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Research Article

Initial experience of single-port robot-assisted radical prostatectomy: A single surgeon's experience with technique description

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ABSTRACT

Background: With the implementation of da Vinci SP robot platform (Intuitive Surgical, Inc., Sunnyvale, CA, USA), we described our initial experience with the da Vinci SP robot platform (Intuitive Surgical, Inc., Sunnyvale, CA, USA) for single-port robotic-assisted radical prostatectomy (SP-RARP).

Methods: This retrospective review included 30 consecutive patients with prostate biopsy-confirmed prostate cancer who underwent SP-RARP by a single surgeon between June and November 2020. SP-RARP was performed with a single-incision plus one method, in which the multichannel guide port was inserted directly with an additional assist port. We report our initial experience of perioperative and early functional outcomes.

Results: The mean operative time (SD), console time (SD), and blood loss were 142.8 (15.1) min, 109.9 (15.7) min, and 133.0 (72.9) mL, respectively. No intraoperative complications or blood transfusions were reported. Of the 30 patients, 21 (70.0%), 7 (23.3%) and 2 (6.7%) had stage pT2, pT3a and pT3b disease, respectively. Positive surgical margins were reported in 5 of the 30 (16.7%) patients in the final pathology report, including 2 of 21 (9.5%) with stage pT2 and 3 of 9 (33.3%) with $\geq$ pT3. At 12 weeks after SP-RARP, 80.0% of patients had achieved continence and the potency was 46.7%; 8 of 11 (72.7%) had sexual health inventory for men (SHIM) scores $\geq$ 17 and 6 of 19 (31.6%) had SHIM scores < 17.

Conclusions: The SP platform for radical prostatectomy was technically safe and feasible. After overcoming the technical learning curve, this platform may provide high-quality outcomes comparable to those of multi-port platforms.

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1. Introduction

The adoption of robotics in the treatment of prostate cancer (PCa), including the development of the DaVinci Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA, USA) has led to a paradigm shift in the surgical management of clinically localized Pca.[1] Robotic-assisted radical prostatectomy (RARP) has become the dominant surgical approach for localized prostate cancer in the United States.[2,3]

After the first robotic laparoendoscopic single-site surgery (R-LESS) was performed in 2008, the technologies have been modified and evolved. Initially, R-LESS radical prostatectomy (RP) was performed using multiarmed robots.[4,5] However, R-LESS RP is technically challenging because of clashing among multiple arms and reduced motion ranges in the limited working space.[6] The da Vinci SP, which has four articulating instruments via a single access trocar, was introduced to overcome the drawbacks of the conventional single-site approach with multiarmed arms.[7] In the era of minimally invasive surgery, the DaVinci SP has the potential to be a significant step forward in robotic surgery for the treatment of PCa. The first case of single-port robot-assisted radical prostatectomy (SP-RARP) (prototype) was reported in 2014 by Kaouk et al.[8] The same group described the first clinical investigation of SP-RARP with the current

Abbreviations: EBL, estimated blood loss; EPE, extraprostatic extension; FDA, Food and Drug Administration; GrGP, grade group; GS, Gleason score; MP-RARP, multiport robot-assisted radical prostatectomy; MRI, magnetic resonance imaging; NVB, neurovascular bundle; PCa, prostate cancer; PSA, prostate-specific antigen; PSM, positive surgical margin; R-LESS, robotic laparoendoscopic single-site surgery; RP, radical prostatectomy; SD, standard deviation; SHIM, sexual health inventory for men; SP-RARP, single-port robotic-assisted radical prostatectomy; US, ultrasound.

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da Vinci SP platform in 2019, and several additional studies on SP-RARP have since been reported.[6] However, most of these studies were performed by a limited number of specific groups. Therefore, the verification of their results by various operators is required. Herein, we report our initial experiences with SP-RARP, including the perioperative and early functional outcomes, with lessons learned from overcoming the learning curve.

