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**Utilisation of magnets to enhance gastrointestinal endoscopy**

Rahman I *et al*. Magnets to enhance Gastrointestinal Endoscopy

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**Abstract**

Methods to assess, access and treat pathology within the gastrointestinal tract continue to evolve with video endoscopy replacing radiology as the gold standard. Whilst endoscope technology develops further with the advent of newer higher resolution chips, an array of adjuncts has been developed to enhance endoscopy in other ways; most notable is the use of magnets. Magnets are utilised in many areas, ranging from endoscopic training, lesion resection, aiding manoeuvrability of capsule endoscopes, to assisting in easy placement of tubes for nutritional feeding. Some of these are still at an experimental stage, whilst others are being increasingly incorporated in our everyday practice.

**Key words:** Magnet; Endoscopy; Training; Therapeutic; Capsule; Nutrition; Child; Paediatric; Colonoscopy; Imaging

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**Core tip:** Magnetic technology is being incorporated into many aspects of endoscopy from diagnostic procedures to assisting in therapeutic interventions. Here we summarise some of the more exciting innovations and the potential future roles magnets will play in this field.

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**INTRODUCTION**

Magnets were traditionally viewed with great scepticism by the endoscopy community due to the potentially hazardous consequence that ingestion of this material led to. However the property of magnets, notably the ability to be sensed and also exert a force from a distance, began to be recognised as a solution to many emerging problems faced by an endoscopist. Magnetic technology is now incorporated within many areas of endoscopy.

***Endoscopic training***

Colonoscopy is undertaken worldwide, with variations in reported caecal intubation rates. Although there are several reasons for this, a common factor elucidated in quality assurance audits is the consequence of recurrent colonic looping leading to a consequent lack of advancement of the endoscope tip, and subsequent patient discomfort[[1](#_ENREF_1)]. Measures to appreciate colonoscopic positioning in the past required fluoroscopy, however, the use were cumbersome and posed a radiation risk[[2](#_ENREF_2),[3](#_ENREF_3)]. In 1993, the technique of magnetic endoscopic imaging (MEI) of the colonoscope was described by Bladen *et al*[[4](#_ENREF_4)]. This was then further developed by Olympus® into a mobile unit known as “Scopeguide”. This technology provides a real time three-dimensional image of the colonoscope as it passes through the colon. The basic principle relies on the generation of pulsed low intensity magnetic fields generated from electromagnetic generator coils positioned at regular intervals within the colonoscope. This is then picked up by a receiver dish which allows calculation of the precise position and orientation of the colonoscope. It enables loops to be visualised and loop resolution to be performed under direct vision as well as assisting in identifying the location of the tip of the scope.

It has been proposed that this device can improve caecal intubation rates, times and patient comfort. This was demonstrated in the first randomized controlled trial (RCT) of MEI on colonoscopy performance in adults[[5](#_ENREF_5)]. However, more recent studies have demonstrated conflicting results in those with enough statistical power to show a difference in the two groups. Two studies have shown higher caecal intubation rates, one study has shown a shorter intubation times and two showed patient comfort scores were better with MEI, although one of the latest studies looking into its role in unsedated colonoscopy failed to show any statistical difference in any of these outcome measures[[5-8](#_ENREF_5)]. The largest RCT on MEI to date (*n* = 810) did however reveal that in less experienced endoscopists the performance, measured by caecal intubation rate, was significantly better than with standard colonoscopy without MEI[[9](#_ENREF_9)]; this also demonstrated by Chen et al in a meta-analysis collating 8 RCT[[10](#_ENREF_10)]. This may lead to the conclusion that the benefit of the device may be more of a training tool for trainee endoscopist through identification of loops, as shown by similar performance improvements in this group in other cohort studies[[11-13](#_ENREF_11)].

