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*European Journal of Medical Research* (2025) 30:154
https://doi.org/10.1186/s40001-025-02408-7

European Journal
of Medical Research

RESEARCH

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# Magnetic anchors with line-guided endoscopic full-thickness resection for gastric submucosal tumors

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## Abstract

The advantage of endoscopic submucosal dissection (ESD) is the ability to achieve high R0 resection and a low local recurrence rate (Oyama in Gastrointest Endosc Clin N Am 24:201–212, 2014;Cai et al. in Gastrointest Endosc 88:160–167, 2018;). Endoscopic full-thickness resection (EFTR) compensates for the deficiency of ESD, and it can treat more ailments (Aslanian et al. in VideoGIE 4:343–350, 2019). However, due to the requirements of EFTR for endoscopic resection experience and defect closure skills, the operation is relatively difficult, which is the greatest obstacle to the widespread clinical use of EFTR (Chu and Xu in Am J Gastroenterol 115:1972–1973, 2020). Here, we propose a useful method—a magnetic anchor with line guidance (MALG-EFTR). In addition, the device provides satisfactory tissue tension within the submucosa, facilitates visualization of the dissection plane, strengthens counter traction, and reduces the difficulty of surgery during EFTR. MALG-EFTR can effectively prevent the magnetic anchor from falling off or remaining in the abdominal cavity or digestive tract, which facilitates the recovery of specimens. Therefore, this technique might reduce procedure time and increase the stabilization and safety of operations.

**Keywords** Endoscopic full-thickness resection, Magnetic anchor with line guidance, Endoscopic submucosal dissection, Gastric submucosal tumor

## Introduction

EFTR, which is an important technique for treating complex gastrointestinal lesions, compensates for the deficiency in ESD [3, 5]. The introduction of EFTR techniques provides a less-invasive treatment option for lesions such as gastric submucosal tumors and lesions in hard-to-reach or high-risk locations of adverse events (e.g., within a diverticulum), which would otherwise require a surgical approach [6–8]. However, due to the difficulty of the EFTR operation and the high requirements for the operator's endoscopic resection experience and closure technique, its wide clinical application is limited [4]. Recently, magnetic traction has emerged as an effective method of traction, as it allows for control of the direction and magnitude of the traction force through an external magnet [9, 10]. However, as magnetic attraction decreases with distance, its effectiveness may vary in patients with different abdominal wall thicknesses [5]. The application of magnetic traction, especially with the advances in neodymium magnets, has the potential to greatly enhance the precision and safety of procedures, suggesting a valuable tool for the future. Compared with other methods, the principal advantage of MAG-ESD is that the traction applied to the ESD site is independent (i.e., easy to adapt without interfering with endoscope movement) [9, 11]. During operation, the magnetic anchor may fall off. In this case,

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Neodymium boron magnet was used as the material for the external magnetic anchor (material density: 7.5 g/$cm^3$), which consisted of one cylindrical magnet with a diameter of 80 mm and a height of 60 mm (magnetic strength: approximately 1.1 Tesla). The internal magnet of the magnetic anchor consisted of a hollow cylindrical Neodymium magnet (diameter: 8 mm, thickness: 4 mm, and magnetic strength: approximately 0.2 Tesla). The following case reports present a useful MALG-EFTR method that may enable satisfactory tissue tension within the submucosa, facilitate visualization of the dissection plane, strengthen countertraction, and reduce the difficulty of surgery during EFTR. This device can effectively prevent the magnetic anchor from becoming stuck in the abdominal cavity or digestive tract and can easily recover the specimen. Therefore, this technique might shorten the procedure time and improve the stability and safety of the operation.

