedures

All MAD procedures were performed by an advanced endoscopist (B.H.), who had performed more than 2000 endoscopic mucosal resection procedures and 500 endoscopic submucosal dissection procedures before the current study.

The patients were under general anesthesia and tracheal intubation. They were given a liquid diet for 1 days and fasted for at least 8 h before the MAD.

During the operation, the endoscopist used an endoscope system (GIF-Q260J, Olympus, Japan), a carbon dioxide insufflator (UCR, Olympus, Japan), a titanium clip release and two titanium clips (ROOC-D-26-195-C, Micro-Tech (Nanjing) Co., Ltd, China), two thin strings, two ring magnets (diameter 12.0 mm and thickness 4.5 mm, N45 sintered NdFeB permanent magnet material, FeiHong Magnetics Limited, Shenzhen, China) (Fig. 1). The composition and size of the magnets were determined according to the previous studies [19, 20]. The surface of the magnets was nickel-plated to strengthen corrosion resistance and avoid leaching of toxic materials.

The MAD procedures involved the following steps (Fig. 2):

1) **endoscopic observation and cleaning.** Preoperatively, we observed the esophageal diverticulum, removed and flushed away food debris using sterilized water;
2) **magnet 1 placement.** The first magnet was connected to a titanium clip in vitro using a thin string. During endoscopy, it was fixed to the middle or lower esophageal wall with a clip, ensuring it was positioned a sufficient distance from the base of the diverticulum to avoid the two magnets attracting each other in advance without clamping the diverticular septum;
3) **magnet 2 placement.** The process was repeated with another identical magnet fixed to the base of the diverticulum using the same method. The second string was shorter than the first one;
4) **magnetic attraction.** The first magnet was pulled back through the clip-releasing device until the two magnets were tightly attracted to each other, effectively sandwiching the upper part of the diverticular septum between them. Finally, after confirming again, the endoscope was exited.

A liquid diet was approved after 24 h of fasting. Patients self-observed the discharge of clips and magnets in their feces. Follow-up endoscopy was scheduled in all cases. The final telephone follow-up period ended in March 2023. The MAD technique for treating a patient with ZD approximately 1.2 cm in diameter, was shown in Fig. 3 and Video 1.

Outcomes and definitions

The primary outcome of the study was clinical success, defined as complete or near-complete symptomatic relief (the postoperative follow-up total symptomatic scores ≤ 2 and each symptomatic score ≤ 1).

Secondary outcomes included the technical success of MAD, procedure time, hospitalization, recurrence, and adverse events. The technical success of MAD was defined as the accurate compression of the upper part of the diverticular septum by two ring magnets. Procedure time was measured from identification of the diverticulum until two magnets attracted each other. Recurrence was defined as higher symptomatic scores during follow-up or the need for additional endoscopic or surgical intervention.

Statistical analysis

Continuous variables were reported as means and standard deviation (SD), range, or median and interquartile range (IQR), where appropriate. Symptomatic score was analyzed as a continuous variable. The paired t-test was

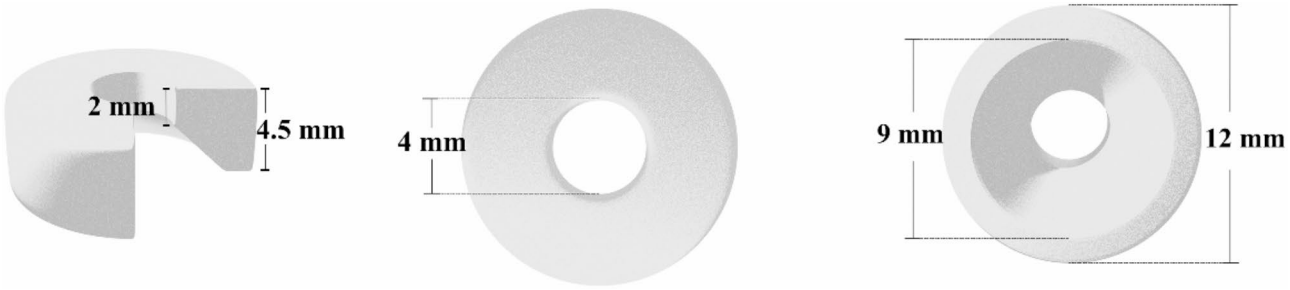

Fig. 1 The three-dimensional structure of ring magnet for magnet-assisted diverticuloplasty

