Journal of Robotic Surgery (2020) 14:753–758
https://doi.org/10.1007/s11701-020-01050-1

ORIGINAL ARTICLE

Single-port robotic-assisted laparoscopic sacrocolpopexy with magnetic retraction: first experience using the SP da Vinci platform

Vishnu Ganesan[1] · Ramy Goueli[1] · Dayron Rodriguez[1] · Deborah Hess[1] · Maude Carmel[1]

Received: 29 October 2019 / Accepted: 30 January 2020 / Published online: 8 February 2020

Abstract
The purpose of this study was to describe technical considerations and first outcomes from a single-port robotic-assisted sacrocolpopexy (RSC) using the da Vinci SP platform (Intuitive Surgical, Sunnyvale, CA) and the Levita™ Magnetic Surgical System (San Mateo, CA, USA), a novel magnetic retraction system. Three females with pelvic organ prolapse elected to undergo RSC using the da Vinci SP platform. The supraumbilical incision length was 25 mm through which SP trocar was placed. A 12-mm assistant port was placed in the right upper quadrant. The external magnet was attached to the left side of the bed and used for bowel and bladder retraction. We then proceeded by duplicating the steps of our approach for a RSC performed using a multi-port robotic platform with necessary modifications given the SP approach. Intra-operative outcomes and peri-operative outcomes were collected and reported. The patients were women of 64, 66 and 73 years of age with BMI of 22, 25, and 34, respectively, and POP-Q stage III and IV prolapse. The RSC was performed between 198 and 247 min, estimated blood loss was 10–50 cc, and there were no complications. All patients were discharged home on post-operative day 1. All patients were doing well 1 month out with resolution of bulge symptoms. To our knowledge, this represents the first case series of robotic, magnetic-assisted sacrocolpopexies using the da Vinci SP platform and the Levita™ Magnetic Surgical System. It appears to be a safe and feasible approach, but long-term comparative studies will be necessary to assess functional outcomes.

Keywords Single port · Sacrocolpopexy · Robotic assisted

Introduction

Abdominal sacrocolpopexy is believed to be the most durable procedure for repair of apical prolapse or multi-compartment prolapse with apical component [1, 2]. However, the superior results of the abdominal approach compared to the vaginal approach have come at the cost of increased short-term morbidity [1]. The use of laparoscopy and robotics have improved blood loss and length of stay allowing for the benefits in durability of the abdominal repair while minimizing the short-term morbidity associated with the open procedure [3].

Evolution from multi-port robotic surgery to single-port robotic surgery has been increasingly used for prostatectomy [4, 5], since the development of specifically designed da Vinci SP robotic system from Intuitive Surgical. For sacrocolpopexy, there has been a report of a case series of 25 patients using a robotic platform adapted for single site, but it has failed to gain traction [6]. Several features make the purpose built da Vinci SP platform more favorable. The instruments of the SP incorporate an additional joint, described as an "elbow", which helps reduce clashes of the instruments that may occur with traditional system in the narrow spaces required for single port. Additionally, the single arm can rotate 360° providing complete anatomic access. Here, we report the first descriptive study that demonstrate the technical considerations, feasibility, and early outcomes regarding the use of the single-port robotic system for robotic sacrocolpopexy (RSC) using magnetic system for non-invasive tissue retraction.

✉ Maude Carmel
maude.carmel@utsouthwestern.edu

[1] Department of Urology, University of Texas Southwestern, 5323 Harry Hines Blvd, Dallas, TX 75390-9110, USA

Materials and methods

A single surgeon (MC) performed three cases of single-port RSC at our institution between June and August 2019. All surgical procedures were completed using the da Vinci SP platform (Intuitive Surgical Inc., Sunnydale, CA, USA) and the Levita Magnetic Retractor (Levita Magnetics Corp, San Mateo CA). The data was collected with institutional review board approval. The Levita Magnetic Retractor is a retraction device that is Food and Drug Administration (FDA) approved for patients with BMI between 20 and 34 kg/m^2 and has shown safety and efficacy for gallbladder retraction in laparoscopic cholecystectomy [7, 8]. It consists of a single use magnetic grasper which is delivered through a $\geq$ 10 mm laparoscopic port and attached to the tissue needing retraction, and a reusable external magnet (Fig. 2c).

