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Systematic Review

Robotic Single-Port da Vinci Surgical System (SP1098) in Gynecologic Surgery: A Systematic Review of Literature

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Abstract

Background: Recently, new surgical systems less invasive than standard laparoscopy have been developed. Among these, robotic single site surgery is playing a pivotal role. In this field, the da Vinci SP (Single-Port) Surgical System (SP1098) is one of the newest surgical technology that presents innovative characteristics that may lead to better surgical outcomes. Few groups have already published their experience and results with this system in gynecology. **Methods**: The aim of the present systematic review was to provide a comprehensive overview of the status and applications of da Vinci SP1098 in gynecologic surgery. A systematic review of the literature was performed. Studies were identified until September 2022. **Results**: Six studies were included, reporting a total of 211 patients. The indication for surgery was both benign and malignant disorders. In terms of operative outcomes, the mean/median docking time varied from 2.1 to 5 min while mean/median operating time from 86.5 to 245 min. There was no conversion to multi-port laparoscopy or laparotomy and no major complications related to SP surgery. **Conclusions**: In conclusion, the preliminary and limited data available regarding the da Vinci SP1098 Surgical System suggest the technical feasibility and safety for its use in gynecologic surgery, with minimal alteration of the surgical technique.

Keywords: minimally invasive surgery; single-port surgery; robotic surgery

1. Introduction

In the last years, minimally invasive surgery has gained more and more ground in surgery. It has helped in reducing patients' scarring, morbidity, post-operative pain and hospitalization time [1,2]. It has been demonstrated by different studies that gynecologic procedures performed by endoscopic approaches have similar or improved outcomes when compared to laparotomic approaches [3,4]. Moreover, in the last decade, there has been an urge to develop new surgical systems with the aim to be less invasive than with standard laparoscopy. In this field, new techniques that employ laparoendoscopic single-port surgery (LESS) instruments were born [5]. LESS can be considered as a less invasive alternative to multiport laparoscopy. It comprehends a variety of surgical procedures that can be performed with one single surgical incision into which all instruments are inserted through one port. Single-port surgery provides better cosmetic outcomes and improved patient satisfaction. Moreover, even if LESS approach requires a revision of the surgical technique and may be challenging to adopt, its efficacy and safety in gynecologic surgery seems to be comparable to traditional laparoscopy [6], even if the surgical time seems to be prolonged. LESS presents some technical difficulties, such as limited movement of instruments, internal and external clashing between instruments, reduced ability to triangulate, ergonomic discomfort and poor visualization [7,8]. Robot surgical systems with optimized ergonomics can compensate for these limitations by improving visualization. Since 2009, robotic single site surgery using the da Vinci® Si or Xi system (Intuitive Surgical Inc., Sunnyvale, CA, USA) has been introduced into urological surgery [9]. Elsewhere, it was incorporated into gynecologic field since 2010 [10] and then it has been applied to a wide range of gynecological procedures for both benign and malignant indications [11,12]. Furthermore, some studies showed that robotic single site surgery is safe, and it has similar outcomes in terms of operative time, complications, and post-operative pain, when compared to traditional robotic surgery [13,14]. However, this platform has no EndoWrist technology and consequently some drawbacks were reported. These were mainly the clashing of the instruments with some limitations during the surgery [15]. The SP1098 da Vinci SP (Single-Port) Surgical System (Intuitive Surgical, Sunnyvale, CA, USA) is the last techno-

logic development in single port surgery, and it presents innovative characteristics that lead to better surgical performance. In 2019, the da Vinci SP1098 was approved by the Food and Drug Administration for urology and otolaryngology. Currently, few groups have published their experience and results with this system in gynecology. The aim of the present review is to provide a comprehensive overview of the status and applications of da Vinci SP in gynecologic surgery.

2. Materials and Methods

2.1 Sources and Study Selection

We conducted a systematic search following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, and this study protocol was previously registered with PROSPERO (CRD42023422995) [16]. This systematic review includes patients' information achieved from previously published studies. A comprehensive literature research was conducted in electronic database (MEDLINE, PubMed and Cochrane Library), from inception through September of 2022. The articles were identified with the use of a combination of the relevant heading term, key words, and word variants for: "Da Vinci Single Port", "SP1098", "gynecology", "gynecologic surgery". The electronic search and the eligibility of the studies were independently assessed by two of the authors (MA, PR). After the first selection, the authors evaluated the full-text copies of selected papers and separately extracted relevant data regarding study characteristics and outcomes. In addition, references in included articles were reviewed to identify additional eligible articles. Differences were discussed with a third author (SC).

2.2 Inclusion and Exclusion Criteria

We included all studies reporting surgical data about the use of da Vinci SP1098 platform in gynecological surgery. Studies evaluating other da Vinci robots or the use of da Vinci SP1098 in non gynecologic surgeries were excluded. Only full text papers were considered eligible for the inclusion. Non-English language articles were excluded.

2.3 Outcomes Measurement

The primary outcome was the feasibility of da Vinci SP1098 in gynecologic surgery, evaluating the rate of conversion to multi-port laparoscopy or laparotomy and complications related to single port surgery. The second outcome was the post-operative data. We have also analyzed the total number of cases and the characteristics of the patients. These were expressed as mean or median. We reported patients' characteristics including age, body mass index, previous history of abdominal surgery, and diagnosed disease. Data collection also included indication for surgery, kind of surgery, estimated blood loss, conversion to multiport robotic surgery or laparotomy and length of hospital stay. The docking time was defined as the time from driving the robot patient cart to the placement of robotic instruments through the port; whereas the operation time was the time from the skin incision to its closure. Clavien-Dindo classification system was used in grading intraoperative and postoperative complications [17].