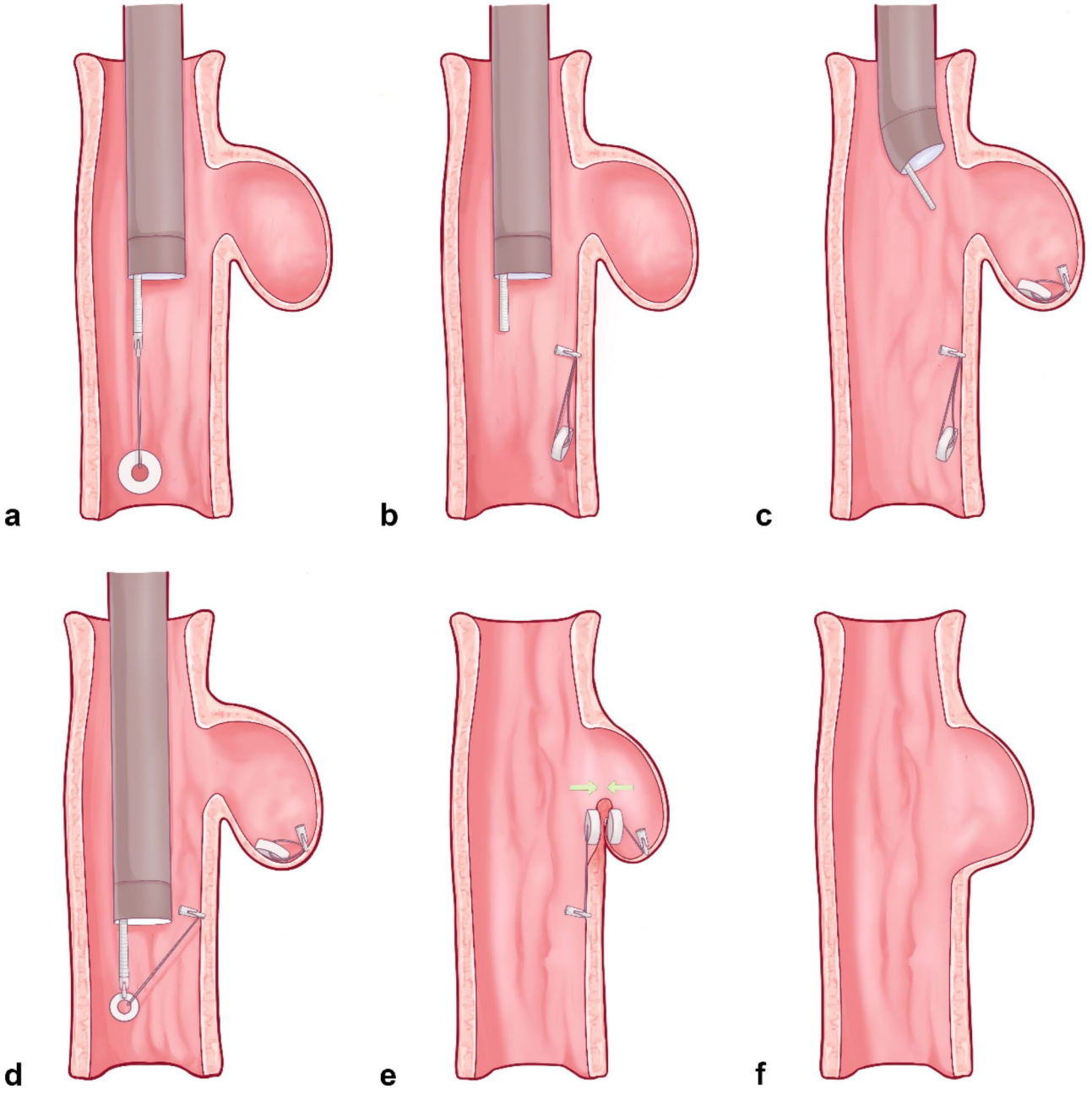

Fig. 2 The illustration of magnet-assisted diverticuloplasty. **a**, **b** the first ring magnet was connected to a clip using a longer thin string, and then was fixed to esophageal wall away from the esophageal diverticulum; **c** the second ring magnet was fixed to the base of the diverticulum with a shorter string; **d** the clip releasing device was used to attract the distal first magnet to move; **e** two magnets were aligned to each other and sandwiched against the diverticular septum (green arrowheads indicate the direction of the magnetic compression); **f** the aim is to shorten the diverticular septum after the MAD

used for those in normal distribution; otherwise, the Wilcoxon signed-ranked test was used. All values were considered statistically significant at $P<0.05$. The analysis was performed by using SPSS Statistics software, version 27.0 (IBM Corp., Armonk, New York, USA).

Results

A total of 7 patients with SED underwent MAD at our hospital between November 2017 and June 2022, but one without available outcome data was excluded. This study included 6 patients, including 3 with ZD, 1 with middle esophageal diverticulum, and 2 with lower esophageal diverticulum (Table 2).

