

Original Research Article

Magnet assisted laparoscopic surgery: first Indian experience

Prem Kumar A.*

Department of Surgery, Bangalore Medical College and Research Institute, Bangalore, India

Received: 16 June 2021

Revised: 21 July 2021

Accepted: 27 July 2021

***Correspondence:**

Dr. Prem Kumar A.,

E-mail: drpremk512@gmail.com

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Background: The problems associated with shaft-based instrumentation include restricted manoeuvrability, restricted visibility and sword fighting of instruments. One of the easiest solutions is to reduce the number of working ports. A unique approach is by the use of a natural force of nature i.e.; magnetism. In this study, we have tried to incorporate the properties of magnetism and magnetic substances to the advantage of surgeons and hence, patients.

Methods: The magnet employed in our study is a 3500 Gauss magnet, of 15×10 cm which was placed over the anterior abdominal wall in a sterile manner. The magnet was moved along the anterior abdominal wall in order to manipulate and mobilize intra-abdominal tissue. Laparoscopic bull dog clamps as well as B. P. handles were used intra-peritoneally to grasp tissue, which in turn are mobilised by the magnet. The end point evaluated was of safety and feasibility to adequately mobilize and manipulate organs to achieve effective exposure for dissection.

Results: In total, we have successfully completed 15 surgical procedures using magnet assisted tool. Eight patients underwent magnet assisted laparoscopic appendectomy. three patients underwent magnet assisted laparoscopic cholecystectomy. Four patients underwent magnet assisted mesh repair for ventral hernias. None of the patients developed magnet related complications.

Conclusions: Magnet assisted laparoscopic surgery is feasible and easy to use. The cost can be minimal. This is a new concept that is here to stay and will become integrated into many other forms in the future. In the rapidly evolving world of surgery, with invasiveness of surgery on the downward trend, magnetism may be the answer to the next leap in surgery: non-invasive surgery.

Keywords: Magnet assisted laparoscopic surgery, Laparoscopic surgery, Minimal access surgery

INTRODUCTION

Surgery has come a long way since its inception. From morbid open surgeries, we evolved to perform laparoscopic surgery. The era of laparoscopic surgery is now leading into the era of robotic surgery. Despite the great advances in surgery, we, as surgeons, have been unable to eliminate invasiveness. We have also not been able to find alternative solutions to shaft-based surgeries. The problems associated with shaft-based instrumentation include restricted manoeuvrability, restricted visibility and sword fighting of instruments. Challenges persist even though many standardized techniques for trocar

placements have been described.¹ The insightful surgical group should consistently be on the inquiry for new strategies and innovations that improve surgical results. In this pursuit, numerous gadgets more of them which are flexible devices are designed.² Innovative procedures have been researched to improve outcomes, for example, post-operative pain, scars, and procedure length. To lessen these possible entanglements of laparoscopic instruments, decreased port many novel procedures have been proposed. Natural orifice transluminal endoscopic surgery procedure (NOTES) main among them has been demonstrated to be plausible in various stomach systems, for example, cholecystectomy, hysterectomy,

nephrectomy, and other urological methods, yet has never acquired acknowledgment somewhat because of various challenges.^{3,4} A unique way to solve this problem was approached. It was clear that one way the problem can be overcome is by the use of a natural force of nature i.e.; magnetism. In this study, we have tried to incorporate the properties of magnetism and magnetic substances to the advantage of surgeons and hence, patients.

Magnetism

Attraction is an undetectable power that can be delivered by magnets, rubbing or electrical flows that can be obviously applied on to explicit metals and amalgams. Attractive powers can draw in or repulse each other relying upon the bearing of their attractive fields, and they are additionally ready to dislodge objects produced using these metals. Attraction can be transitory (e.g. temporary by electrical flow), or it very well may be lasting (e.g. permanent magnets). Even though magnet assisted laparoscopic surgery is not new it is a fresh concept in minimally invasive surgery. The purpose of this work is to study the clinical application and feasibility of a magnet-based shaft-less retraction, manipulation and mobilisation of tissue during surgery.