These devices are not in general routine practice on all endoscopy sessions, in part because they are expensive to purchase and require the use of Olympus® equipment. However, what studies have not recorded is the current trainee and trainer satisfaction with this equipment. As the dynamics of the colon can be visualised, there can be a more logical discussion between the trainer and trainee, to resolve an issue of lack of tip advancement or patient discomfort. In practice, trainees appear to be more satisfied with the use of MEI during colonoscopy. One explanation for this is that it allows the trainer to explain the decision making required to facilitate tip advancement without taking the colonoscope over from the trainee. With the growing pressure to train a greater number of generic healthcare endoscopists, the additional cost may thus be justified. With other endoscope manufacturers, such as Pentax®, incorporating MEI into their equipment in the near future it is likely this technology becomes increasingly embedded in day to day colonoscopy practice.

***Therapeutic endoscopy***

Going beyond the realms of basic diagnostic endoscopy, into an era where the endoscopist has now developed the proficiency to undertake therapy, comes an explosion of technology. Endoscopic polypectomy has evolved since its first undertaking by Hiromi Shinya in 1969, from the basic “lassoing” of a polyp to endoscopic mucosal resection (EMR) to endoscopic submucosal dissection (ESD) which allows en-bloc resection of large lesions[[14](#_ENREF_14)]. ESD is however a technically demanding procedure with relatively longer procedure times compared with EMR, and significant complication rates with perforation risk as high as 18% in some series[[15](#_ENREF_15)]. A common reason for this difficulty is the limited field within which the endoscopist, with his “one handed knife”, is operating in. Current standard technique requires the use of a combination of submucosal fluid injection and utilisation of gravity. However, these methods often lead to difficulty in maintaining a safe field of dissection due to a lack of elevation to expose the submucosal plane. To overcome this issue, Gotoda *et al*[16] designed a magnetic anchor device to apply counter-traction. The anchor consisted of a small magnetic weight that was attached to an endo-clip with a thread. Once the standard circumferential incision had been made for ESD, the anchor, which was loaded on the end of a standard endoscope, was deployed by attaching the clip to one end of the flap of the lesion[[16](#_ENREF_16)]. Initially, an extracorporeal magnetic control system of a C-arm type was used to attract the anchor away from the lesion to allow sufficient counter-traction of the flap by the endoclip, which behaved as micro-forceps. The external magnet has since been miniaturised by other investigators to a smaller hand held magnet which is positioned over the torso of the patient. This method has been shown to be feasible as well as reduce procedural times, with no reported complications on 25 gastric lesions[[17](#_ENREF_17),[18](#_ENREF_18)]. This is a promising method and adds to the arsenal of ways to allow possible endoluminal triangulation.

At a more endoscopic surgical level, the use of magnets has been used to create suture free anastomoses. The concept relies on a pair of identical magnetic rings being applied to each end of the intestinal segments to be joined. When they are then brought into close proximity, the magnets align and mate together. Over a period of about 5 d the inner area necroses off while the surrounding non compressed tissue heals and remodels itself. The coupled magnets then fall off into the created lumen leaving a magnetic compression anastomosis. Initial animal model experiments have shown encouraging safety and efficacy. But unfortunately this did not transpire into the clinical setting, with reports of serious adverse events[[19-21](#_ENREF_19)]. Further disadvantages in this technique were the inevitable delay in anastomotic formation as well as a restriction on the circumference of the anastomosis due to the initial fixed size magnets used. To get over this drawback, more recent research has looked into using “nano-magnets” delivered via an endoscopic catheter device. These self-assemble at the two opposing desired sites to occupy a larger perimeter. The lumen of the anastomosis is then created with the aid of a needle knife. An early proof of concept studys on live porcine models, as well as a human cadaver, has shown the successful formation of gastro-jejunostomies[[22](#_ENREF_22)]. Although currently not commercially available, magnetic compression anastomosis seems a viable option to aid in the formation of a secure gastro-enteric anastomosis during future natural orifice transluminal endoscopic surgery (NOTES), replacing the standard methods of suturing or stapling which has its associated complications of leakage and stricture formation.