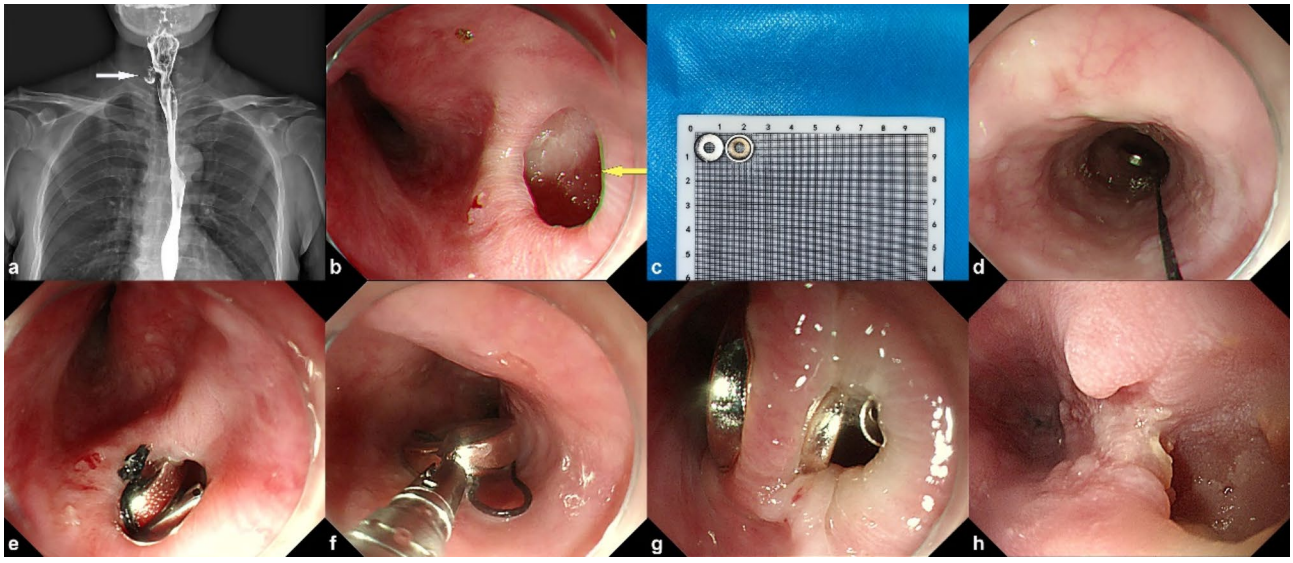

Fig. 3 Endoscopic images of magnet-assisted diverticuloplasty (MAD) for treating Zenker's diverticulum (ZD). **a**, **b** barium meal radiography (white arrowhead) and the upper endoscopy demonstrated (yellow arrowhead) a ZD approximately 1.2 cm in diameter, 20 cm from the incisors; **c** two ring magnets used in the MAD (one side was flat and the other was concave); **d** the first magnet was fixed to the middle esophageal wall; **e** the second magnet was fixed to the base of the diverticulum; **f**, **g** took the first magnet through titanium clip until two magnets were attracted each other, sandwiching the diverticular septum between them; **h** follow-up upper endoscopy on postoperative day 20 showed that the diverticular septum was shortened

Table 2 Baseline characteristics of the patients and diverticulum

Case	Sex	Age (years)	Diverticular type	Diverticular size (cm)	Prior surgical or endoscopic interventions
1	Male	82	Middle	2.50	No
2	Male	62	Lower	3.00	No
3	Male	48	Zenker's	1.50	No
4	Male	65	Zenker's	2.50	No
5	Male	58	Zenker's	1.20	No
6	Male	59	Lower	2.00	No

Table 3 Patients' procedure details and follow-up

Case	Procedure time (minutes)	Adverse events	Hospitalization (days)	Endoscopy follow-up (days)	Telephone follow-up (months)	Clinical success	Recurrence	Additional surgical interventions	Additional endoscopic interventions
1	23	No	2	10	52	Yes	No	No	No
2	22	No	3	62	22	Yes	No	No	No
3	22	No	2	10	64	Yes	No	No	No
4*	60	No	3	15	24	No	Yes	No	Yes
5	30	No	1	20	22	Yes	No	No	No
6	10	No	2	34	9	Yes	No	No	No

*According to the telephone follow-up, his symptoms were completely relieved within 18 months after MAD (with only a dysphagia score of 1), but dysphagia recurred again (with a dysphagia score of 2) before receiving an additional intervention). He underwent diverticular-peroral endoscopic myotomy (D-POEM) 24 months after MAD

The technical success rate was 100% (6/6) and no adverse events occurred during and after the procedure (Table 3). The median procedural duration was 22.5 min (IQR 18.5). The mean hospitalization was 2 days (range 1–3). The median time of follow-up endoscopy was on postoperative day 18 (IQR 31), revealing a shortened diverticular septum under endoscopic examination. Following a median telephone follow-up of 23 months (IQR 36), the median total symptomatic score decreased significantly from 4.00 (IQR 3.25) to 1.00 (IQR 2.00) ($P = 0.015$), indicating notable improvement in various symptoms after MAD (Fig. 4 and Table 4). The clinical success rate was 83.3% (5/6). Only one patient underwent an additional operation due to recurrent dysphagia and the discovery of substantial food debris in the diverticulum two years after the MAD. Magnets were found in the stools of 2 patients on postoperative days 7 and 15 following MAD respectively, while no such findings in