In this study, we had tried to harness the power of magnetism to perform different surgeries and demonstrate the applicability of magnetism in minimal access surgery. In this regard, we have tried to incorporate different creative methods to perform different laparoscopic surgeries. These surgeries have been performed without costly technology or devices. All surgeries have been performed using simple and commonly available standard surgical instruments.

This study was not meant to propose methods to perform different surgical procedures. It was meant to demonstrate the applicability of magnetism in surgery, which can be applied in numerous and varied ways, far beyond the examples stated in this study, and open up new avenues in minimal access surgery.

Objective

The objective of this study was to determine feasibility of magnet assisted laparoscopic surgery.

METHODS

The study was conducted at Victoria Hospital, affiliated to Bangalore Medical College and Research Institute. The was a prospective study and was conducted from June to December of 2017. Ethical Committee clearance was taken from the institutional ethical committee.

Inclusion criteria

Patients with following criteria were included- (a) aged 18 years or above; (b) consent for the surgery; (c) elective

laparoscopic appendectomy for recurrent appendicitis; (d) elective laparoscopic cholecystectomy; and (e) elective laparoscopic inguinal/ventral hernia repair

Exclusion criteria

Patients with following criteria were excluded- (a) patients not giving consent; (b) emergency cases; (c) patients with pacemakers; (d) patients with ferromagnetic stents or joint replacements; and (e) obese patients (BMI>30).

The sample size was calculated as follows,

$$N = \frac{2(Z_{\alpha} - Z_{1-\beta})^2}{d^2}$$

where N=sample size; z_{α} was standard Table value for 95% CI, 1.96; $z_{1-\beta}$ s standard table value for 80% power, 0.8; σ is standard deviation; d is effect size by substituting in the above equation.¹¹

$$N = \frac{2(1.96 + 0.84)^2(0.54)^2}{d(0.5)^2} = \frac{4.572288}{0.25} = 18.28$$

The collected data was analysed using SPSS statistics program.

The end point evaluated was of safety and feasibility to adequately mobilize and manipulate organs to achieve effective exposure for dissection.

The two parts of the magnet assisted procedure was, one the external controller magnet and second intra-abdominal a magnetic grasping instrument which here was a bulldog clamp and in few the scalpel handle (without blade).

All surgeries were started as standard procedure. Pneumoperitoneum created and camera port inserted. Peritoneal cavity was inspected and pathology identified. The magnet employed in our study is a 3500 Gauss magnet, of 15×10 cm which was placed over the anterior abdominal wall in a sterile manner (Figure 1). The magnet was moved along the anterior abdominal wall in order to manipulate and mobilize intra-abdominal tissue which was held by the intra-abdominal grasper.

In cases of appendectomy, a bull dog clamp introduced into the abdomen and was applied to the tip of appendix. The magnet was placed upon the abdominal wall of the patient. Due to the magnetic power the external magnet could easily mover the grasper.

The appendix was hence lifted, enabling shaft-less manoeuvring of the appendix (Figure 2). This enabled easy transection of the meso-appendix followed by ligation of the appendix base with just one working port. This procedure aided in mobilisation of the appendix in all directions necessary without the need of an additional laparoscopic instrument or port.

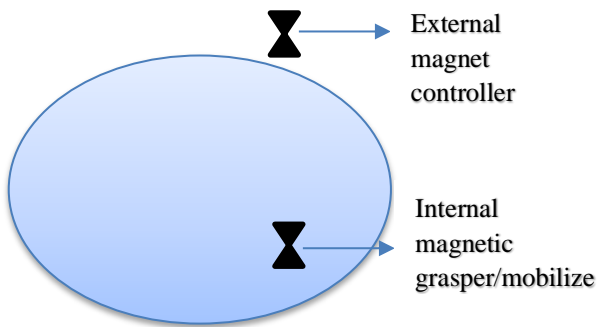


Figure 1: Two parts of the magnet system.



Figure 2: The external magnet and intra-abdominal grasper (bulldog clamp).