Operative technique

The patient is placed in a low lithotomy position using the Allen stirrups. Similar to our multi-port approach, the bedside magnetic traction device is secured to the bed on the left side of the patient. An EEA sizer is placed in the vagina for support and a Foley catheter is placed. Patients are prepped from vagina, perineum and abdominal wall up to the infraxyphoid. A single 25 mm incision is made 1–4 cm above the umbilicus and carried down to fascia. Particular care is taken to estimate the location of the sacral promontory to make the port incision at least 10 cm cephalad to this location but no further than 25 cm cephalad to the pelvis. The SP robot port needs to be placed 10–25 cm cephalad to the operative field to ensure proper reach and articulation of the instrument. An open Hassan technique is performed, two stay sutures of 0 Vicryl are placed and the fascia is incised in the midline. The fascia is opened, and the peritoneum is entered. The SP trocar is then introduced through this incision and the camera is placed through the port. Following this, a 12 mm assistant port is placed 10 cm laterally to the right of the SP trocar. The SP robot is then docked in a 45-degree side dock position on the patient's right side (Fig. 1).

Sacral dissection

For the sacral dissection, the SP port is rotated to place the camera at the 12 o'clock location with a 30 degree down angle. The robotic arms are setup as follows: monopolar scissors at the 3 o'clock position, fenestrated bipolar at 6 o'clock and Cadiere forceps at 9 o'clock. To improve exposure and retract the sigmoid laterally, the Levita Magnetic Retractor (Levita Magnetics Corp, San Mateo CA) can be used. The magnet is attached to the mesentery of the sigmoid and the external magnet is attached to the left side of the bed to retract the sigmoid to the left side (Fig. 2). It is difficult to use the Cadiere forceps to retract the bowel with the SP platform given the limited working space. This magnet eliminates the need for an additional trocar. After adequate exposure of the sacrum, the peritoneum overlying the sacral promontory is grasped and incised with the monopolar scissors. Using blunt and sharp dissection the sacrum and the anterior longitudinal ligament of the promontory is exposed (Fig. 3). The posterior peritoneum overlying the right pelvic sidewall is incised down to the level of the uterosacral ligaments laterally to the vagina.