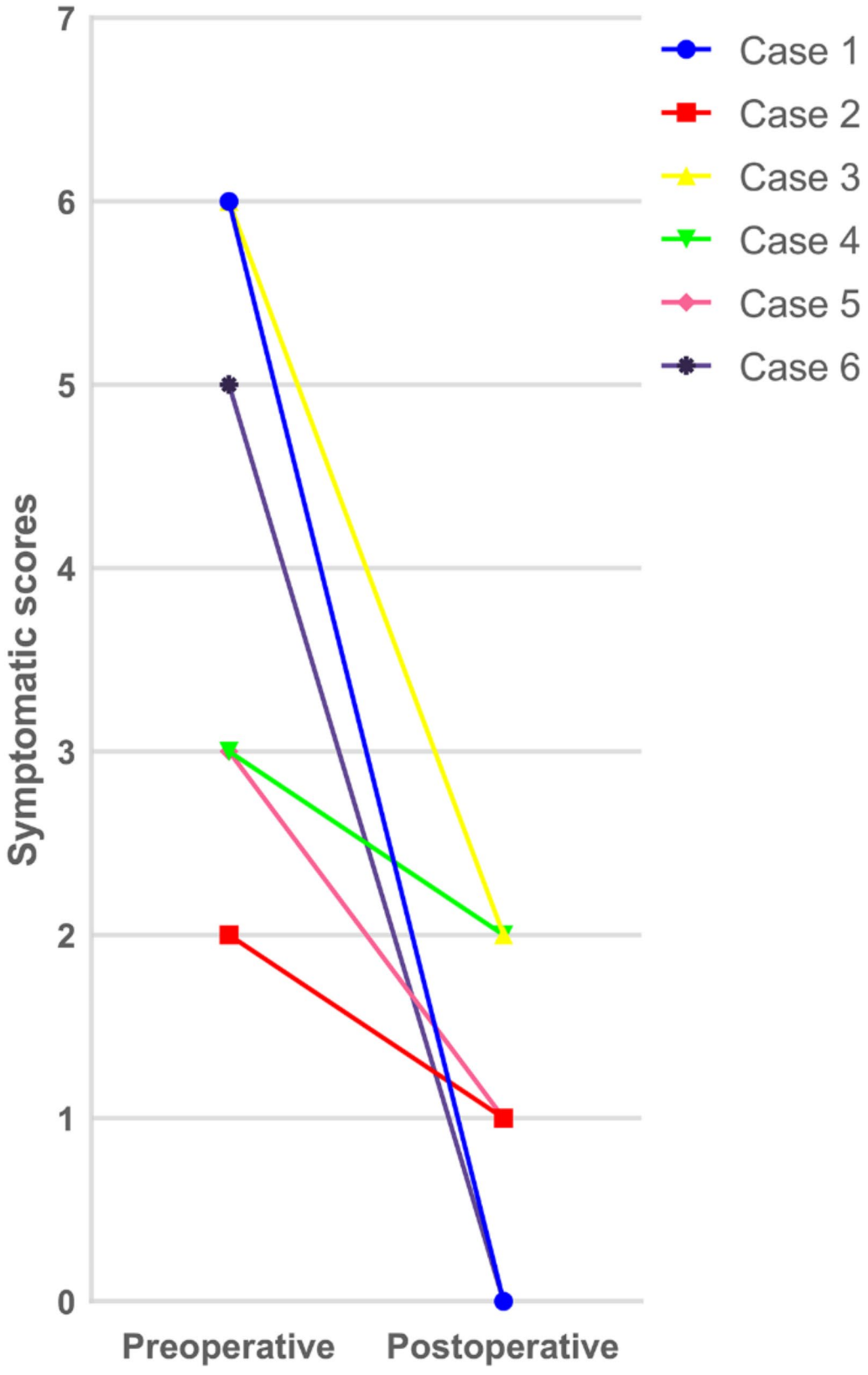

Fig. 4 The Eckardt symptomatic scores of 6 patients. The median total symptomatic score decreased significantly from 4.00 (interquartile range (IQR) 3.25) to 1.00 (IQR 2.00) ($P = 0.015$, paired samples t-test) after the MAD

Table 4 The preoperative and postoperative Eckardt symptomatic scores of patients

Case	Preoperative					Postoperative				
	Dysphagia*	Chest discomfort*	Regurgitation*	Weight loss†	Total score	Dysphagia*	Chest discomfort*	Regurgitation*	Weight loss†	Total score
1	2	0	2	2	6	0	0	0	0	0
2	0	1	1	0	2	0	0	1	0	1
3	3	0	2	1	6	1	0	1	0	2
4	2	1	0	0	3	2	0	0	0	2
5	0	0	2	1	3	0	0	1	0	1
6	2	1	1	1	5	0	0	0	0	0

*Scored: 0 for none, 1 for "occasional", 2 for "daily", and 3 for "each meal"

†Scored: 0 for none, 1 for < 5 kg, 2 for 5–10 kg, and 3 for > 10 kg

other patients. No magnets-related adverse events were observed during the follow-up period.

