



# Magnetic-assisted robotic surgery: initial case series of reduced-port robotic prostatectomy

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## Abstract

Minimally invasive radical prostatectomy has rapidly been adopted as the primary means of surgical intervention for prostate cancer. Intraoperative tissue retraction relies on either gravity (via positioning) or use of additional ports and instrumentation. We report the use of a novel trocar-less magnetic retractor system to aid with tissue retraction. Three patients underwent robotic-assisted radical prostatectomy in the treatment of prostatic adenocarcinoma at a single tertiary care institution. All surgeries utilized the Levita™ Magnetic Surgical System (San Mateo, CA) without the use of a fourth robotic arm. The magnetic grasper was used to manipulate the bowel, peritoneum, seminal vesicles, and prostatic capsule. Demographic, pre-operative, and perioperative information were collected. No cases required placement of any additional ports. No intraoperative or immediate post-operative complications occurred. No tissue tearing or subjective tissue damage was noted by placement or removal of the magnetic retractor. Mean operative time was  $216 \pm 17$  min and mean blood loss was  $333 \pm 57$  mL. All patients were discharged to home on post-operative day 1. Robotic prostatectomy utilizing a magnetically anchored tissue grasper appears to be safe and effective while reducing the number of ports (fourth robotic arm) needed. Further investigation is warranted.

**Keywords** Robotic surgical procedures · Minimally invasive surgery · Prostatectomy · Magnetics

## Introduction

Robotic urologic surgery has demonstrated multiple advantages over open surgery, including decreased blood loss and improved post-operative recovery [1, 2]. Tissue retraction can be complicated, especially when working in small spaces (e.g., deep pelvis). Traditionally, tissue retraction is achieved with patient positioning (use of gravity) and the use of additional ports for the bedside assistant and/or a fourth robotic arm.

Magnetic actuation of laparoscopic surgical equipment has previously been explored, particularly with single-site laparoscopic surgery [3–6]. The Levita™ Magnetic Surgical System (San Mateo, CA, USA), a novel magnetic grasper/retraction device for use in minimally invasive surgery, has been investigated as a means of gallbladder retraction during

laparoscopic cholecystectomy. Use of the magnetic retractor has demonstrated safety and efficacy [7, 8]. This led to the recent Food and Drug Administration (FDA)-approval for use in patients with a body mass index (BMI) of 20–34. We now report our initial case series of magnetic-assisted robotic surgery (MARS) to perform reduced-port robotic-assisted radical prostatectomy.

## Materials and methods

Three patients underwent robotic-assisted radical prostatectomy in the treatment of prostatic adenocarcinoma at a single institution by a single surgeon in June 2018. A single Levita™ magnetic retractor (LMR) was used in place of the fourth robotic arm for tissue retraction. All surgical procedures were completed using the da Vinci Si surgical system (Intuitive Surgical Inc., Sunnydale, CA, USA). Table 1 details patient demographics and pre-operative details.

With regards to intracorporeal manipulation of the LMR, the back end of the tissue grasper affixes to a deployment handle by magnetic attraction (Fig. 1a). The jaws of the

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**Table 1** Pre-operative and post-operative characteristics of three patients undergoing magnetic-assisted robotic prostatectomy