Case description

A 27-year-old male patient was admitted to our hospital complaining of "stomachache for 1 year". Denial of medical, family, or psychosocial history. Esophagogastroduodenoscopy revealed a 2.0 cm protruded lesion in the gastric corpus with smooth overlying mucosa (Fig. 1a). Endoscopic ultrasonography revealed a 2.0 cm*2.0 cm large tumor, with predominantly extraluminal growth and extensive connections between the tumor base and the muscularis propria, and no signs of perigastric lymph-node metastasis (Fig. 1b). After a multidisciplinary team discussion, we decided to perform EFTR on this patient. The borders of the mass were marked with a Hook-Knife, and an incision was made with the Hook-Knife. The tumor was predominantly extraluminal, and the lesion was not clearly exposed. As dissection progresses, the lesion is likely to fall into the abdominal cavity. Therefore, we developed a new method involving a magnetic anchor with line guidance and a magnetic anchor with a line attached to the mucosal edge of the lesion by a clip (Fig. 2a). The external magnet was maneuvered/moved around the abdominal surface to obtain adequate traction. The device pulled the lesion into the gastric lumen/cavity (Fig. 2b). By traction, the serosal surface of the lesion was well exposed, and the part that needed to be resected was fully exposed (Fig. 2c). Dissection was performed successfully under magnetic counter traction (Fig. 2d). The operation procedures were performed as follows: (1) circumferential incision around the tumor; (2) submucosal excavation as deep as the muscular layer around the tumor body; (3) when we suffered difficulties in the exposure of the dissection site between the tumor and the seromuscular layer, the magnetic anchors with line-guided method would be conducted. The endoscope was withdrawn and a rotatable hemoclip with repeatable opening-closing function was inserted through the endoscope accessory channel. A silk thread, with magnetic anchors, was tied to either claw of the hemoclip. After subsequently reinsertion of the endoscope into the stomach, the hemoclip was anchored on the proximal edge of the resected mucosa, so that the magnetic anchors with line-guided can help improve the visibility (line traction is applied first, and if further fine adjustments to visibility are

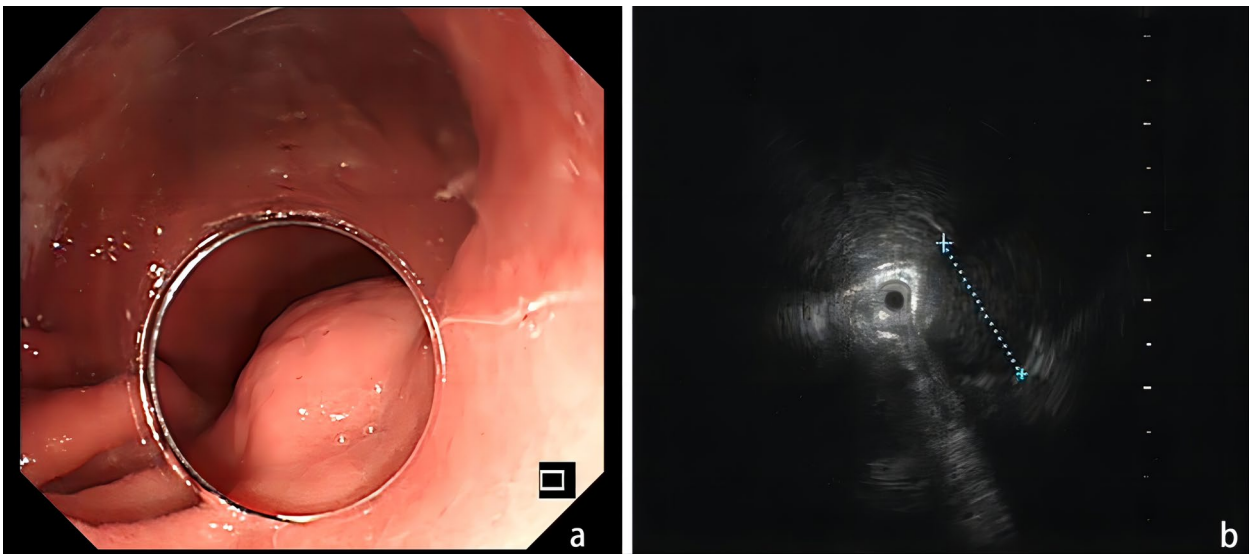


**Fig. 1** Images of the lesion from conventional endoscopy and endoscopic ultrasound examination: **a** esophagogastroduodenoscopy revealed a 2.0 cm protruding lesion in the gastric body, with smooth overlying mucosa; **b** endoscopic ultrasonography revealed a 2.0 cm by 2.0 cm tumor, predominantly growing extraluminally and originating from the muscularis propria