Discussion

Our results showed that the MAD was a minimally invasive and effective procedure that could be used to perform endoscopic plasty of the esophageal diverticulum. Due to the diverticular septum, the food in the diverticulum could not pass through the GI tract. During the MAD, a pair of ring magnets were used to compress on either side of the diverticular septum. The magnetic force compressed and induced ischemic necrosis, forming an anastomosis, which subsequently shortened the diverticular septum, reduced food retention within the diverticulum and alleviated the patients' symptoms. Therefore, our team used MCT to achieve the diveticuloplasty.

Some studies have explored the use of MCT to treat esophageal diverticulum. In a retrospective study, endoscopists cut the diverticular septum using compression-cutting technique in four patients [21]. Some researchers tried to simplify endoscopic procedures by designing and using the MAgnetic GI Universal Septotome device composed of magnets and a self-retractable wire to cut the diverticular septum in animal model study and two patients with epiphrenic esophageal diverticulum [22]. However, it's essential to consider the potential risk of perforation associated with direct cutting [1]. Based on previous studies, our team used two magnets to clamp the diverticular septum without cutting it, so we named this technique MAD.

The MAD procedure achieved a clinical success rate of 83.3% (5/6), surpassing the rates reported in the above-mentioned studies (75%, 3/4 or 50%, 1/2), demonstrating satisfactory outcomes using the MAD approach alone [21, 22]. Of course, the choice of whether to cut or not and the cutting method warrants further investigation. In addition, neither of these previous studies quantitatively assessed symptom relief. Since there was no specific symptom scoring system for the esophageal diverticulum, we employed the Eckardt symptomatic scoring system, which comprehensively covered the symptoms of the patients in this study. This was the first to quantitatively analyze the symptomatic relief of MCT in patients with esophageal diverticulum. The patient's preoperative and postoperative follow-up scores suggested that MAD significantly improved symptoms. Another advantage was that this paper explored the effect of MAD in various diverticula rather than being limited to a single type.

Although there have been no reports of complications or side effects caused by magnetic compression technique of esophageal diverticulum, we should pay attention to the postoperative recovery of patients. At present, the most important situation to consider was that the ring magnets fails to discharge successfully, which might lead to likely serious complications, such as intestinal fistula, stenosis, or obstruction. Therefore, appropriate magnet selection and radiological follow-up were necessary to reduce the risk of complications and side effects. In addition, the cost-effective analysis of a novel technique needed to consider. We believed that the cost-effective of MAD was advantageous compared to these procedures. The main reason was that the price of two ring magnets was much lower than that of electric knife and needle. Of course, the detailed cost-effective analysis comparing MAD with other procedures required further research, which might help to optimize and popularize this novel technology.

There were some limitations in this study. First, if these two ring magnets became displaced, the disconnection and reconnection of magnets were challenging. Endoscopists needed to adjust the mal-coupling position the upper part of the diverticular septum similarly to step 4 above. We plan to make MAD's equipment automated and easier to perform. Second, the discharge of clips and magnets were relied on patient' stool observation than X-ray follow-up. This decision was influenced by the uncertainty of the shedding time, and patient concerns about the cost of multiple tests, radiation exposure, and the impact of the COVID-19 epidemic at that time. None of our 6 patients developed new fistulas attributed to the magnets, consistent with findings from other studies using MCT for GI anastomosis, which also reported

no new fistulas. In order to ensure patients' safety, radiological follow-up after MAD was necessary to monitor clips and magnets discharging. Third, the small sample size ($n=6$) and short median telephone follow-up (23 months) were limited. Fourth, no comparison was made between MAD and other procedures, such as open surgery, FESD, Z-POEM, or D-POEM. Therefore, a prospective, larger-scale, randomized controlled trail was needed to conduct, to evaluate the efficacy and safety of this novel technique compared to other procedures. Of course, the long-term follow-up was essential to monitor the recurrence. In this study, the same size magnets were used for different diverticulum sizes in MAD. The magnet diameter should be adjusted according to diverticulum size and diverticular location needs to be further studied. Our team has designed and customized magnets with different diameters, and is considering their application for clinical use.