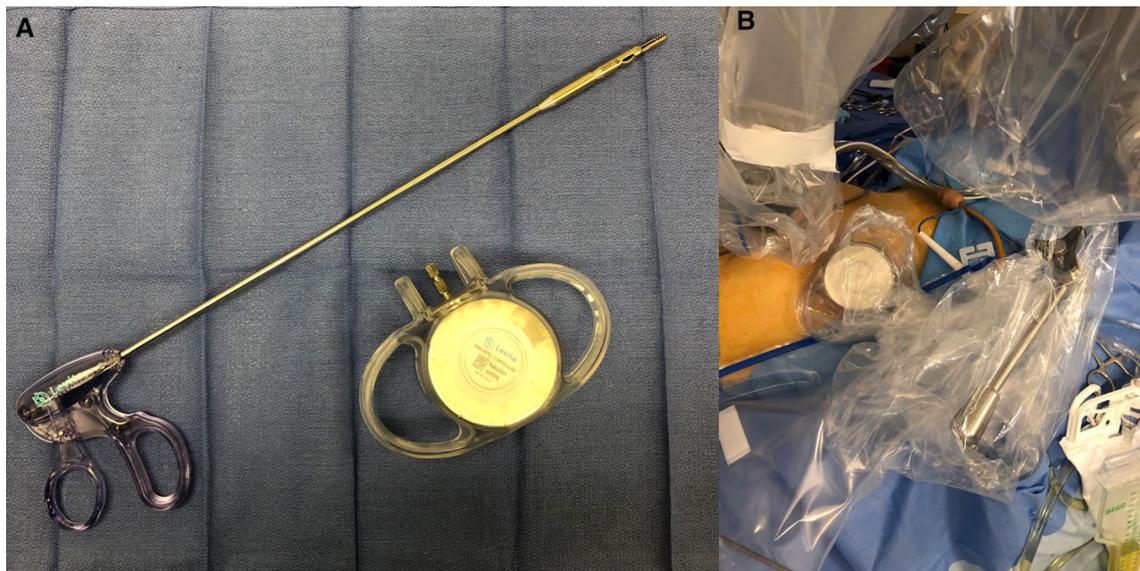
Pt #	Pre-operative characteristics						Post-operative characteristics							
	Age (years)	BMI (kg/m <sup>2</sup> )	PSA (ng/mL)	Prostate volume (g)	Biopsy Gleason group	Clinical stage	EBL (cc)	OR time (min)	Clavien–Dindo complications	Discharge day	Final T stage	Final N stage	Final grade group	Margin status
1	57	35.4	3.8	38	4	T1c	400	211	0	POD 1	T3a	N0	4	Positive
2	57	28.1	13.8	28	1	T1c	300	207	0	POD 1	T3a	N0	2	Negative
3	68	35.3	5.5	38	2	T2a	300	238	0	POD 1	T2	N0	2	Negative

LMR are opened when the deployment handle is spread and closed with squeezing. Once the jaws have been closed, the handle can be squeezed further which releases the tissue grasper from the handle. The tissue grasper is moved to the desired location for retraction and the bedside assistant moves the external magnet over the corresponding site until the magnets are coupled. The external magnetic can be connected to an articulating arm affixed to the operative bed to stabilize the retractor (Fig. 1b). The total time for deployment and positioning of the device is seconds. As an aside, the jaws of the LMR function by a spring-loaded lever which can be opened/closed by the surgeon using robotic instruments for repositioning.

## Operative technique

Each patient underwent the same procedure as detailed below. The patient was placed in Trendelenburg position on a split leg bed with arms tucked. Pneumoperitoneum was obtained using a Veress needle through the umbilicus. A 12 mm camera port was placed just superior to the umbilicus. 2, 8-mm robotic ports were placed 8 cm inferolateral to the camera port for the working instrument arms. One 5 mm port was placed in the far left lateral abdomen and a 12 mm port in the left mid abdomen for the assistant. Figure 2 shows the robotic port layout, along with the zone in which the external magnetic is placed. Most notably, the fourth robotic arm trocar was not placed.

Initial dissection began by exposing the vasa and seminal vesicles. The LMR was utilized to retract the colon out of the pelvis while incising the posterior peritoneum; it was later repositioned to provide anterior retraction during isolation of the vas deferens and seminal vesicles, as well as the opening of Denonvillier's fascia. The anterior dissection of the prostate was then performed. The LMR was utilized to provide cephalad retraction of a 3–0 polyglactin suture placed for DVC back-bleeding at the anterior prostatic base. After the bladder was dissected free from the prostate in a bladder neck-sparing fashion, the LMR was successfully used to retract the seminal vesicles superiorly, allowing for the lateral bladder attachments and prostatic pedicles to be isolated and clipped in the standard fashion. The LMR was then repositioned to aid with nerve sparing. A novel, adjustable suture “handle” was placed through the left levator fascia system to retract the prostate during nerve sparing. The suture handle is made of a 2–0 polyglactin suture, 2 cm segment of a 16 Fr red rubber catheter and small Hem-o-lok clip which allows for fine adjustments in tension during nerve sparing (Fig. 3). After completion of the prostatectomy, the LMR was utilized to retract the bladder during pelvic lymphadenectomy. The anastomosis was performed in a



