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ORIGINAL ARTICLE

Intraoperative Complications and Perioperative and Surgical Outcomes of Single-Port Robotics-Assisted Sacrocolpopexy

Sumin Oh[1,2] · Johnny Yi[3] · A.-young Song[1] · Junghyun Jee[1] · Nayoung Bae[1] · Jung-Ho Shin[1,2]

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Abstract

Introduction and Hypothesis The objective was to assess intraoperative and postoperative complication rates, along with perioperative and surgical outcomes, following single-port robotics-assisted sacrocolpopexy.

Methods This retrospective case series included 200 patients who underwent single-port robotics-assisted sacrocolpopexy to treat Pelvic Organ Prolapse Quantification (POPQ) stage 2–4 symptomatic prolapse between April 2020 and August 2023 by a single surgeon. Intraoperative and postoperative complications and perioperative outcomes were evaluated for all the patients, whereas surgical outcomes for 74 patients were assessed at 1-year follow-up. Surgical failure was defined as the presence of any of the following: the presence of vaginal bulging symptoms, any prolapse beyond the hymen, or retreatment for prolapse.

Results During the study period, 200 single-port robotics-assisted sacrocolpopexies were performed. The median age and body mass index were 65.0 years and 24.6 kg/m^2 respectively. Most patients had POPQ stage 3 or 4 prolapse and underwent concomitant total hysterectomy. The median total operation time was 212.0 min, and none of the patients required conversion to laparoscopy or laparotomy. The intraoperative cystotomy rate was 2.5%, and one patient had a blood transfusion owing to presacral vessel injury. Postoperative complications of mesh exposure and wound hernia were 0.5% and 2.0% respectively. At 1 year postoperatively, the rate of composite surgical failure was 9.5%, with a 5.4% anatomical recurrence rate. None of the patients experienced apical prolapse recurrence, and one received anterior colporrhaphy for anterior compartment prolapse recurrence.

Conclusions Single-port robotics-assisted sacrocolpopexy is safe and effective, with low complication rates and favorable perioperative and surgical outcomes.

Keywords Pelvic organ prolapse · Robotic surgery · Sacrocolpopexy · Single-port surgery

Introduction

Robotics-assisted surgery (RAS) has been adopted quickly around the world as a route of minimally invasive gynecological surgery [1, 2]. According to the 2022 annual report of Intuitive Surgical Korea, gynecological procedures constitute approximately 23% of RAS worldwide and 34% in South Korea. Since the Korea Ministry of Food and Drug Safety cleared the da Vinci SP® system (da Vinci SP®, Intuitive Surgical, Sunnyvale, CA, USA) for gynecological surgery in 2018, a total of 5,500 single-port robotics-assisted surgeries had been performed in 2022, 37% of which were gynecological procedures. The single-port robotics platform is a novel platform that allows for intra-abdominal robotics-assisted surgery using up to three articulating arms and an articulating camera, through a 2- to 3-cm incision. Published reports of gynecological procedures using the SP® platform include hysterectomy, myomectomy, ovarian cystectomy, and sacrocolpopexy (SCP) [2–5]. In terms of SCP, the cumulative use of the SP® system in Korea increased from 9 to 252 between 2019 and 2022.

Literature evaluating the outcomes of single-port robotics-assisted SCP are very limited, necessitating an evaluation

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Editor in Chief: Maria A. Bortolini

✉ Jung-Ho Shin
lateroman@gmail.com

1 Department of Obstetrics and Gynecology, Korea University Guro Hospital, Seoul, Korea

2 Department of Obstetrics and Gynecology, Korea University College of Medicine, 148 Gurodong-Ro, Guro-Gu, Seoul 08308, Republic of Korea

3 Department of Medical and Surgical Gynecology, Mayo Clinic Arizona, Phoenix, AZ, USA

of this new platform for pelvic reconstructive surgery. We therefore report our initial experience of single-port robotics-assisted SCP, detailing its intraoperative and postoperative complication rates, along with perioperative and surgical outcomes.