2. Materials and methods

2.1. Data source and patient selection

We reviewed the medical records of 30 consecutive patients who underwent SP-RARP by a team of experienced surgeons and tableside assistants from June to November 2020. The operator had experience performing more than 600 RARPs using a multiport robotic system prior to the adoption of the SP platform. All patients had localized prostate cancer confirmed by magnetic resonance imaging (MRI)-ultrasound (US) fusion transperineal prostate biopsy.

2.2. Inclusion criteria and variables

The preoperative covariates included age at surgery, body mass index (BMI), comorbid conditions, preoperative Sexual Health Inventory for Men (SHIM) score, prostate-specific antigen (PSA) level, and MRI-US fusion transperineal biopsy Gleason score (GS) by MRI. The selection criteria for the learning curve were based on prior literature.[9] A prostate volume > 80 g, suspicious extraprostatic extension (EPE) on MRI, and BMI $\geq$ 35 kg/m^2 were excluded.

2.3. Endpoint

The present study aimed to report our initial experience with SP-RARP performed in 30 consecutive patients, including lessons from the learning curve that provided selection criteria for beginners learning the SP-RARP technique. We also aimed to report the safety and feasibility of SP-RARP through perioperative data, as well as data on complications, oncologic outcomes, and early functional outcomes including potency and continence.

2.4. Data collection and statistical analysis

We retrospectively reviewed perioperative data including operation time (total operation time/console time), estimated blood loss (EBL), and complications. The pathologic analysis included pathologic stage, nodal yield, number of positive nodes, extraprostatic extension (EPE), and positive surgical margins. The perioperative complications were categorized and analyzed according to the Clavien–Dindo classification. Early function outcomes were analyzed by continence outcome with the number of pads used/achievement days to continence and erectile function with SHIM scores. All statistical analyses were performed using IBM SPSS Statistics for Windows version 24.0 (IBM Corp., Armonk, NY, USA).

2.5. Definitions of terms

2.5.1. Nerve-sparing classification

1. Bilateral full nerve sparing: Complete bilateral preservation (> 95%)
2. Unilateral full and contralateral partial nerve sparing: > 95% preservation on one side and 50–95% preservation on the contralateral side
3. Bilateral partial: 50–95% bilateral preservation

2.5.2. Postoperative continence and potency

We defined continence as the use of no pads and potency as the ability to achieve and maintain an erection for successful intercourse (SHIM questions 2, 3: achieve and maintain erection for intercourse more than half the time with or without the use of oral phosphodiesterase type 5 inhibitors.)

2.6. Steps of SP-RARP

2.6.1. Trocar placement and docking technique

We used the single-incision plus one port method. A supraumbilical 3 cm vertical incision, 20 cm from the symphysis pubis in the midline was performed to place the SP multichannel port under direct vision with Hasson's technique with the patient placed in the supine position. An additional 12 mm-port was placed for the tableside assistant's use in the right lower abdominal quadrant. The SP robot was then side-docked with the patient in a full-range Trendelenburg position (24° to 26°). The scope was placed at the 12 o'clock position and angled to target the field of operation. All instruments were then inserted with the bipolar forceps at the 9 o'clock position, Cadiere at the 6 o'clock position, and scissors at the 3 o'clock position (bipolar-Cadiere-scissors).