**Fig. 1** **a** The complete Levita™ magnetic surgical system and **b** external magnet attached to bed-mounted articulating arm

standard van Velthoven fashion and a 16 Fr suprapubic tube was placed, as per standard for all robotic-assisted prostatectomies at our institution. No drains were left at the completion of the procedures.

## Results

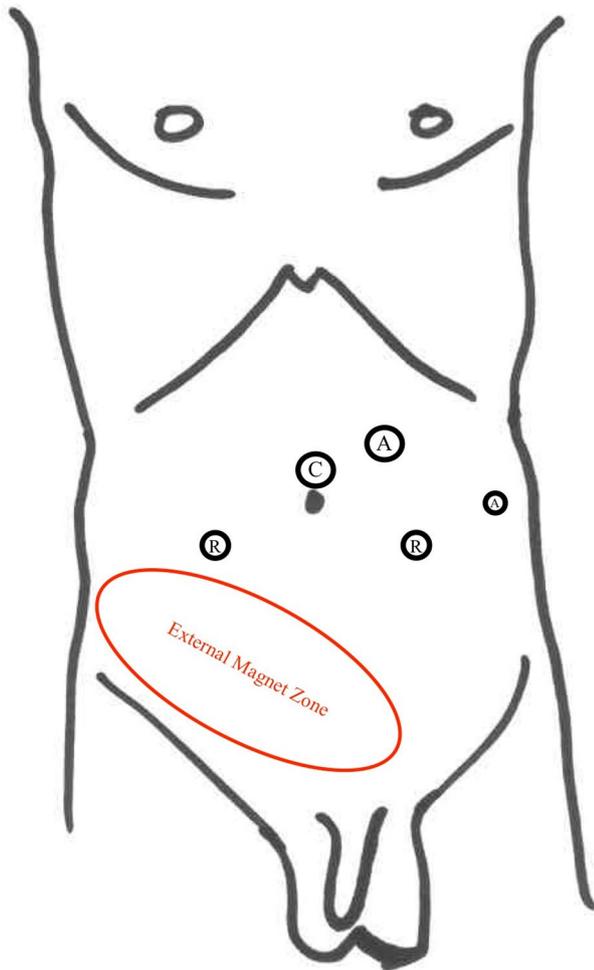
Table 1 lists demographic information, operative details, and pathologic outcomes for each case. No cases required the placement of a fourth robotic arm or additional assistant port. No cases required conversion to an open procedure. No intraoperative or immediate post-operative complications were noted. Subjectively, no tissue tearing, crush injuries or other damage was noted after removal of the magnetic retractor from grasped tissues. A few device limitations were noted during surgery including weaker magnetic coupling related to body wall thickness at some locations in the two patients with BMI > 35, as well as detachment of the grasper when attempting to directly grasp the prostate/bladder neck margin. Mean operative time was  $216 \pm 17$  min and mean blood loss was  $333 \pm 57$  mL. All patients had the suprapubic tubes opened and urethral catheters removed on post-operative day 1 (POD) as per institutional protocol. All patients were discharged to home on POD 1. No patients were readmitted within 30 days. One patient was found to have a positive margin at the site of extracapsular extension on final pathology. This was not felt to be related to inadequate visualization or tissue retraction.

## Discussion

This is the first report detailing the use of an intracorporeal magnetic retractor as a replacement of the fourth robotic arm in performing reduced-port radical robotic prostatectomy. No cases required placement of additional ports, nor conversion to open procedures.