Materials and Methods

Patients and Data Collection

With the approval of our institutional review board for this retrospective cohort study, we reviewed the medical charts of 200 consecutive female patients who underwent single-port robotics-assisted SCP to correct Pelvic Organ Prolapse Quantification (POPQ) stage 2–4 symptomatic prolapse at Korea University Guro Hospital, between April 2020 and August 2023. Intraoperative and postoperative complication rates and perioperative outcomes were analyzed for all 200 patients. Surgical outcomes were evaluated for 74 patients who completed at least 1 year of follow-up.

All examinations and operations were performed by a single specialist. Preoperatively, all patients provided a complete medical history, and underwent POPQ examination in a 45° upright sitting position with an empty bladder. All patients had POPQ stage 2 or greater symptomatic prolapse and underwent single-port robotics-assisted SCP using the da Vinci SP® system.

Standard postoperative care for robotics-assisted SCP included an in-patient hospitalization with urinary catheter removal and an active voiding trial on postoperative day 2. Successful spontaneous voiding was defined as having < 100 ml of residual urine on at least two repeated measurements using a bladder scanner. Scheduled in-person postoperative follow-ups were conducted at 1, 3, and 12 months, and then yearly thereafter. At each visit, the patients underwent a POPQ examination and a speculum examination to evaluate for anatomical support and mesh complications. All patients were asked about vaginal bulge symptoms and any other subjective complaints at every visit. Intraoperative complications included adverse events, such as visceral injuries (i.e., cystotomy) or presacral hemorrhage. Perioperative outcomes included estimated blood loss (EBL), total operation time (from incision to closure), and length of hospital stay, in order to reflect the safety or short-term morbidity of the surgery. Concomitant procedures (i.e., hysterectomy and/or colporrhaphy), when performed, were included in the total operation time. Surgical failure was defined as the presence of any of the following: vaginal bulge symptoms, any prolapse beyond the hymen, or retreatment for prolapse (i.e., pessary or re-operation).

Statistical Analysis

Data were analyzed using R software and its necessary packages (R Foundation for Statistical Computing, Vienna, Austria). Baseline characteristics of the study population, number of intraoperative adverse events, perioperative outcomes, and surgical failure rates were assessed via descriptive analysis. Data normality was assessed using the Shapiro–Wilk test.

Surgical Techniques

The surgical technique has been described in previous studies [6, 7]. In brief, the procedure involved lifting the bladder upward using a Cadiere forcep docked on the left side, followed by vaginal dissection using a centrally positioned fenestrated bipolar forceps and right-sided monopolar spatula, guided by a spatula-shaped vaginal manipulator (Fig. 1). Anterior dissection was extended to the distal third of the vagina, and the posterior dissection descended to the level of the perineal body. Employing the retroperitoneal tunneling method, the dissection extended from 2–3 cm below the sacral promontory to the dissected pouch of Douglas (Fig. 2) [8]. A partially absorbable, lightweight, type I, polypropylene mesh (Seratex® PA B2 type; Serag-Wiessner KG, Naila, Germany) was used. The mesh was secured to the anterior and posterior vaginal wall with delayed absorbable barbed sutures (Monofix®; Samyang Biopharmaceuticals Corp., Seongnam-si, Republic of Korea) in a continuous running manner. The tail end of the mesh was anchored to the anterior longitudinal ligament at the S1 level with two interrupted sutures of non-absorbable Prolene® (Prolene 0; Ethicon).

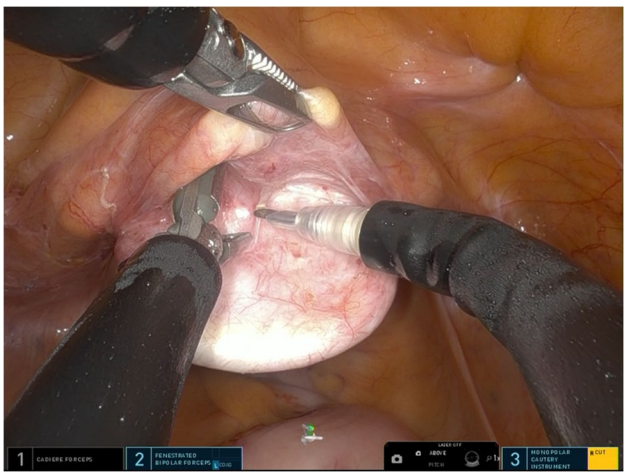

Fig. 1 Position of the equipment in the da Vinci SP® system. Cadiere forcep is lifting the bladder up on the left side (9 o'clock), and fenestrated bipolar forceps (6 o'clock) and monopolar spatula (3 o'clock) perform the dissection of the vesicovaginal space