2.6.2. Surgical technique

1. We started with the instruments in the positions described above (bipolar-Cadiere-scissors) and a neutral straight position of the scope for bladder dropping and developing the Retzius space.
2. After bladder neck identification with movement of the Foley catheter balloon and recognition of the cessation of vesicoprostatic fat, dissection of the anterior and posterior bladder wall was performed.
3. For dissection and exposure of the seminal vesicle and Vas deferens, the position of the instrument sat the 6 and 9 o'clock positions (bipolar and cadiere) were changed to retract the Foley catheter. The bipolar and scissors were used to dissect the vas deferens and seminal vesicles while minimizing thermal damage, with the assistant applying the clips for athermal ligation (Fig. 1).
4. Next, we developed the plane between the prostate and rectum and the interfascial plane for neurovascular bundle (NVB) retrograde early release and preservation with the toggling technique. After releasing the Denonvilliers' fascia, the scope was deflected into an upward angulation facing the posterior aspect of the prostate for toggling. Dissection was performed between the posterior aspect of the prostate and the medial side of the NVB (toggling technique) (Fig. 2).
5. After toggling for early retrograde NVB release, the scope was deflected into a downward angulation facing the posterior. The endopelvic fascia was opened sharply and minimally. After exposing the lateral prostatic fascia, it was dissected from the NVB through the interfascial plane. After penetrating and tunneling to the previously dissected Denonvillier space, the NVB was separated using a sweeping motion and H-lok, which was clipped by the assistant through an additional 12-mm port. We performed NVB preservation and pedicle control based on the athermal retrograde early release of the NBV (Fig. 3).
6. We next performed apical dissection and sutured the Santorini plexus. In this step, we preserved the anterior apical attachments of the prostate through modified apical dissection. We transected the Santorini plexus and sutured it with a 2–0 barbed running suture (Quill®).
7. Finally, the urethra was transected with maximum urethral length. Bladder neck reconstruction and posterior reconstruction were performed using a 2–0 barbed suture (Quill®). Vesicourethral anastomosis was also performed with a running 2–0 bidirectional barbed suture (Quill®). Anterior reconstruction was also performed with 2–0 barbed sutures (Quill®).

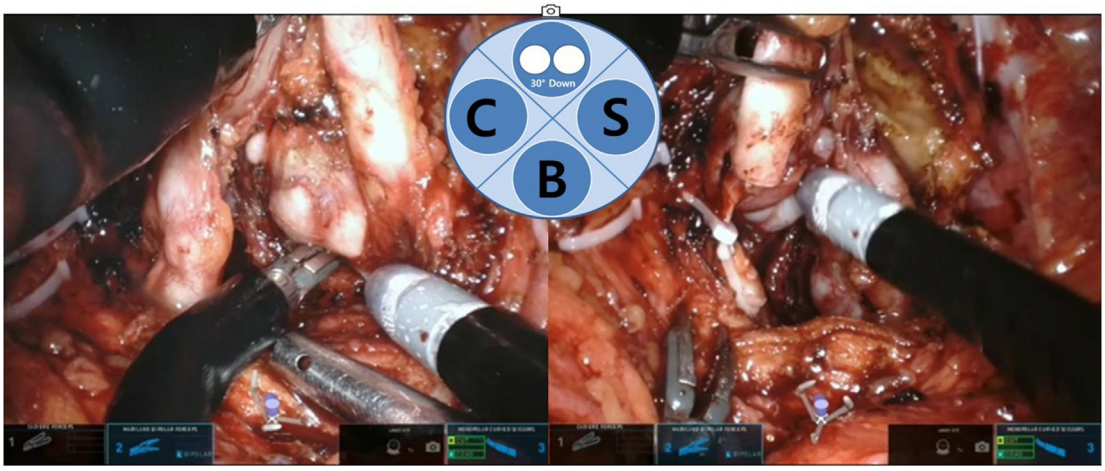

Fig. 1. Athermal dissection of the seminal vesicles.