Our limited experience suggested that MAD could be an alternative option for patients with SED. While our study included only 6 patients in a single center, it represented one of the largest sample sizes using MCT for SED treatment. To comprehensively assess this novel technique's effectiveness, safety, and complexity, there was a need for larger-scale, long-term follow-up, multicenter research. In addition, comparative studies with other procedures were essential to conduct, which might help to optimize and popularize this novel technology.

Supplementary information

The online version contains supplementary material available at https://doi.org/10.1186/s12876-025-03783-5.

Supplementary Material 1

Acknowledgements
We sincerely acknowledge the financial contributions from the West China Hospital, Sichuan University and National Natural Science Foundation of China.

Author contributions
RL, XZ and XY collected and analyzed the data and drafted the original manuscript; WL, SL and YZ contributed to the study design, edited the images and video; BH revised the manuscript. All authors reviewed and approved the final manuscript. RL, XZ and XY contributed equally to this paper.

Funding
This research was supported by the 1·3·5 project for disciplines of excellence, West China Hospital, Sichuan University (ZYJC21011), and National Natural Science Foundation of China (Grant No: 82170675).

Data availability
All data analyzed during this study are included in this published article.

Declarations

Ethics approval and consent to participate
This study involved human participants and was approved by the Ethics Committee on Biomedical Research, West China Hospital of Sichuan University [Review (557) No. 2023]. It used medical records obtained from previous clinical diagnosis and treatment, and the written informed consent was exempted also by the Ethics Committee on Biomedical Research of West China Hospital of Sichuan University.

Consent for publication
All of the participants gave written informed consent to the publication of identifying images or other personal or clinical details.

Competing interests
The authors declare no competing interests.

Received: 20 February 2024 / Accepted: 13 March 2025
Published online: 21 March 2025