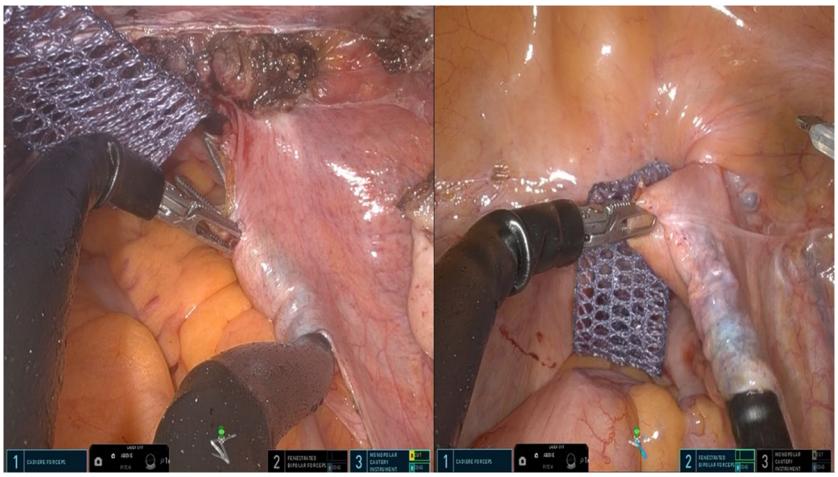

Fig. 2 Retroperitoneal tunneling method using multi-joint endo-wrist SP® equipment

Results

A total of 200 single-port robotics-assisted SCPs were conducted during the study period. The overall baseline characteristics of the study population are summarized in Table 1. The median age and body mass index of the total study population were 65.0 years and 24.6 kg/m$^{2.}$ respectively. Most patients had POPQ stage 3 and 4 prolapse and underwent concomitant total hysterectomy. Other concomitant procedures included 2 cases of subtotal hysterectomy, 7 posterior repairs, and 17 trans-obturator tape sling operations. Table 2 shows intraoperative complications and perioperative outcomes. The median operation time was 212.0 min, and the median duration of hospital stay was 3 days. Urinary catheter removal on postoperative day 2 and with discharge the day after catheter removal is the standard care for the study center after robotics-assisted SCP. Five intraoperative cystotomies were noted (5 out of 200, 2.5%), with 2 of them occurring during the dissection of the vesicovaginal space in cases of post-hysterectomy vaginal vault prolapse. All cystotomies were primarily repaired without changing the route of access. Other intraoperative adverse events such as bowel injury and vaginal wall tear were 1.0% and 2.0% respectively. Bowel injuries were all serosal in nature, and primary repairs were performed by the operating surgeon. SCP was completed in all cases and no infectious sequelae were noted. One patient required a blood transfusion as a result of presacral bleeding. None of the patients required conversion to laparoscopy or laparotomy.

Postoperative complications, which can be found outside the perioperative period, included wound hernia and mesh exposure. During the median follow-up duration of 4.2 (range 0.4—40.3) months, one mesh exposure was detected, which was managed conservatively with topical estrogen. Four patients were diagnosed with umbilical wound hernias, with one electing for surgical repair (Table 2).

To assess surgical outcomes, 74 patients who completed at least 1 year of follow-up were evaluated. Surgical failure rates at 1 year postoperatively are detailed in Table 3. The composite surgical failure rate was 9.5%, with 5.4% anatomical failure. No cases of apical prolapse recurrence were noted, whereas 3 cases

Table 1 Baseline patient demographics ($N=200$)

Characteristics	Values
Age, years	65.0 (59.0 to 69.0)
Vaginal parity	2 (2 to 4)
BMI, kg/m^2	24.6 (22.5 to 26.7)
Menopause	181 (90.5)
Diabetes	39 (19.5)
Prior hysterectomy	33 (16.5)
Prior prolapse surgery	14 (7.0)
Prior anti-incontinence surgery	13 (6.5)
Prior abdominal surgery	56 (28.0)
POPQ stage	
II	18 (9.0)
III	147 (73.5)
IV	35 (17.5)
POPQ values, cm	
Ba	1.5 (1.5 to 2.5)
C	0.0 (−1.0 to 2.0)
Bp	−1.5 (−2.0 to 0.0)
Concomitant procedures	
Total hysterectomy	163 (81.5)
Supracervical hysterectomy	2 (1.0)
Adnexal surgery[a]	183 (91.5)
Anterior repair	0 (0.0)
Posterior repair	7 (3.5)
Anti-incontinence surgery[b]	17 (8.5)