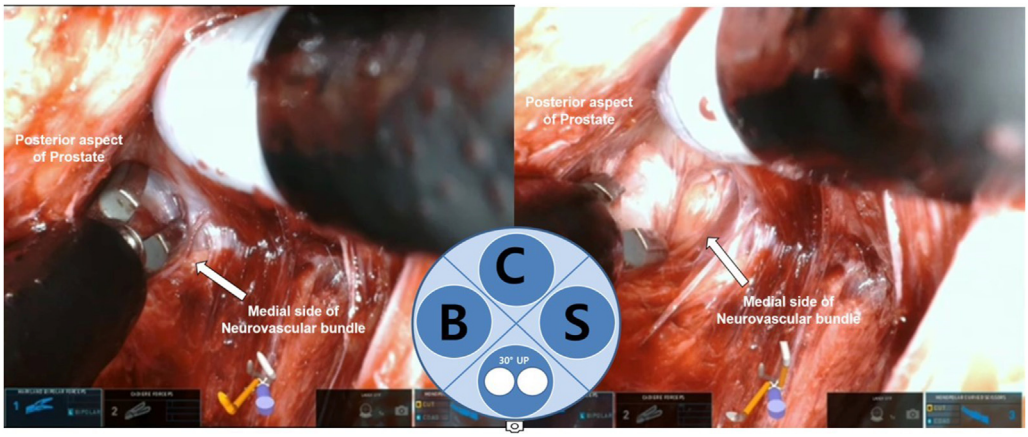

Fig. 2. Neurovascular preservation with the toggling technique.

3. Results

Data were obtained from the initial 30 cases of SP-RARP performed by a team of surgeons and tableside assistants experienced in multiport robot-assisted radical prostatectomy (MP-RARP) between June and November 2020.

3.1. Patient demographics

The mean patient age and body mass index (SD) was 68.7 (7.4) years and 24.7 (5.2) kg/m^2. The mean PSA level (SD) was 10.8 (6.5) ng/mL and the mean prostate volume was 33.9 (10.9) mL. The mean preoperative SHIM (SD) score was 10.5 (6.2); 11 of 30 patients had SHIM scores $\geq$17; the remainder had SHIM scores <17. Transperineal targeted and systematic prostate biopsy finding showed, twelve patients (40.0%) had grade group (GrGp)1, nine (30.0%) had GrGp2, two (6.7%) had GrGp3, six (20.0%) had GrGp4, and one (3.3%) had GrGP5. The mean (SD) hospital length of stay was 5.6 (1.8) days (Table 1).

3.2. Intraoperative evaluation

The total mean (SD) operative time was 142.8 (15.1) min, the total mean (SD) console time was 109.9 (15.7) min, the mean pelvic lymph node dissection time was 40.7 (11.3) min, and the mean (SD) EBL was 133.0 (72.9) mL (Table 2). There were no intraoperative complications or blood transfusions. In all, 19 patients (63.3%) had bilateral full nerve-sparing, while 11 (36.7%) had partial nerve-sparing.

3.3. Postoperative outcomes

The final pathology report showed that four patients (13.3%) had GrGp1, fourteen (46.7%) had GrGp2, nine (30.0%) had GrGp3, two (6.7%) had GrGp4, and one (3.3%) had GrGp5 (Table 3). Regarding pathological stages, 21 of 30 patients (70.0%) had pT2; the remaining (30.0%) patients had $\geq$ pT3 disease. The pathologist in this study defined a positive surgical margin (PSM) as resection margins involved by the tumor. Overall, five patients (16.7%) had a PSM (2 of 21 [9.5%] patients with stage pT2 and 3 of 9 (33.3%) with stage $\geq$ pT3). None of the patients had PSA recurrence during the short follow-up period.

3.4. Complications

Complications with SP-RARP were observed in three of 30 (10.0%) patients, all of which were minor (Clavien–Dindo classification 1–2). Two patients had mild hematuria (grade 1), and Foley catheter reinsertion was required in one because of retention after its removal at postoperative day 7. Serious complications necessitating readmission (Clavien–Dindo classification > 2) have not been reported (Table 3).