References

1. Ishaq S, Hassan C, Antonello A, Tanner K, Bellisario C, Battaglia G, et al. Flexible endoscopic treatment for Zenker's diverticulum: a systematic review and meta-analysis. Gastrointest Endosc. 2016;83(6):1076–e10891075.
2. Soares R, Herbella FA, Prachand VN, Ferguson MK, Patti MG. Epiphrenic diverticulum of the esophagus. From pathophysiology to treatment. J Gastrointest Surg. 2010;14(12):2009–15.
3. Yang J, Zeng X, Yuan X, Chang K, Sanaei O, Fayad L, et al. An international study on the use of peroral endoscopic myotomy (POEM) in the management of esophageal diverticula: the first multicenter D-POEM experience. Endoscopy. 2019;51(4):346–9.
4. Maydeo A, Patil GK, Dalal A. Operative technical tricks and 12-month outcomes of diverticular peroral endoscopic myotomy (D-POEM) in patients with symptomatic esophageal diverticula. Endoscopy. 2019;51(12):1136–40.
5. Hernández Mondragón OV, Solórzano Pineda MO, Blancas Valencia JM. Zenker's diverticulum: submucosal tunneling endoscopic septum division (Z-POEM). Dig Endosc. 2018;30(1):124.
6. Huberty V, El Bacha S, Blero D, Le Moine O, Hassid S, Devière J. Endoscopic treatment for Zenker's diverticulum: long-term results (with video). Gastrointest Endosc. 2013;77(5):701–7.
7. Zhang LY, Hernández Mondragón O, Pioche M, Steinway SN, Nieto J, Ujiki MB, et al. Zenker's peroral endoscopic myotomy for management of large Zenker's diverticulum. Endoscopy. 2023;55(6):501–7.
8. Yang J, Novak S, Ujiki M, Hernández Ó, Desai P, Benias P, et al. An international study on the use of peroral endoscopic myotomy in the management of Zenker's diverticulum. Gastrointest Endosc. 2020;91(1):163–8.
9. Zeng X, Bai S, Zhang Y, Ye L, Yuan X, Hu B. Peroral endoscopic myotomy for the treatment of esophageal diverticulum: an experience in China. Surg Endosc. 2021;35(5):1990–6.
10. Gottlieb KT, Banerjee S, Barth BA, Bhat YM, Chauhan SS, Konda V, et al. Magnets in the GI tract. Gastrointest Endosc. 2013;78(4):561–7.
11. van Hooft JE, Vleggaar FP, Le Moine O, Bizzotto A, Voermans RP, Costamagna G, et al. Endoscopic magnetic gastroenteric anastomosis for palliation of malignant gastric outlet obstruction: a prospective multicenter study. Gastrointest Endosc. 2010;72(3):530–5.