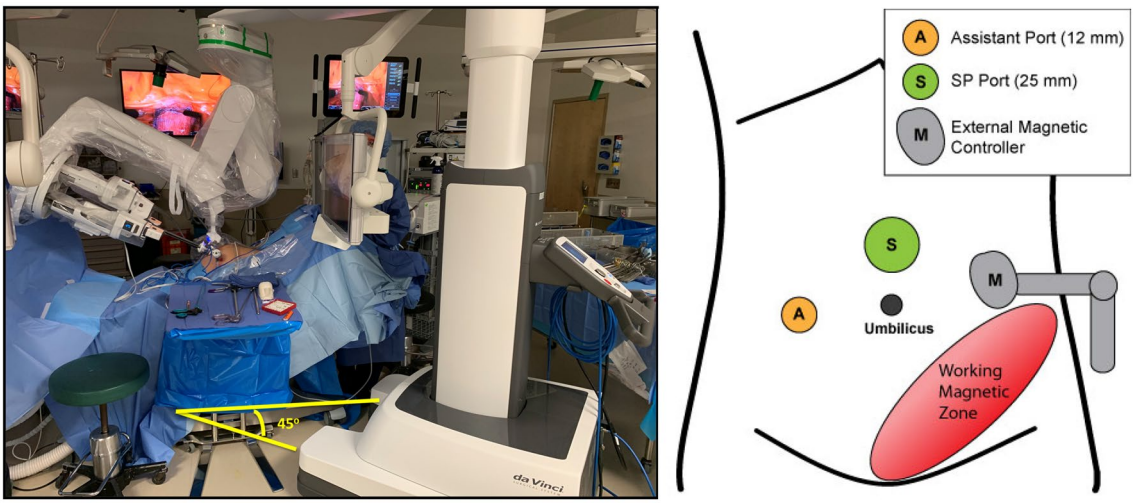

Fig. 1 da Vinci SP platform is docked in a 45-degree side dock position. The 12 mm assistant port on the patient's right side can be seen. The side dock position allows for the assistant to easily access to the patient's vagina and manipulate when needed by the operating surgeon. Sub-figure on the right shows placement of the ports. The SP robot port is few centimeters above umbilicus but needs to be 10–25 cm from the pelvis

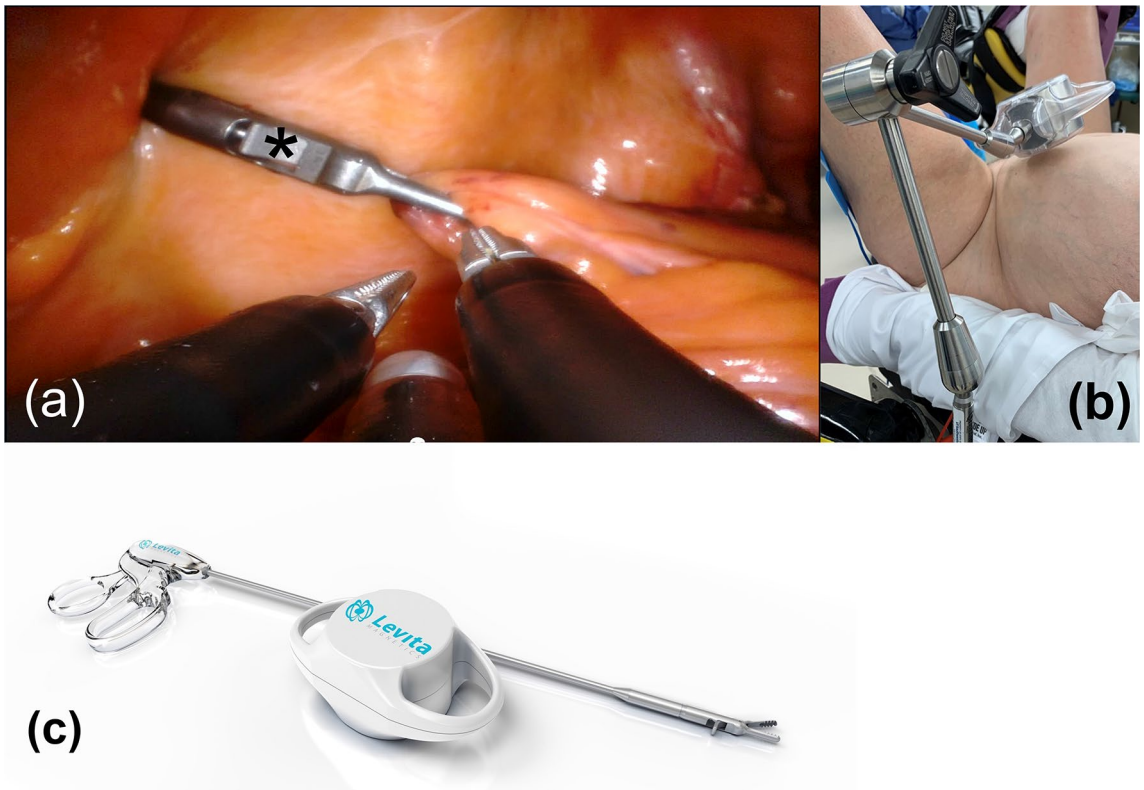

Fig. 2 Using the Levita Magnetic Retractor to retract the sigmoid laterally. The magnet (marked with *) is attached to the mesentery of the sigmoid (**a**) and the external magnet is attached to the left side of the bed (**b**) to retract the sigmoid to the left side. **c** shows the external magnet and a grasper with a detachable grasper tip and handle. Image courtesy of Levita Magnetics Corp