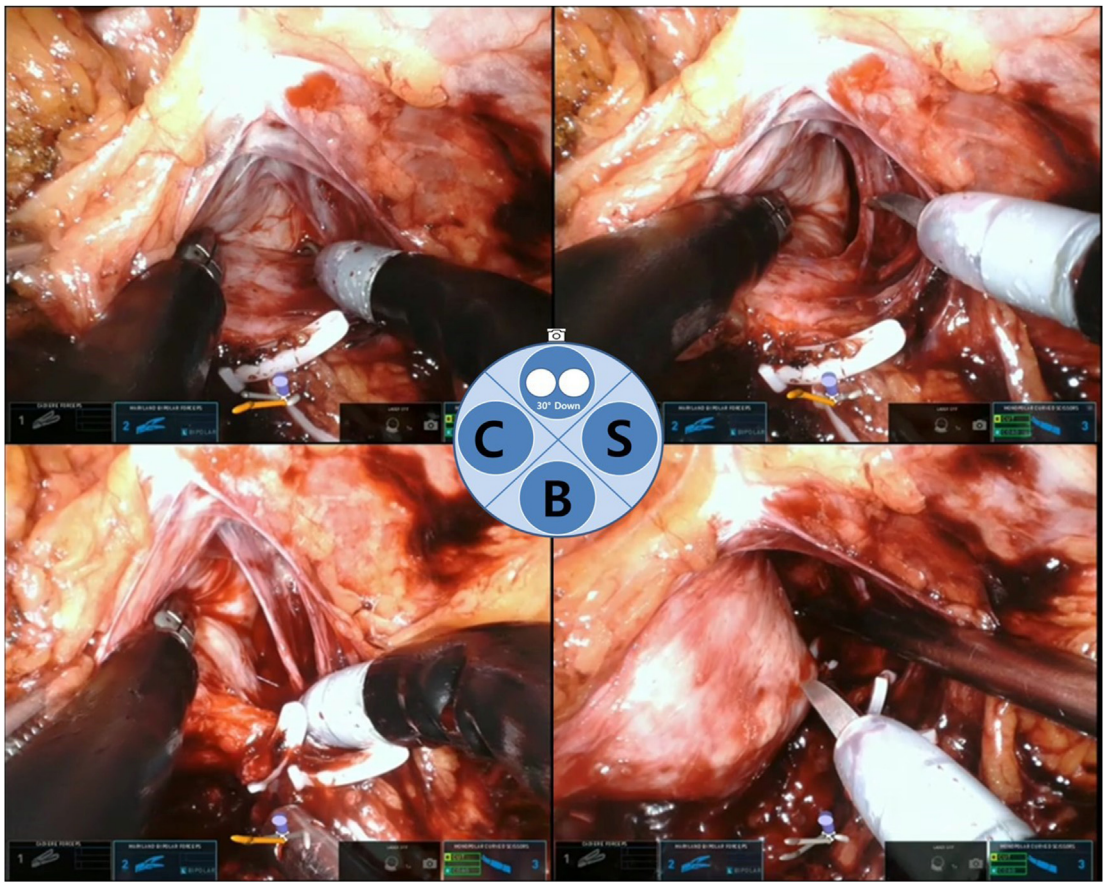

Fig. 3. Retrograde early release of the neurovascular bundle and pedicle control.

3.5. Learning curve

After the fifth SP prostatectomy, the operator had adapted to the new instrumentation and camera controls to manipulate the SP flatform, with temporal stability observed. Console time was affected by prostate size, severity of periprostatic adhesion and BMI. In specific, console times were increased compared to other patients in the fourth, eighth, eleventh, fifteenth, and twenty-seventh patient due to severe periprostatic adhesion, a large prostate volume (> 60g), and obesity (BMI > 30 kg/m^2), respectively (Fig. 4).

Table 1
Patient characteristics

Characteristics	Number	Mean (SD) or %
Number of cases	30	
Age, years		68.7 (7.4)
BMI, kg/m^2		24.7 (5.2)
PSA (ng/mL)		10.8 (6.5)
Prostate volume, mL		33.9 (10.9)
PSAD, ng/mL/g		0.32 (0.14)
Biopsy grade group[a)]		
1	12	40.0
2	9	30.0
3	2	6.7
4	6	20.0
5	1	3.3
Preoperative MRI		
PI-RADS score		
0, 1, 2	1	3.3
3	6	20.0
4	15	50.0
5	8	26.7
Suspicion of EPE	6	20.0
SHIM score		10.5 (6.2)
≥ 17	11	36.7
< 17	19	63.3