12. Muensterer OJ, Evans LL, Sterlin A, Sahlabadi M, Aribindi V, Lindner A et al. Novel device for endoluminal esophageal Atresia repair: First-in-Human experience. Pediatrics. 2021;148(5): e2020049627.
13. Kamada T, Ohdaira H, Takeuchi H, Takahashi J, Ito E, Suzuki N, et al. New technique for magnetic compression anastomosis without incision for Gastrointestinal obstruction. J Am Coll Surg. 2021;232(2):170–177e2.
14. Parlak E, Koksal AS, Kucukay F, Eminler AT, Toka B, Uslan MI. A novel technique for the endoscopic treatment of complete biliary anastomosis obstructions after liver transplantation: through-the-scope magnetic compression anastomosis. Gastrointest Endosc. 2017;85(4):841–7.
15. Pichakron KO, Jelin EB, Hirose S, Curran PF, Jamshidi R, Stephenson JT, et al. Magnamosis II: magnetic compression anastomosis for minimally invasive gastrojejunostomy and jejunojejunostomy. J Am Coll Surg. 2011;212(1):42–9.
16. Hu B, Ye LS. Endoscopic applications of magnets for the treatment of Gastrointestinal diseases. World J Gastrointest Endosc. 2019;11(12):548–60.
17. Ye L, Zeng H, Wang S, Jiang J, Tang H, Li C, et al. Magnet-assisted diverticuloplasty for treatment of Zenker's diverticulum. Endoscopy. 2018;50(7):E170–1.
18. Eckardt VF, Aignherr C, Bernhard G. Predictors of outcome in patients with achalasia treated by pneumatic dilation. Gastroenterology. 1992;103(6):1732–8.

19. Graves CE, Co C, Hsi RS, Kwiat D, Imamura-Ching J, Harrison MR, et al. Magnetic compression anastomosis (Magnamosis): First-In-Human trial. J Am Coll Surg. 2017;225(5):676–681e1.
20. Ryou M, Cantillon-Murphy P, Azagury D, Shaikh SN, Ha G, Greenwalt I, et al. Smart Self-Assembling magnets for endoscopy (SAMSEN) for transoral endoscopic creation of immediate gastrojejunostomy (with video). Gastrointest Endosc. 2011;73(2):353–9.
21. Bouchard S, Huberty V, Blero D, Devière J. Magnetic compression for treatment of large oesophageal diverticula: a new endoscopic approach for a risky surgical disease? Gut. 2015;64(11):1678–9.
22. Huberland F, Rio-Tinto R, Cauche N, Dugardeyn S, Delattre C, Sandersen C, et al. Magnets and a self-retractable wire for endoscopic septotomies: from concept to first-in-human use. Endoscopy. 2022;54(6):574–9.

Publisher's note