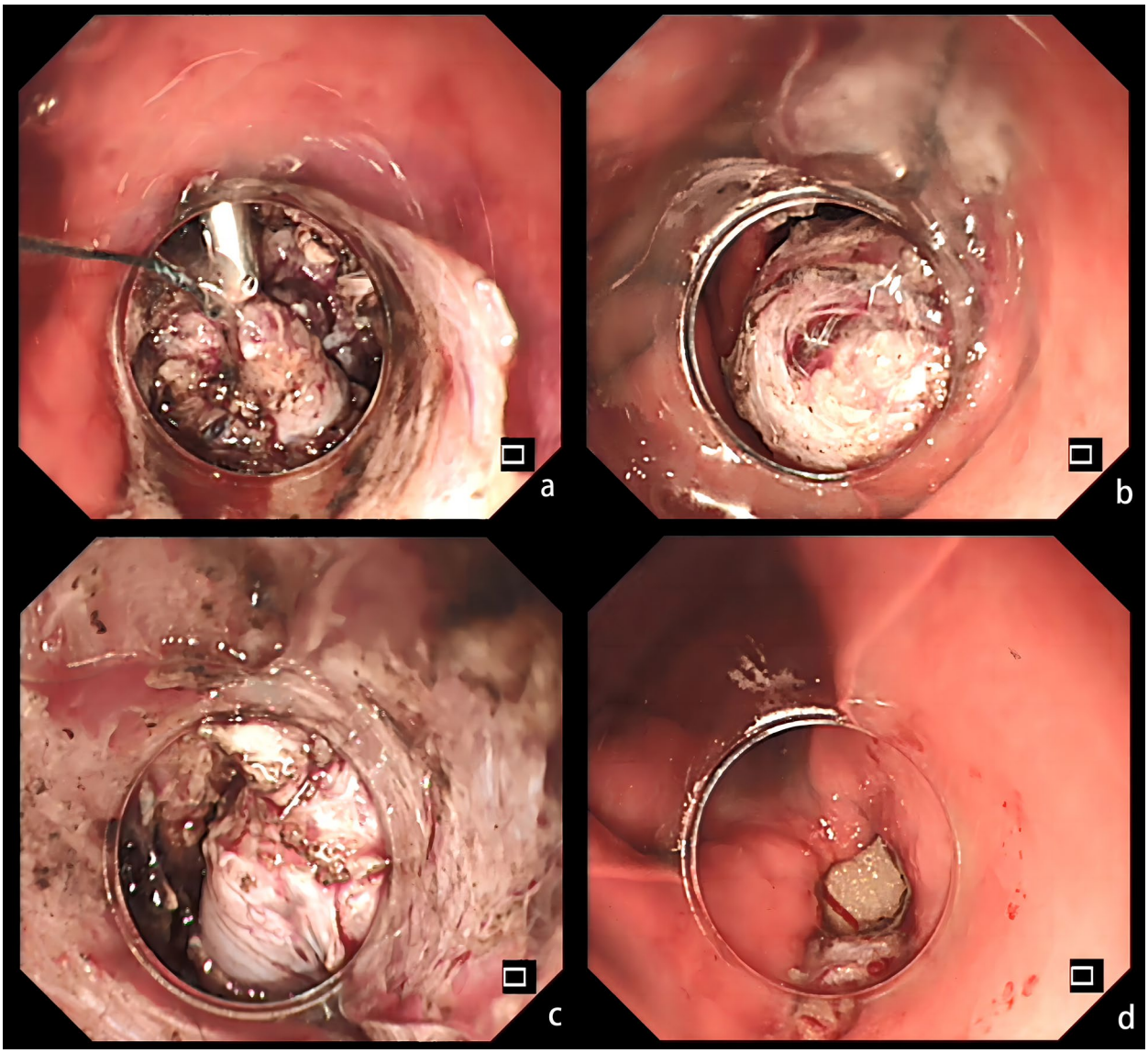


**Fig. 2** Endoscopic view of the full-thickness resection procedure with magnetic anchor and line guidance assistance: **a** when the edge dissection extends outside the gastric cavity, and the field of view is poorly exposed, the intervention of the MALG system; **b** the target lesion was grasped and pulled into the gastric lumen using the device; **c** the target lesion was grasped and pulled into the gastric lumen using the device; **d** the resection site was observed after completion of the procedure

needed, magnetic traction is then used to assist). The seromuscular layer under the tumor could be clearly visualized when traction was applied to the thread; (4) after the intra-luminal side of the tumor was fully revealed, an iatrogenic gastric perforation was created in the proximal seromuscular layer of the tumor with an Hook knife and the target lesion was grasped and pulled into the gastric lumen using the device; (5) the tumor was removed; and (6) closure of gastric wall defects by the hemoclip and nylon rope. After dissection, the resected tissue and the device were retrieved simply using the line of the device. In addition, the device prevented the resected specimen from falling into the peritoneal cavity. Finally, we closed the gastric wall defect with metal clips and reinforced it with nylon rope rings. The lesion was resected en bloc with no complications and measured 2.8*2.0*1.2 cm. The MALG-EFTR procedure was completed in approximately 86 min, with less blood loss, not exceeding 20 ml. Some challenges arose in tissue manipulation, especially in areas with limited visibility, but magnetic and line traction were successfully used to maintain tissue stability and enhance dissection precision. The procedure