BMI, body mass index; DM, diabetes mellitus; EPE, extraprostatic extension; HTN, hypertension; PSA, prostate-specific antigen; PI-RADS, prostate imaging reporting and data system; SHIM, sexual health inventory for men.
[a)] Biopsy grade groups: 1 = Gleason 6 (or less), 2 = Gleason 7 (3 + 4), 3 = Gleason 7 (4 + 3), 4 = Gleason 8, 5 = Gleason 9 or 10.

3.6. Early continence outcomes

According to the patient's visit schedule after SP-RARP, continence outcomes were evaluated at 7 days, 1 month, and 3 months after discharge. The average length of hospitalization was 5 days.

Table 2
Intraoperative outcomes

	Value (SD; range)
Operative time, min	
Total console time[a)]	109.9 (15.7; 95–158)
Total operative time[a)]	142.8 (15.1; 129–187)
PLND time	40.7 (11.3; 28.7–52.9)
Neurovascular bundle sparing, n (%)	
Bilateral full nerve sparing	19 (63.3)
Partial nerve sparing	11 (36.7)
Unilateral full and contralateral partial	4 (13.3)
Bilateral partial	7 (23.3)
Total EBL, mL	133.0 (72.9; 40–280)
Drain, n (%)	4 (13.3)

EBL, estimated blood loss; PLND, pelvic lymph node dissection; SD, standard deviation.
[a)] Time except for PLND.

Table 3
Postoperative outcomes

	Number (%)
Pathologic outcomes	
Pathologic grade group[a)]	
1	4 (13.3)
2	14 (46.7)
3	9 (30.0)
4	2 (6.7)
5	1 (3.3)
Stage	
pT2	21 (70.0)
pT3a	7 (23.3)
pT3b	2 (6.7)
PSM	5 (16.7)
≤ pT2c	2 (9.5)
≥ pT3	3 (33.3)
Lymphadenectomy	7 (23.3)
Positive node	0 (0.0)
Extraprostatic extension	7 (23.3)
Lymphovascular invasion	6 (20.0)
Seminal vesicle invasion	1 (3.3)
Complications[b)]	
Grade 1	2 (9.5)
Grade 2	1 (3.3)

PSM, positive surgical margin.
[a)] Grade groups: 1 = Gleason 6 (or less); 2 = Gleason 7 (3 + 4); 3 = Gleason 7 (4 + 3); 4 = Gleason 8; 5 = Gleason 9 or 10.
[b)] Complications: No cases were classified as grade 3 on the Clavien–Dindo classification.

On the first visit (day 7), 15 patients (50.0%) showed full continence (no pads used). Nineteen patients (63.3%) achieved full continence at the one-month visit. Overall, 24 patients (80.0%) achieved full continence at 3 months (Table 4).

3.7. *Erectile function outcomes*

Of the 30 patients, 11 (36.7%) and 19 (63.3%) had preoperative SHIM scores of ≥ 17 and < 17, respectively. At 5–6 weeks after SP-RARP, six patients showed potency (20%; however, only 13 of 30 patients underwent evaluation for potency by themselves). At 12–13 weeks after SP-RARP, 14 patients (46.7%) were potent (among the 21 of the 30 patients who underwent assessment for potency by themselves) (Table 4).

4. Discussion

The first case of SP-RARP (prototype) was reported in 2014 by Kaouk et al.[8] After receiving approval from the US Food and Drug Administration (FDA), various case series have reported the intraoperative and early functional outcomes of SP-RARP.[10-12]

A meta-analysis by Checcucci et al of six published studies in the intraoperative outcomes of SP-RARP demonstrated its safety and feasibility.[7] The mean operative time was 190.55 min, EBL was 198.4 mL, and the PSM rate was 15%. The intraoperative complication rate was almost zero. In addition, postoperative complications of two or more according to the Clavien–Dindo system were reported in 15% of cases, with only one instance of urinary leakage and a major complication (transient ischemic attack) recorded. Based on the published literature on pathologic outcomes, the overall positive margin rate is 33%.[7] However, most of these studies were performed by a few specific groups. Thus, the verification of these results by various operators is required. We report our initial experiences, and lessons from the learning curve, including selection criteria for beginners initially performing SP-RARP.