Values are presented as mean ± standard deviation, median (interquartile range) or number (%)

BMI body mass index, *POPQ* Pelvic Organ Prolapse Quantification

[a]Includes unilateral or bilateral salpingectomy and salpingo-oophorectomy

[b]All patients underwent trans-obturator tape operations

Table 2 Intraoperative and postoperative complications and perioperative outcomes ($N=200$)

Variables	Values
Intraoperative complications	10 (5.0)
Cystotomy	5 (2.5)
Bowel injury	2 (1.0)
Vaginal wall tear	4 (2.0)
Sacral vessel injury	1 (0.5)
Conversion to laparotomy	0 (0.0)
Perioperative outcomes	
Total operation time (min)	212.0 (189.8 to 236.0)
Transfusion	1 (0.5)
Hospital stay (days)	3 (3 to 4)
Postoperative complications	
Mesh exposure	1 (0.5)
Wound hernia	4 (2.0)

Values are presented as median (interquartile range) or number (%)

Table 3 Surgical outcomes among patients who completed 1 year of follow-up ($N=74$)

Variables	Values
Surgical failure[a]	7 (9.5)
Symptomatic recurrence[b]	7 (9.5)
Anatomical recurrence[c]	4 (5.4)
Ba > 0	3 (4.1)
C > 0	0 (0.0)
Bp > 0	2 (2.7)
Retreatment for prolapse[d]	1 (1.4)

Values are presented as number (%)

[a]Symptomatic or anatomical recurrence or retreatment for prolapse

[b]Presence of vaginal bulging symptoms at the interview

[c]Any prolapse beyond the hymen

[d]Refers to pessary insertion or reoperation for prolapse recurrence

of recurrent anterior prolapse and 2 cases of recurrent posterior prolapse were identified. One patient underwent re-operation for prolapse recurrence with anterior colporrhaphy, due to a stage 3 anterior vaginal wall prolapse 29 months after the index surgery.

Discussion

This study showed that the single-port robotic platform is a safe modality for performing SCP with a low intraoperative and postoperative complication rate and favorable perioperative outcomes. The data also support its efficacy, with an anatomical success rate of 94.6% at 1 year postoperatively with no apical recurrence.

To date, few articles have been published regarding single-port robotics-assisted SCP [2, 5, 6, 9–13], and most have been preliminary reports or video presentations. Lee et al. reported on their first 8 single-port robotics-assisted SCP cases in 2021, where they compared this approach with single-site robotics-assisted SCP under the da Vinci Xi® or Si® systems [5]. They also presented the outcomes of 20 single-incision robotics-assisted SCPs, with most (18 out of 20) performed using the da Vinci SP® system, and compared the outcomes with those of conventional multi-port robotics-assisted SCP [11]. In this report, the perioperative outcomes of single-port robotics-assisted SCP were favorable, with its total operation time (121 min), EBL (37 ml), and duration of hospital stay (2 days). They had 1 case of bladder injury that was primarily repaired during the operation, 2 cases of transfusion, and no prolapse recurrence beyond POPQ stage I at a follow-up of 4 weeks postoperatively. Although multi-port robotics-assisted SCP had a shorter operation time, all other perioperative and postoperative outcomes were equivalent between multi-port robotics-assisted SCP and single-port robotics-assisted SCP.

Oh et al. reported its safety and feasibility by comparing the outcomes of 57 single-site and 66 single-port robotics-assisted SCP, revealing no differences in overall intraoperative and perioperative outcomes [6].