Fig. 3 Sacral dissection: sacrum and the anterior longitudinal ligament of the promontory is exposed

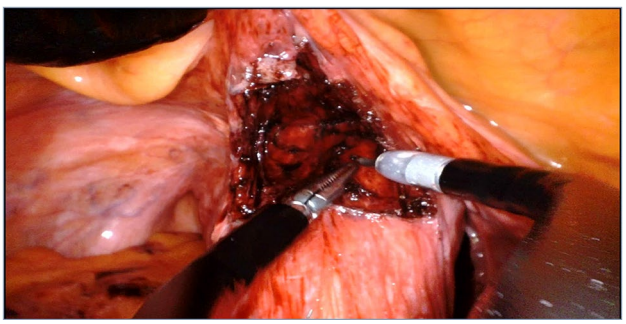

Fig. 4 Avascular plane between the anterior aspect of the vagina and the posterior wall of the bladder is developed to the junction with upper trigone

Vaginal dissection

The peritoneum is incised horizontally at the level of the junction of the posterior aspect of the bladder with the anterior aspect of the vagina. This avascular plane is developed, and the bladder carefully dissected off the vagina down to the junction with the upper trigone, location estimated by the location of the Foley balloon (Fig. 4). During the anterior vaginal wall dissection, the Levita Magnetic Retractor can be used to elevate the bladder. Following this, the SP port is rotated to place the camera at the 6 o'clock position of the port with a 30° up angle and the instruments are replaced to obtain the same instrument configuration. The posterior peritoneum is dissected off the posterior vagina down to the junction with the rectum.

Securing the mesh

The Vertessa® (Caldera Medical. Inc., Agoura Hills, CA, USA) mesh is brought into the surgical field through the assistant port. The suturing of the mesh is more efficient placing the needle drivers at 3 and 9 o'clock and using the scissors in the remaining port to cut the sutures. To preserve full breath of movement during suturing, it is preferable to keep the scissors into the cannula of the port. No suture-cut needle drivers are currently available for the SP robot. The mesh is trimmed to cover the entire surface of the anterior and posterior vaginal wall and fixed with several 2–0 PDS (Fig. 5). The sacrocolpopexy mesh is tensioned to place the vagina mid-tension between complete support with the EEA in place and no tension at all. The mesh is then secured to the sacral promontory with two sutures of #1 Prolene (Fig. 6). The posterior peritoneum is reapproximated to cover the mesh completely with 2–0 Vicryl. The robot is undocked, and cystoscopy is performed to confirm efflux bilaterally and to ensure there are no foreign bodies in the bladder. A Foley catheter is replaced as well as a betadine-soaked vaginal packing. The fascia is then closed with 0 PDS. The skin is closed with 4–0 monocryl. The patient is admitted for monitoring overnight. On post-operative day 1, the vaginal packing and Foley catheter are removed, and the patient is discharged home after a voiding trial.

Data collection

Clinical data was collected by retrospective chart review. This included patient demographics including age, gender, body mass index, clinical characteristics such as Pelvic Organ Prolapse Quantification (POP-Q)grading [9], prior surgeries, and intra-operative and post-operative parameters including blood loss, operative time, length of stay and complications within 30 days. All analysis was descriptive.