The present study performed SP-RARP in 30 cases, in whom the procedure was performed without any serious complications, even in our initial experience. The intraoperative outcomes were also safe and feasible. The reported PSM rate of MP-RARPs was 25.1%.[13] The PSM rate in the present study was 16.7% (2 of 21 [9.5%] patients with stage pT2 disease and 3 of 9 [33.3%] with stage ≥ pT3 disease), a rate comparable to that for MP-RARPs. Moreover, 80% of patients in this study achieved full continence and 46.7% showed potency recovery at 12 weeks after the SP-RARP. In terms of these functional outcomes reported in the published literature for SP-RARP, the 12-week continence and potency recovery rates were 55% and 42%, respectively.[7] The results from our initial experience with SP-RARP support its safety and feasibility, with perioperative and early functional outcomes comparable to those of the established multiport system. In addition, an SP approach could reduce pain and has clear merits in terms of cosmetic aspects.[14,15] We observed no major difficulties in using the SP system at the same level as the multiport regarding suturing; thus, prostatectomy using the SP system complements the drawbacks of the existing R-LESS. Therefore, these findings provide a basis for the use of SP-RARP.

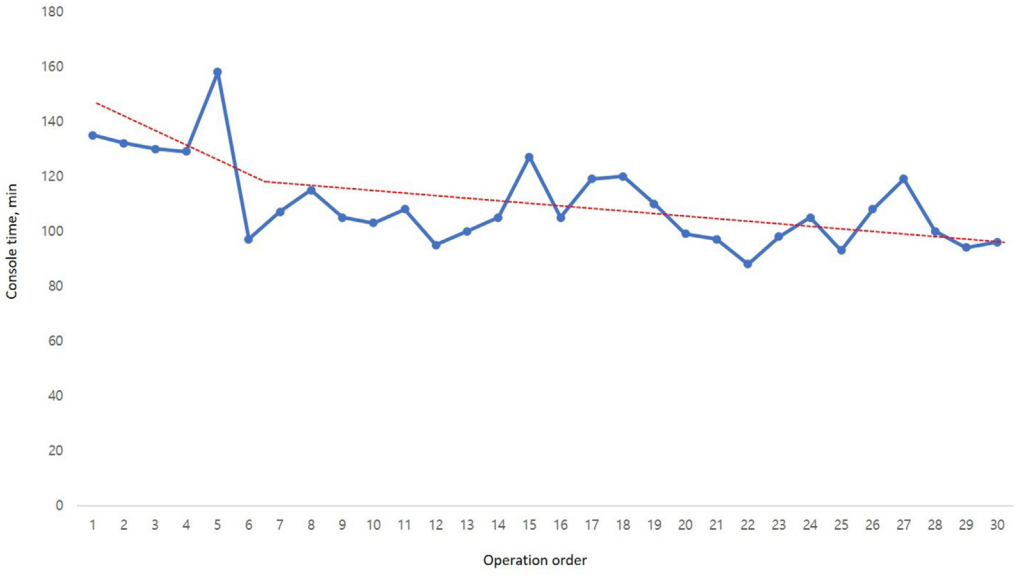

Fig. 4. Console time.

Table 4
Early functional outcomes

	First visit (2 weeks)	Second visit (6 weeks)	Third visit (12 weeks)
Continence, n (%)	15 (50.0)	19 (63.3)	24 (80.0)
Potency, n (%)	-	6 (20.0)	14 (46.7)
SHIM score ≥17 ($n = 11$)	-	4 (36.7)	8 (72.7)
SHIM score <17 ($n = 19$)	-	2 (10.5)	6 (31.6)

SHIM, sexual health inventory for men.