***Capsule endoscopy***

The demand for capsule endoscopes has grown exponentially, and it is unlikely that even Paul Swain when he took it upon himself to swallow this first “pill” in 1999 would have envisaged that over 2 million of these would have been ingested worldwide subsequently. The market is well established in the small bowel, and beginning to grow in force progressively for the colon. The upper GI tract seemed to have eluded this technology, firstly due to the speed of travel down the oesophagus and secondly because the larger more capacious stomach really necessitated capsule maneuverability. This has led to several investigators trialling various methods for capsule control, with magnetic assisted capsule endoscopy (MACE) being the most promising. Four systems have been developed, all of which have incorporated magnetic inclusion bodies into the capsule endoscope and controlled externally either by a magnetic field generated by a guidance system or more simply by a fixed magnet on a hand held device. The largest comparative trial to date (n=189) comparing MACE to standard upper GI endoscopy was undertaken in France using a system developed jointly by Olympus® and Siemens®. The mean examination time was 11 min compared to the 6 min for standard gastroscopy, with the specificity and sensitivity of 94% and 62% respectively for major lesions[[23](#_ENREF_23)]. However, the magnetic guidance system was similar in size to that of an MRI scanner and was limited to the examination of the stomach.

A simpler system which utilises a hand held magnet has recently been developed by Intromedic Ltd®, the MiroCam-Navi, and which for the first time was capable of exploring the entire upper GI tract. Although awaiting a randomised comparison trial the first feasibility study undertaken on volunteers showed promising visualisation of all the landmarks of the upper GI tract from the GOJ, cardia, fundus, body, incisura, antrum and pylorus of 92%, 88%, 100%, 96%, 96% and 100% respectively[[24](#_ENREF_24)]. This system even has the possibility to aid in small bowel examination by reducing gastric transit time, through manoeuvring the capsule across the pylorus. Due to the simplicity of its use and high patient acceptance this technology certainly seems a true prospect for the future of upper GI tract examination, with the possibility of accurate capsule localisation and even targeted drug delivery being a distinct likelihood in the future[[25](#_ENREF_25),[26](#_ENREF_26)]. The opportunity to support a community based screening programme, if one was to ever occur for upper GI tract pathology, is an attractive proposition with this technology. This MACE system would not require the expensive set-up costs or decontamination equipment needed with standard endoscopy. However, the current cost of this capsule would need to drop considerably, which should be within the realms of the manufacturers should mass use occur.

***Nutritional feeding***

In recent times there has been a growing demand for endoscopically placed naso-gastric/jejunal tubes largely due to increase demand for enteral feeding in those unable to maintain an adequate oral intake[[27](#_ENREF_27),[28](#_ENREF_28)]. Jejunal tube placement is often undertaken at the bedside blindly, although this approach is associated with a significant failure rate. The alternative of direct endoscopic or radiological placement requires significantly resources. To attempt to solve these issues, two “bedside magnetic” devices have been developed; the Syncro-Blue tube and the Cortrak system. The Syncro-Blue tube uses a magnetic stylet placed at the end of the feeding tube which is then maneuvered into position via attraction of a hand held magnet. This system was evaluated in a case series of 288 critically ill patients, with successful post pyloric placement in 89% and a mean procedure time of 15 min[[29](#_ENREF_29)]. Each tube costs approximately 95 dollars, which is likely to be cost saving given the associated expense of endoscopic or radiologically placed tubes. The more widely used Cortrak system, which has an electromagnetic transmitting stylet and a receiver placed in the epigastrium, allows real time tracking of the feeding tube as it is passed down the upper GI tract to its desired position. Although the Cortrak system does not allow external control, a recent systematic review has shown that procedure times as well as tube related adverse events are significantly lower compared to endoscopy with similar successful insertion rates[[30](#_ENREF_30)]. The advantage of this system over the former is that it does not need X-ray imaging to confirm its position, with studies demonstrating 99.5% correlation with X-ray positioning[[31](#_ENREF_31)]. In addition, there is the benefit of re-inserting the tube if accidental dislodgement to the stomach was to occur.

**CONCLUSION**

So it seems that magnets are truly an ally to GI endoscopy, with several establishing methods. Those that are in an experimental stage are growing in momentum with even newer concepts being conceived. With more and more collaborations being undertaken between scientists, physicians and surgeons this seems to be an innovating field and the application of magnets is and will remain an attractive proposition enhancing endoscopy.

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