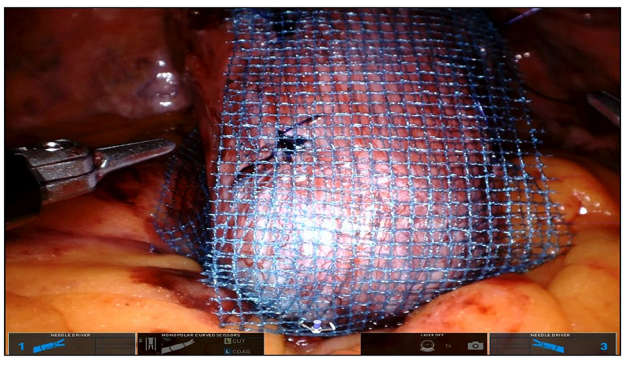

Fig. 5 Mesh is fixed to cover the entire surface of the anterior and posterior vaginal wall using several 2–0 PDS

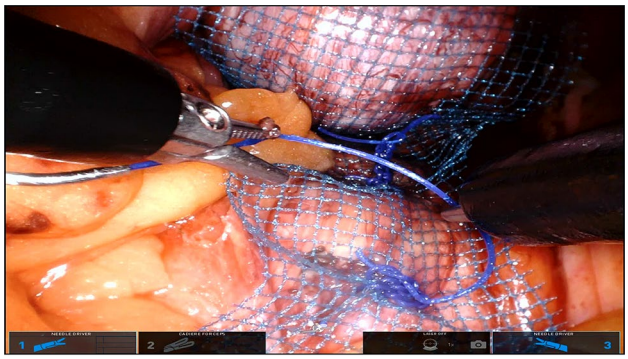

Fig. 6 Mesh is then secured to the sacral promontory with 2 sutures of #1 Prolene

Results

Three patients underwent single-port RSC between June and August 2019. They were 64 and 66 and 73 years of age with BMI of 22 and 25 and 33, respectively. Two women had POP-Q stage IV prolapse, while one had stage III prolapse. No cases required conversion to open procedure or multi-port robotic surgery and no intra-operative or immediate post-operative complications were noted. No transfusions were required. The operative times ranged from 198 to 247 min and estimated blood loss was 10–50 cc. All three patients were discharged on post-operative day 1 (Table 1). At the 1-month follow-up visit, all patients were doing well with resolution of bulge symptoms with no evidence of hernia or mesh extrusion. Vaginal examination also revealed

Table 1 Pre-operative and post-operative characteristics

Patient #[a]	1	2	3
Age, years	64	66	73
Body mass index, kg/m^2	22	25	33
Charlson comorbidity index	2	2	4
Pelvic organ prolapse-Q stage[b]	4	4	3
Prior hysterectomy	Yes	Yes	Yes
Prior colporrhaphy	Yes	No	Yes
Estimated blood loss, cc	10	10	50
Operative time, min	198	247	232
30-day complication	No	No	No
Length of stay, days	1	1	1

[a]Number assigned in chronologic order

[b]POP-Q Stage 2: the vagina is prolapse between 1 cm above the hymen and 1 cm below the hymen. Stage 3: The vagina is prolapsed more than 1 cm beyond the hymen but less than totally everted; and stage 4: the vagina is everted to within 2 cm of its length

Table 2 Pre- and post-operative pelvic organ prolapse quantification measurements

Patient #	1		2		3	
	Pre	Post[a]	Pre	Post[a]	Pre	Post[a]
Aa	+3	−3	+3	−3	+3	−3
Ba	+7	−3	+9	−3	+6	−3
C	+7	−15	+9	−14	−4	−15
Ap	−2	−3	+3	−3	0	0
Bp	+7	−3	+9	−3	0	0
TVL	10	15	12	14	12	15

The values are measured in cm and are negative if above the hymen and positive if below the hymen

TVL total vaginal length

[a]4–6 weeks after surgery

complete resolution of pelvic organ prolapse in all patients. Pre-operative and post-operative POP-Q measurements are summarized in Table 2.

Discussion

This is the first report detailing the use of the da Vinci single-port robotic system to perform a RSC. It is also the first to detail the use of a novel magnetic retraction device in this setting. Our initial experience shows that use of the SP platform is feasible to perform RSC with satisfactory intra-operative and post-operative outcomes for surgical management of women with pelvic organ prolapse and that the Levita Magnetic Retractor is a valuable adjunct to complete this surgery with the SP platform.