Moschovas et al reported that the SP system requires a longer working distance and a wide working space for the use of a double-articulated wrist. In addition, they described several concerns regarding SP-RARP; for example, it is difficult to retract the structures with appropriate traction due to reduced grip and dissection strength and in tissue dissection owing to reduced sweeping motion and strength; thus, NVB release may be difficult. When adopting the new SP platform, we attempted to perform high-quality radical prostatectomy while maintaining patient safety. The SP platform requires constant use of the relocation pedal to target the operative field. It is necessary to adjust the system using a relocation pedal while maintaining all instruments in sight to avoid potential injury. The SP platform was adopted after sufficient experience with multiport RARP and the surgeon-led procedure training program supported by the sponsor (Intuitive Surgical). We believe that the description of our technique will aid in the successful adoption of the SP platform. Therefore, a learning curve is required to rotate and position the arms during different surgical steps.[16] We believe that the description of our technique will aid in the successful adoption of the SP platform.

To our perspectives, there are limitations in the range motion of the joint and a lack of sweeping power compared to the multiport system. These limitations may become more significant in patients with high BMI, large prostate, and high oncologic stage. In another study, Moschovas et al also reported selection criteria for SP-RARP including low BMI, medium or small-sized prostate, and medium- or low-volume oncological disease.[9] The limited range of motion and lack of grasping and sweeping strength in cases with large prostate size may require repositioning of the arms for holding and effective traction; these procedures may result in increased operative times and insufficient space to perform the procedure. The range of motion and sweeping power of the SP arms may be insufficient for NBV preservation through the toggling technique and retrograde early release of NBV. The third arm maintained traction on the prostate and seminal vesicles while developing the plane between the prostate and rectum and toggling for further Denonvilliers' space dissection and NVB preservation. During this procedure, there is a limit to the distance between both arms performing dissection and the third arm holding the prostate. We could recognize this limitation in motion ranges using an alarm during system navigation. Several complex factors may influence nerve sparing and postoperative potency (e.g., periprostatic adhesion, PCa stage, and medical history of pelvic radiation or previous pelvic surgery). Moreover, the limitations in the range of arm motion and weak arm strength of SP platform may have influenced the NVB dissection. As NVB preservation is a reliable predictive factor for postoperative potency[17], a comparative study of single- and multi-port RARPs to investigate these aspects of the SP platform will be necessary.

Based on our initial experience and lessons learned from overcoming the learning curve, we suggested the following criteria for surgeons first performing SP-RARP: 1) small prostate size (< 60 cc), 2) patient BMI < 30 kg/m^2, and 3) clinical stage < T3. In addition, it is advised to avoid performing SP-RARP in patients with a medical history of prostatitis, pelvic radiation or previous pelvic surgery which are known factors for severe peri-prostatic adhesion.

A small number of specific groups have applied the SP system in a limited number of patients and with relatively short follow-up periods to assess the long-term outcomes. We also selected suitable patients among all candidates for our initial experience with the SP approach. Regarding intraoperative and perioperative outcomes, larger and more well-designed comparative studies between SP and MP are required. Technological development could lead to improvement in not only the quality of the operations but also the quality of life (QOL) including pain and cosmetic aspects after surgery. These reports of developments and applications to SP-RARP could also provide the basis and clues to improve the oncological, functional outcomes, and QOL of patients with PCa.

SP-RARP can be performed safely and feasibly by operators with sufficient MP-RARP experience, in whom the learning curve does not require as many (5) cases. However, additional well-designed comparative studies are required.

5. Conclusion

SP-RARP can be performed safely and feasibly by operators with sufficient MP-RARP experience, in whom the learning curve does not require as many (5) cases. However, additional well-designed comparative studies are required.

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Conflicts of interest

The authors have no conflicts of interest to disclose.

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