Recently, Whitmyre et al. compared total operative time, and the number and severity of adverse events among single-port robotics-assisted SCP, multi-port robotics-assisted SCP, and laparoscopic SCP [13]. Interestingly, they found that based on the Clavien–Dindo grading system, laparoscopic SCP exhibited greater severity of adverse events than that of single-port robotics-assisted SCP, although the other outcome measures were similar. Despite the small study population in each group, their findings suggested that the novel technique in performing SCP was at least non-inferior to pre-existing methods. Although different surgical methods (i.e., supracervical vs total hysterectomy) or surgeon's proficiency may give rise to some discrepancies between study results, these four studies collectively demonstrate that single-port robotics-assisted SCP is comparable with other SCP modalities in terms of perioperative and postoperative outcomes.

In addition, Ganesan et al. demonstrated the use of magnetic retraction of the sigmoid colon during the single-port robotics-assisted SCP procedures to overcome the limited field and use of the third arm of the SP® system [9, 10]. The limited use of the third arm in retraction and mesh suturing in the SP® system, when all of the instruments are docked in the SP® trocar, sometimes requires an additional beds.de port, negating the truly single-port approach. They described three cases of single-port robotics-assisted SCP with magnetic retraction, with operative times ranging from 198 to 247 min, which are comparable with that of multi-port robotics-assisted

SCP. No conversion or change in the treatment plan and no 30-day complications were reported. There may be cosmetic and pain benefits to considering the single-port robotics-assisted platform, although further clinical studies are needed to assess these outcomes.

This study has several strengths. It presents to our knowledge the largest number of results for single-port robotics-assisted SCP reported in the literature thus far. Moreover, perioperative outcomes were coupled with medium-term 1-year prolapse outcomes of single-port robotics-assisted SCP, revealing a promising anatomical success rate. The inclusion of composite success rates, consisting of objective and subjective recurrence, offers greater clinical relevance than those with anatomical success alone.

Some limitations are present. Validated questionnaires were not utilized to assess prolapse outcomes. However, the patients were asked if they had vaginal bulging symptoms, which is known to be the most relevant question statement on the Pelvic Organ Prolapse Distress Inventory (POPDI)-6. Another limitation was that the operating surgeon was not blinded to the postoperative assessment; thus, the underestimation of surgical failure could be factored in. However, our results are comparable with those of other studies evaluating the SP® platform [5, 11]. In addition, among total 200 cases, 126 have been past 1 year postoperatively and only 74 women (58.7%) have returned for the 1-year follow-up. However, no inter-group differences were observed between the patients who returned and those who did not (data not shown); therefore, these may have had a limited impact on the outcome. However, longer follow-up data are still indicated.

The single-port robotics-assisted system has several limitations, such as decreased grip strength, and a limited range of motion, which may lead to instruments clashing. Further, the articulating scope is a new tool that surgeons using robotics-assisted techniques need to gain expertise in. However, multi-articulating instruments and a flexible scope are specifically suitable for performing SCP, which requires multiple sutures at various angles for the fixation of the mesh to the vaginal apex and the anterior longitudinal ligament of the sacrum. These instruments allow further access beyond the sacral promontory to permit safe attachment of the mesh at the S1 level to avoid the lumbosacral disk. The articulating scope also benefits from deep dissection into the posterior cul-de-sac. The advancements in multi-joint instruments compared with the prior robotics-assisted single-site platform and laparoscopic equipment are helpful for repetitive intracorporeal suturing with minimal collisions among instruments [6]. Comparative studies are still needed to evaluate benefits compared with the alternative minimally invasive techniques.

In conclusion, based on this large single-surgeon case series, single-port robotics-assisted SCP was found to be a safe and effective procedure for correcting apical prolapse, which may offer a less invasive approach. Collecting long-term data from a larger population and discussing the advantages and drawbacks of the state-of-the-art techniques should be continued, to investigate whether the single-port robotics-assisted SCP could possibly be the modality of choice.

Authors' Contributions S.O.: project development, data collection, data management and analysis, and manuscript writing; J.Y.:: data management and analysis, and manuscript editing; J.H.S.: project development, data management and analysis, and manuscript editing; A.Y.S., J.J., and N.B.: data collection. All authors approved the final manuscript.

Data Availability Data is available from the corresponding author upon reasonable request.

Declarations

Ethics Approval The study was approved by the institutional review board of Korea University Guro Hospital (2023GR0550) and informed consent was waived by the institutional review board because of the nature of the retrospective study.

Conflicts of Interest None.

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