In cases of laparoscopic cholecystectomy, a laparoscopic bull dog clamp was applied to the fundus of the gallbladder. The magnet placed over the abdomen and the gallbladder was retracted with magnetic force. This reduced a port, but more importantly, improved the working space due to less instruments in the abdomen.

Placement of synthetic meshes in inguinal and ventral wall hernias can be difficult. The use of magnetism can be of assistance in holding up the mesh against the anterior abdominal wall. We employed laparoscopic bull dog clamps in some cases, and in others, used B. P. Handles (Figure 3). The magnet was placed over the anterior abdominal wall. The mesh was held in place due to the magnetic force between the magnet and the laparoscopic bull dog clamps, enabling easy suturing/stapling without worrying about the mesh falling or getting misplaced. A questionnaire was answered by the operating surgeon on

the advantages felt using this simple yet innovative technique.



Figure 3: Introduction of the internal controller-bulldog clamp.



Figure 4: The external controller magnet.

RESULTS

In total, 15 surgeries were successfully completed using magnetism in the procedure. Eight patients underwent magnet assisted laparoscopic appendectomy. 5 females and 3 males. Average BMI was 26.6. The average operating time was 16.23 min. Average hospital stay was 2 days. The surgeon in the answer to the questionnaire felt that the traction provided was adequate and mobilization of tissues was easy.

Three patients underwent magnet assisted laparoscopic cholecystectomy, all female. Average BMI was 27.6. The

average operating time was 26.33 minutes. Average hospital stay was 2 days. The surgeon felt that gallbladder traction was sufficient. Mobilizing of the gallbladder in all directions was possible to allow dissection of the Calot's triangle as well as dissection off the liver bed.

Four patients underwent magnet assisted mesh repair for ventral hernias. All male. Average BMI was 27.7. The average operating time was 33.24 min. Average hospital stay was 2 days. None of the patients suffered any complications related to the magnet system and experienced uneventful post-operative periods. All surgeries were completed without the use of costly devices and with standard instruments available in any laparoscopic setup.

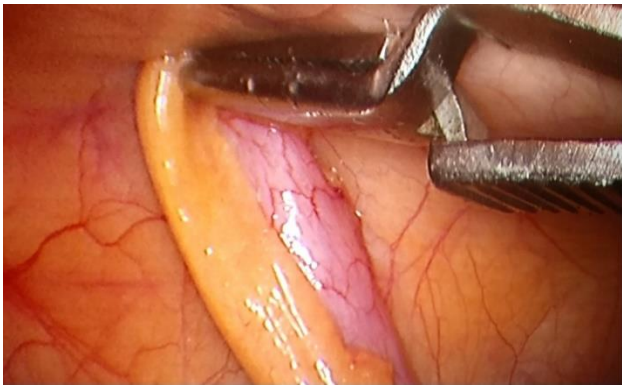


Figure 5: Appendix tip being held by the grasper and controlled by the external magnet.

DISCUSSION

The Magnetic Anchoring and Guidance Systems (MAGS), presented by Cadeddu and his group in 2007⁵, are careful devices that profit by attractive mooring between an outer permanent magnet (PM) and an interior PM implanted in the inner gadget.

Currently, laparoscopic and robotic surgery involves the use of shaft-based instrumentation. Shaft instrumentation is associated with numerous problems. A major problem with shaft-based instrumentation is manoeuvrability of instruments. The surgeon cannot move his instruments with unlimited degree of freedom. Struges et al have suggested that an increase in degree of freedom from 4 to 6 increases dexterity by a factor of 1.5.⁶ The laparoscopic instruments, which are most commonly used at present, offer only 4 degrees of freedom of movement.⁷

Laparoscopic instrument length is limited. If the trocar is too far from the desired position, then one has to push abdominal wall towards target organ to gain a few centimetres. This not only makes these movements less precise but also causes strain on the fingers and hand muscles. Similarly, if the angle between the target and instrument is too wide or obtuse, manipulation of curved instrument is very difficult. Most surgeons customise

trocar position. If there is wrong placement of port, one has to push the abdominal wall causing physical strain to the surgeon.