progressed smoothly without major complications, demonstrating the effectiveness of the MALG-EFTR technique in complex cases. Histological findings revealed a gastrointestinal stromal tumor. Immunohistochemical staining revealed DOG-1, CD117, and CD34 expression, while Desmin, SMA, and S-100 expression was negative. The percentage of Ki67-positive cells was 5%. During the postoperative hospitalization period, the patient's condition remained stable, with no significant complications such as infections or excessive bleeding. The follow-up gastroscopy 3 months after the surgery indicated good mucosal healing, with no erosion or ulcer formation on the surface. Ongoing monitoring indicated good recovery, and recent follow-up showed no significant discomfort, suggesting that the MALG-EFTR technique is safe and efficient for complex cases (Fig. 3).

## Discussion

To some extent, the EFTR fills the gap of conventional endoscopic resection. However, this technique has not been widely used among endoscopists, because it is challenging. Endoscopic resection of subepithelial lesions (SELs) involving the muscularis propria (MP) was considered a contraindication owing to the high perforation rate. However, with the development of new techniques, adverse events have been minimized [12]. One of the obstacles to EFTR is the difficulty of closing the wall defect after resection [4]. The feasibility and advantages of the MALG-EFTR method in gastric EFRT patients were demonstrated in this clinical case study, and the magnetic anchor may have fallen off during the operation. It should be noted that patients with a cardiac pacemaker or implantable cardioverter-defibrillator are not indicated for this method. [13] In addition, full-thickness resection lesions may fall into the abdominal cavity. If the magnetic anchor or lesion falls into the abdominal cavity, it may cause difficulty in detection and removal and may even result in complications related to abdominal retention. Simple EFTR carries a higher risk, with difficulty in exposing the surgical field, and the lesion may fall into the abdominal cavity, making it difficult to retrieve. Traction techniques can stabilize the surgical field, fully expose the lesion, provide appropriate tension, assist in incision, and prevent the lesion from falling into the abdominal cavity, making it easy to retrieve the lesion for histologic assessment. Traction can effectively expose the serosal surface of the lesion, preventing and controlling bleeding, and improving the success rate and safety of resection. The anti-fall design of the traction improves the surgical field, reduces the risk of bleeding, and enhances EFTR cutting efficiency. Potential limitations include that magnetic force decays over distance exponentially. Therefore, the strength of magnetic force varies based on the patient's abdominal thickness which depends mainly on the amount of abdominal fat. For patients with a thin abdominal wall, magnetic traction can be applied directly. For those with a thicker abdominal wall, stronger external magnets may be employed to achieve adequate traction. If the traction force remains insufficient, traction lines can be utilized to supplement the magnetic traction. In cases where further reinforcement is needed, internal traction methods, such as rubber band traction, can be incorporated. However, MALG-EFTR can deliver satisfactory tissue tension, facilitating the visualization of the dissection plane. Moreover, MALG-EFTR improves traction during an EFRT procedure when traction is limited

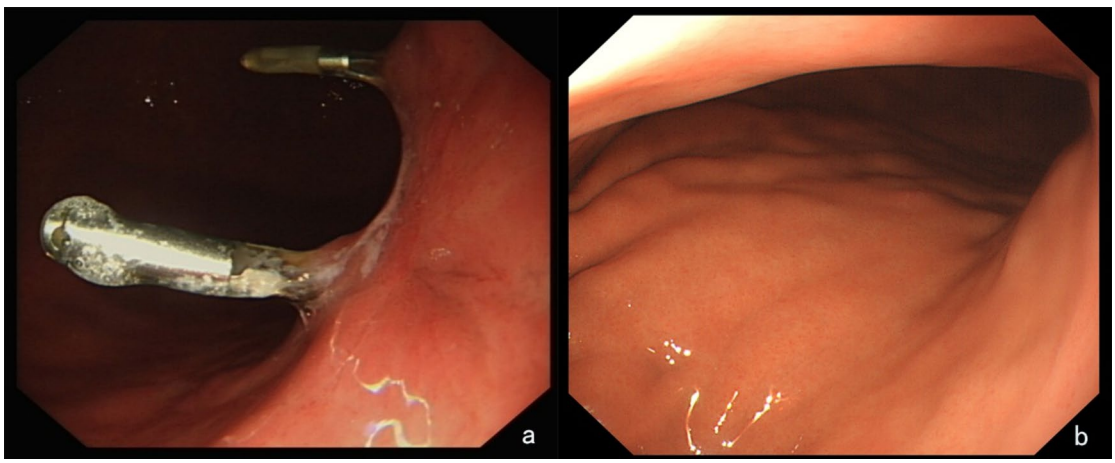


**Fig. 3** Postoperative follow-up: **a** 3 months after surgery, a follow-up gastroscopy showed good mucosal healing, with two clips still in place and no erosion or ulceration on the surface. **b** Approximately 3 years after surgery, a follow-up gastroscopy revealed no significant abnormalities at the surgical site