Retraction in minimally invasive surgery typically relies on gravity by means of patient positioning or the use of instruments placed through additional ports. The LMR described herein permits a new method (MARS) for retraction without the need for a fourth robotic arm. It is important to note that the 3-arm robotic prostatectomy completed in this experience was completed without altering the fundamental steps of the operation. The potential advantages of minimizing the number of ports include negating the risk of a port site hernia and damage to abdominal wall vessels (e.g., epigastric or intercostal artery and vein). Additionally, a potential cost savings was recently identified in an analysis when only three robotic arms, as compared to four, are utilized [9].

In addition, patient cosmesis has been proven to be an important consideration with regards to post-surgical satisfaction. Golkar et al. showed that in a cohort of 120 patients undergoing LESS surgery that satisfaction was directly linked with scar appearance and cosmesis [10]. Similarly, Kudsi et al. showed improvement in cosmesis satisfaction and body image perception in patients undergoing robotic single-site cholecystectomy, as compared to multiport laparoscopic cholecystectomy [11].



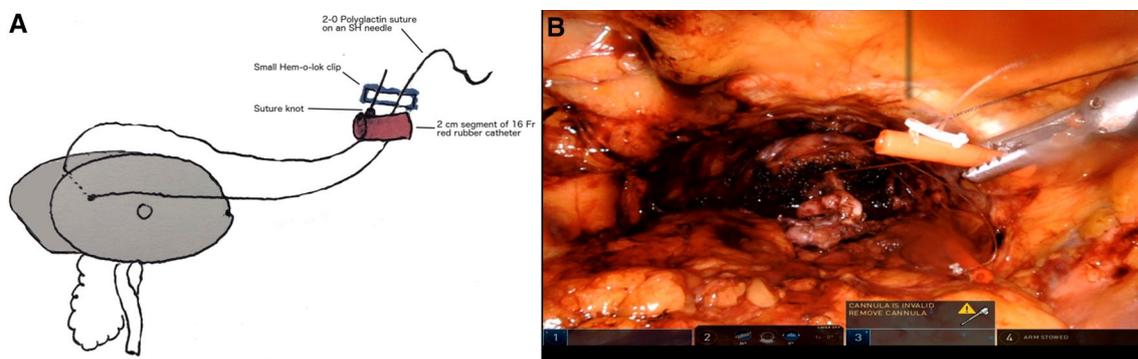
**Fig. 2** Robotic port layout with highlighted external magnetic zone for magnetic-assisted robotic prostatectomy (C=camera, A=assistant, R=robotic)

In a prospective and retrospective observational cohort study, Park et al. demonstrated that patients prefer favor cosmetic outcomes with less surgery and have superior scar satisfaction [12]. While aesthetics can never supersede the importance of safety and surgeon comfort with performing a procedure, magnetic retraction may improve patient-perceived outcomes by minimizing the number of surgical scars.

MARS appears to be a promising advancement in minimally invasive surgery. Initial reports of magnetically actuated laparoscopic surgery were first published in both animals [13] and humans [3] over a decade ago. Since the initial report, robotic surgery has become the dominant means to minimally invasive urologic surgery in the United States. The magnetic retractor system used in this report now provides a way to capitalize on the advantages of magnetics, along with the enhanced optics and features of robotics. While this technology provides the possibility of reducing the invasiveness of surgery, cost analysis and other systemic considerations will need to be considered and investigated.

## Conclusions

In this initial small case series, magnetic-assisted robotic prostatectomy utilizing a magnetically anchored tissue grasper/retractor appears to be both safe and effective. Use of the system obviates the need for a fourth robotic arm, thereby reducing the number of ports, minimizing the morbidity of surgery, and incrementally improving post-operative cosmesis.



**Fig. 3** Drawing (a) and still image (b) of the novel suture handle used for retraction of the levator fascia during nerve sparing

## Compliance with ethical standards

**Conflict of interest** J. Cadeddu is a member of the advisory board and an investor in Levita Magnetics, Inc. R. Steinberg and B. Johnson declare they have no conflict of interest.

**Informed consent** Written informed consent was obtained from the patient for publication of this Case Report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

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