Laparoscopic instruments interfering with each other intracorporeally, sword fighting, is another problem faced by surgeons. This can be caused by improper port placement and variations in instrument length. Magnetism incorporated by the means of the magnet system can be the key to overcoming these problems. Magnetism provides the advantage of being an invisible force which can penetrate the abdominal wall without physical penetration. It is a force, which when used correctly, is harmless.

Types of stainless-steel is broadly classified as: i) austenitic, ii) ferritic, iii) martensitic, iv) duplex, and v) precipitation hardenable alloys.¹⁰ Standard surgical instruments are made out of stainless steel. Based on the different atomic arrangement they exhibit different magnetic properties. Due to this variance, ferritic stainless steels are magnetic while austenitic stainless steels are not. A ferritic stainless steel owes its magnetic properties to a high concentration of iron, and its fundamental structure. The metallic atoms in ferritic stainless steel are located on a body centred cubic lattice. Alloying the stainless steel with chromium, molybdenum and silicon make it more likely to exhibit this lattice structure at room temperature. Surgical instruments made of ferritic stainless steel can hence be utilised in magnet assisted laparoscopic surgeries.

Apart from the examples stated in this study, it is suggested that the assistance of magnetism can be used in procedures such as (a) percutaneous endoscopic gastrostomy; (b) sleeve gastrectomy; (c) intestinal resection and anastomosis; (d) fallopian tube mobilisation; (e) liver retraction; and (f) urinary bladder retraction in pelvic surgeries.

Magnetism also provides the advantage of providing retraction, or mobilisation of tissues in areas which are not well accessible due to the presence of bones such as the ribs and pelvis. This advantage can be utilized in scenarios such as pulling of the stomach during gastric sleeve surgery or in pelvic surgeries. Research is currently underway to improve and expand the use of magnetism in surgery after the first demonstration of the Magnetic Anchoring and Guidance System (MAGS).⁸

Though these systems are path breaking and will guide the future of minimally invasive surgery, they are also, economically, a burden on setups which are not financially well endowed. The financial stress upon the patient may hamper the popularity of the concept of using magnetism in surgery. In developing countries where patient load is very high, innovative ideas are imperative in dealing with the workload. In setups without much financial assistance, the need for improvisation of concepts is a must. Out of the box thinking can go a long way in patient care.

Working within the resources available is a hurdle most surgeons face in the developing world.

Magnetic devices have been designed and tried for both laparoscopic surgery, which has shown providing alternatives for retraction, anchoring, and manoeuvrability among other critical surgical steps.⁹ Magnet and magnetic materials open a new world of application in biomedical science.¹⁰ Rivas et al suggested their current work on magnetic system indicated an attractive medical procedure, possibly an answer for obstacles in the developments of present-day endoscopic procedure: keeping up powerful triangulation while reducing the ports.¹¹ Magnet assisted surgeries, though very lucrative, are still a work in progress. Large trials need to be conducted to standardise the magnetic strength. The abdominal wall thickness is another factor that must be studied. Specialized instruments and devices must be created to make magnet assisted laparoscopic surgery catch on amongst surgeons. Effort must also be put into making magnet assisted surgeries affordable and readily available.

Future directions

The area of magnetisms needs to be explored further in associations with team of engineers who can give inputs. These inputs will help us, the surgical fraternity in diverse clinical applications.

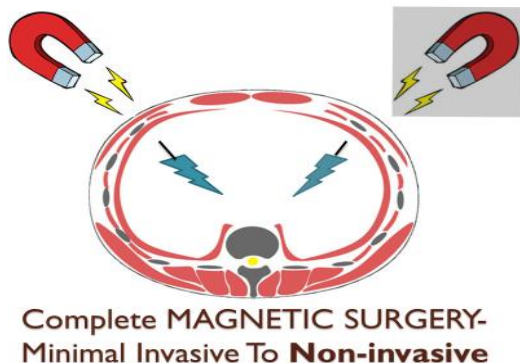


Figure 6: Future of magnet based surgical systems.