by the distance between magnets. In addition, the lines can assist in traction and removal of the specimen, preventing the magnetic anchor from being stuck in the abdominal cavity or digestive tract. In conclusion, our study demonstrated that MALG-assisted EFTR is a safe and effective technique.

Beyond gastric submucosal tumors, we would like to briefly discuss whether this technique could be adapted for lesions in other gastrointestinal locations. The esophagus is relatively straight but has limited space, making it challenging to employ magnetic traction for assisting in the resection of submucosal tumors. In contrast, the rectum and distal colon, being closer to the anus, are more suitable for line-guided magnetic traction techniques. The intestinal lumen provides sufficient space to easily adjust the position of the magnetic anchor, making MALG-EFTR an effective approach for resecting submucosal tumors in these regions. However, the proximal colon, with its numerous curves, may be at risk of damage from the traction line, rendering MALG-EFTR unsuitable for the resection of submucosal tumors in this area.

In the future, multi-dimensional magnetic gradient measurement techniques could be utilized to track magnetic anchors, enabling precise positioning and directional control. Electromagnets could generate a strong magnetic force to enhance the coupling strength of the anchors. By miniaturizing electromagnetic devices, a multi-vector controllable magnetic field could be created, which, through computer control, would allow for precise regulation of internal magnetic anchors. The greatest advantage of magnetic traction lies in its ability to provide reverse, contactless traction, offering effective support for endoscopic robots. This technology helps overcome the limitations in the maneuvering angles of robotic arms, making it a promising complement to endoscopic robotic procedures.

## Conclusion

The MALG-EFTR method is effective for resecting lesions that are difficult to cure. Essentially, this traction technique is designed to facilitate visualization of the operating field, thus enabling accurate identification of the cutting line and submucosal vessels. Moreover, traction is independent to deliver satisfactory tissue tension, facilitate visualization of the dissection plane, strengthen countertraction, and reduce the difficulty of the operation. When resection is nearly complete, the lesion can be grabbed by the line, so that it does not fall into the peritoneal cavity. Compared with other methods, the MALG-ESD method may represent a promising approach to help reduce the complications of the procedure and may lead to more widespread adoption of endoscopic procedures.

### Abbreviations

| | |
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| MALG | Magnetic anchor with line guidance |
| EFTR | Endoscopic full-thickness resection |
| ESD | Endoscopic submucosal dissection |
| MAG-ESD | Magnetic anchor-guided endoscopic submucosal dissection |
| MALG-EFTR | Magnetic anchor with line-guided endoscopic full-thickness resection |
| EUS | Endoscopic ultrasonography |
| SELs | Subepithelial lesions |
| MP | Muscularis propria |

### Author contributions

Xueyan Zhang and Hongli Wang performed and designed the study. Zhenghan Xiao, Lin Cui and Yanshun Zhang performed relevant experiments, the data analysis, and wrote. Bo Qu revised the manuscript. All authors contributed to the article and approved the submitted version.

### Funding

The study was supported by grants from Innovation and Entrepreneurship Training Programme for College Students in Heilongjiang Province (S202310226037).

### Availability of data and materials

No datasets were generated or analysed during the current study.

## Declarations

### Ethics approval and consent to participate

All human studies were reviewed by the Medical Ethics Committee of the Second Affiliated Hospital of Harbin Medical University and were conducted in accordance with the ethical standards of the corresponding version of the 1965 Declaration of Helsinki. Although MALG-EFTR shows significant potential in improving surgical precision and safety, the current clinical evidence remains limited. Further case reports and small case series are needed to validate its efficacy and safety, helping to assess its broader clinical applicability and long-term outcomes.

### Informed consent

Informed consent was obtained from all individuals participating in the study and consent was given for publication.

### Competing interests

The authors declare no competing interests.

Received: 23 July 2024 Accepted: 25 February 2025
Published online: 06 March 2025

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## Publisher's Note