In the present study, there were no conversions or change in the treatment plan for both cases. This demonstrates the feasibility of the SP surgical platform in performing the procedure. The operative time ranging from 198 to 50 min was comparable to that reported in the literature for a randomized trial of traditional RSC [10]. It was also comparable to a series, where a multi-port robot was adapted for single-port RSC [6] as well across multiple other reported series of multi-port RSC [11]. This suggests that learning curve for transition to the single-port surgical system from the multi-port robotic platform is easier compared to the transition from open to robotic approach, which have typically showed initially longer operative times [12, 13]. There are multiple limitations of the SP platform compared to the multi-port robotic platform. The surgical field is limited to 10–25 cm from the port, which requires an accurate estimation of the location of the sacral promontory. We have found that the location of the sacral promontory can be estimated by identifying the superior border of the anterior superior iliac spine. The port incision should be supraumbilical, at least 3 cm superior to landmark. Second, the operative field and possible movements are restricted when all the instruments are deployed. This is the reason we have found limited use of the "3rd arm" for retraction and suturing the mesh was easier while keeping the 3rd instrument into the trocar. The difficulty of being unable to use the "3rd arm" for retraction was overcome using the Levita Magnetic Retractor. The Levita Magnetic Retractor offered a great advantage to manipulate the sigmoid laterally during the sacral dissection and to elevate the bladder during the vaginal dissection. It is easy to manipulate and adjust and we believe this instrument will allow the expansion of indications for the SP platform.

As mentioned earlier, the Levita Magnetic Retractor consists of an external magnet and a grasper with a detachable grasper tip and handle. The magnetic grasper assembly delivers and applies the detachable grasper tip to the structure to be retracted. With the detachable grasper tip secured to the organ, the external magnet is placed over the abdominal wall and a magnetic attraction is achieved with the detachable tip. The external magnet can then be freely moved to optimize retraction and mobilization. To remove the grasper, the detachable grasper tip is decoupled from the external magnet, reconnected to the handle. Rivas et al. published a prospective study of 50 patients undergoing laparoscopic cholecystectomy using the Levita Magnetic Retractor [8]. The use of the magnetic retractor allowed to reduce the number of ports from 4 to 3. They reported no evidence of device failure at all, including device failure requiring additional surgical intervention or reoperation and/or device removal, and there were no serious device-related adverse events. The exposure obtained using the device was judged to be excellent in 90% of cases.

The placement of the extra port for the bedside assistant takes away from a truly single-port surgery. This was planned from the beginning of the case, but access to the surgical field for the bedside assistant remains a challenge that the SP platform has not completely resolved. Other initial case reports using the single-port system for procedures such as prostatectomy have also needed to use a separate assistant port [14, 15].

The potential benefits of the single site approach include less post-operative pain and improved cosmesis. The

cosmesis benefits have been shown for laparoscopic endoscopic single site surgery. In one study using survey to assess patient preferences, assuming equivalent surgical risk, patients favored the cosmetic outcomes in single site surgery compared to traditional laparoscopic or open surgery [16].

The main limitation of the SP platform for RSC remains in patient selection. Because of the limited working space and limited use of the 3rd arm for retraction, we have preferred to offer this approach to patient with lower BMI (< 30 kg/m^2), with a previous hysterectomy and with minimal additional previous abdominal surgeries. One of our patients had a BMI of 33 kg/m^2 and had a history of perforated diverticulitis. This proved to be a very difficult surgery to complete with the SP platform secondary to the lysis of adhesion required to gain access to the deep pelvis and the thick sigmoid mesentery, which was difficult to retract properly during the sacral dissection. Even though we were able to complete the surgery with the SP platform, the Levita Magnet Retractor was essential to the completion of that surgery. This confirmed that patient selection is extremely important for the success of such surgery.