We need to explore more capabilities of magnetism. Maybe in future a complete system utilizing magnetisms may enable us to perform a complete shaftless surgical procedure. It is demonstrated by Chen et al how magnetic micro actuators and their wireless operation.¹³ Even a magnetic system manipulator has been conceived by the research team. These are the guiding path towards we should work on a new innovative system based on the principles of magnetism.

CONCLUSION

Magnet assisted laparoscopic surgery is feasible and easy to use. The cost can be minimal. This is a new concept that

is here to stay and will become integrated into many other forms in the future. In the rapidly evolving world of surgery, with invasiveness of surgery on the downward trend, magnetism may be the answer to the next leap in surgery: non-invasive surgery.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Ferzli GS, Fingerhut A. Trocar placement for laparoscopic abdominal procedures: a simple standardized method. *J Am Coll Surg.* 2004;198(1):163-73.
2. Rivas H, Calderon D. Present and future advanced laparoscopic surgery. *Asian J Endosc Surg.* 2013;6(2):59-67.
3. Arulampalam T, Brown S, Morris AJ, Parker MC. Consensus statement: natural orifice transluminal endoscopic surgery. *Ann R Coll Surg Engl.* 2009;91(6):456-9.
4. Dunkin BJ. Natural orifice transluminal endoscopic surgery: Educational challenge. *World J Gastrointest Surg.* 2010;2(6):224-30.
5. Park S, Bergs RA, Eberhart R, Baker L, Fernandez R, Cadeddu JA. Trocar-less instrumentation for laparoscopy: magnetic positioning of intra-abdominal camera and retractor. *Ann Surg.* 2007;245(3):379-84.
6. Falk V, McLoughlin J, Guthart G, Salisbury JK, Walther T, Gummert J, et al. Dexterity enhancement in endoscopic surgery by a computer-controlled mechanical wrist. *Minim Invasive Ther Allied Technol.* 1999;4:235-42.
7. Supe AN, Kulkarni GV, Supe PA. Ergonomics in laparoscopic surgery. *J Minim Access Surg.* 2010;6(2):31-6.
8. Tugwell J, Brennan P, Shea C, Donoghue K, Power T, Shea M, et al. Electropermanent magnetic anchoring for surgery and endoscopy. *IEEE Trans Biomed Eng.* 2015;62(3):842-8.
9. Diaz R, Davalos G, Welsh LK, Portenier D, Guerron AD. Use of magnets in gastrointestinal surgery. *Surg Endosc.* 2019;33(6):1721-30.
10. Riley M, Walmsley A, Speight J, Harris I. Magnets in medicine. *Materials Sci Technol.* 2002;18(1):1-12.
11. Rivas H, Robles I, Riquelme F, Vivanco M, Jimenez J, Marinkovic B, et al. Magnetic Surgery: Results From First Prospective Clinical Trial in 50 Patients. *Ann Surg.* 2018;267(1):88-93.
12. Park S, Bergs RA, Eberhart R, Baker L, Fernandez R, Cadeddu JA. Trocar-less instrumentation for laparoscopy: magnetic positioning of intra-abdominal camera and retractor. *Ann Surg.* 2007;245(3):379-84.

13. Liu K, Lu Q, Huang GB, Zhou JW, Wang XY, Chang PK, et al. Use of the magnetic compression technique in sleeve gastrectomy: a preliminary study. *Chin Med J.* 2020;133(22):2768-70.
14. Dutta S. Different types and new applications of stainless steel. *Stainless steel.* 2018;62(5):86-91.
15. Kobiela J, Grymek S, Wojanowska M, Lubniewski M, Makarewicz W, Dobrowolski S, et al. Magnetic instrumentation and other applications of magnets in NOTES. *Wideochir Inne Tech Maloinwazyjne.* 2012;7(2):67-73.
16. Chen N, Shamsudhin M, Hoop R, Pieters E, Siringil MS, Sakar BJ, et al. Magnetoelectric micromachines with wirelessly controlled navigation and functionality, *Materials Horizons.* 2016;3(2):113-8.

Cite this article as: Kumar PA. Magnet assisted laparoscopic surgery: first Indian experience. *Int Surg J* 2021;8:2650-5.