Our report on the first cases on the use of the da Vinci SP platform for RSC is quite limited by its small number and the short follow-up but nonetheless we feel this work is important, as it is the first such use reported.

Conclusion

To our knowledge, this represents the first case of a RSC using the da Vinci SP platform and the Levita Magnetic Retractor. We have demonstrated technical feasibility, safety, and comparable operative times to prior da Vinci systems. The potential advantage includes improved cosmesis, but future larger studies will be needed to assess for differences in peri-operative and long-term functional outcomes, cost, and optimizing the surgical technique.

Compliance with ethical standards

Conflict of interest Author Ganesan, Author Goueli, Author Rodriguez, Author Hess, and Author Carmel declare that they have no conflict of interest.

References

1. Maher C, Feiner B, Baessler K et al (2013) Surgical management of pelvic organ prolapse in women. Cochrane Database Syst Rev. https://doi.org/10.1002/14651858.CD004014.pub5
2. Nygaard IE, McCreery R, Brubaker L et al (2004) Abdominal sacrocolpopexy: a comprehensive review. Obstet Gynecol 104:805–823
3. Coolen ALWM, van Oudheusden AMJ, Mol BWJ et al (2017) Laparoscopic sacrocolpopexy compared with open abdominal sacrocolpopexy for vault prolapse repair: a randomised controlled trial. Int. Urogynecology J. 28:1469–1479
4. Agarwal DK, Sharma V, Toussi A et al (2019) Initial experience with da vinci single-port robot-assisted radical prostatectomies. Eur Urol. https://doi.org/10.1016/j.eururo.2019.04.001
5. Kaouk J, Bertolo R, Eltemamy M et al (2019) Single-port robot-assisted radical prostatectomy: first clinical experience using the SP surgical system. Urology 124:309
6. Matanes E, Lauterbach R, Mustafa-Mikhail S et al (2017) Single port robotic assisted sacrocolpopexy: our experience with the first 25 cases. Female Pelvic Med Reconstr Surg 23:e14–e18
7. Haskins IN, Strong AT, Allemang MT et al (2018) Magnetic surgery: first US experience with a novel device. Surg. Endosc 32:895–899
8. Rivas H, Robles I, Riquelme F et al (2018) Magnetic surgery: results from first prospective clinical trial in 50 patients. Ann Surg 267:88–93
9. Bump RC, Mattiasson A, Bø K et al (1996) The standardization of terminology of female pelvic organ prolapse and pelvic floor dysfunction. Am J Obstet Gynecol 175:10–17
10. Paraiso MFR, Jelovsek JE, Frick A et al (2011) Laparoscopic compared with robotic sacrocolpopexy for vaginal prolapse: a randomized controlled trial. Obstet Gynecol 118:1005–1013
11. Serati M, Bogani G, Sorice P et al (2014) Robot-assisted sacrocolpopexy for pelvic organ prolapse: a systematic review and meta-analysis of comparative studies. Eur Urol 66:303–318
12. Geller EJ, Siddiqui NY, Wu JM et al (2008) Short-term outcomes of robotic sacrocolpopexy compared with abdominal sacrocolpopexy. Obstet Gynecol 112:1201–1206
13. McDermott CD, Hale DS (2009) Abdominal, laparoscopic, and robotic surgery for pelvic organ prolapse. Obstet Gynecol Clin North Am 36:585–614
14. Kaouk J, Garisto J, Bertolo R (2019) Robotic urologic surgical interventions performed with the single port dedicated platform: first clinical investigation. Eur Urol 75:684–691
15. Dobbs RW, Halgrimson WR, Madueke I et al (2019) Single port robot-assisted laparoscopic radical prostatectomy: initial experience and technique with the da vinci SP platform. BJU Int 124(6):1022–1027
16. Park SK, Olweny EO, Best SL et al (2011) Patient-reported body image and cosmesis outcomes following kidney surgery: comparison of laparoendoscopic single-site, laparoscopic, and open surgery. Eur Urol 60:1097–1104