3. Results

3.1 Study Selection

The first search, retrieved a total of 303 studies. 2/303 studies were excluded because of non-English language; 276/303 studies were excluded because they were about non-gynecologic surgeries; 19/303 studies were instead excluded because they were not specifically about da Vinci SP108. This selection, retrieved a final number of six studies (Prisma Flow Diagram, Fig. 1). Of the six identified studies, five were retrospective while one was a prospective observational study [18].

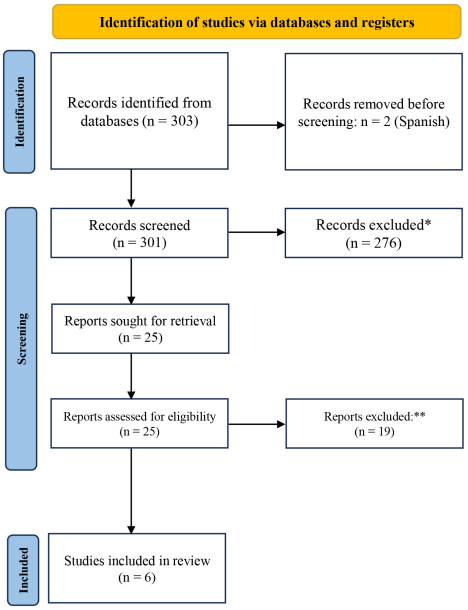

Fig. 1. Study selection flow diagram (in accordance with PRISMA 2020 flow diagram). *276 studies were excluded because, even if they regarded da Vinci Single Port, they were not about gynecologic field. **19 studies were excluded because they were not about da Vinci Single Port (they regarded other da Vinci robots instead).

One study was a comparative report: Lee *et al.* [19] compared two types of single-incision robotic sacrocolpopexy, single-site robotic sacrocolpopexy, using da Vinci Xi or Si system and single-port robotic sacrocolpopexy, using da Vinci SP. In our review, we have considered only the 9 cases of robotic sacrocolpopexy with da Vinci SP. All the studies were published between 2020 and 2022.

Table 1. Studies using the da Vinci SP system—patient and disease characteristics.

Study	Institution	Study design	N	Age (years) mean	BMI mean (kg/m^2)	Prior surgery	Indications	Procedures (number)
Shin HJ, *et al.* (2020) [22]	Ewha Womans University Seoul Hospital	Retrospective	31	47.7	22.7	15: TH, myomectomy, ovarian cystectomy for endometriosis, salpingectomy, C-section, and appendectomy	Uterine fibroid (18), Adenomyosis (1), Benign ovarian cyst (6), POP (6)	TH + AS (7), Hysteroscopy + AS, SCP (6), Hysteroscopy + AS, SCP, TOT 1), Myomectomy 6), Myomectomy + AS (5), Myomectomy + hysteroscopy (1), AS (3), AS + hysteroscopy (2)
Misal M, *et al.* (2020) [21]	Mayo Clinic, Arizona	Retrospective	8	46.3	27.8	5: C-section, ablation of endometriosis, salpingectomy and uterine artery embolization for fibroids	AUB (5), post-menopausal bleeding (2), risk reduction surgery (1)	TH + BS (3), MRH + BS + E (1), TH + BS + E (2), TH + BSO (1), TH + BSO + E (1)
Ganesan V, *et al.* (2020) [20]	University of Texas Southwestern	Retrospective	3	67.6	26.7	TH (3/3) Colporrhaphy (2/3)	POP	SCP
Lee SR, *et al.* (2021) [19]	University of Ulsan College of Medicine, Seoul Asan Medical Center	Retrospective	8	66.1	23.9	NR	POP	SCP
Lee JH, *et al.* (2022) [18]	Ewha Womans University Seoul Hospital	Prospective	61	38.5	22.7	10	Uterine fibroid	Miomectomy
Kwak YH, *et al.* (2022) [8]	Women's Cancer Center, Yonsei Can- cer Center in Seoul, Korea	Retrospective	100	37 (median)	21.5 (median)	14	Uterine fibroid (76), Adenomyosis (1), Benign ovarian cyst (2), Endometrial cancer (14), Cervical cancer (7)	Myomectomy (76), TH (2), Endometrial cancer surgical staging (14), RH (3), Radical trachelectomy (3), ovarian cystectomy (2)

SP, Single-Port; AS, adnexal sugery; AUB, abnormal uterine bleeding; BMI, body mass index; BS, bilateral salpingectomy; BSO, bilateral salpingo-oophorectomy; C-section, cesarean section; E, resection of endometriosis; MRH, modified radical hysterectomy; NR, not recorded; POP, pelvic organs prolapse; RH, radical hysterectomy; SCP, sacrocolpopexy; TH, total hysterectomy; TOT, Transobturator midurethral tension free vaginal tape insertion.

Table 2. Studies using the da Vinci SP system—primary outcomes and post-operative complications.

Study	Operative time mean (min)	Docking time mean (min)	Hospital stay mean (day)	Estimated blood loss mean (mL)	Need for conversion to LPT or MP	Post-operative complications	Follow-up (months)
Shin HJ, *et al.* (2020) [22]	126.3	2.2	4.6	93.9	None	1 (3.2%)	NR
Misal M, *et al.* (2020) [21]	86.5	NR	same-day discharge	37.5	None	2 (25%)	1.5
Ganesan V, *et al.* (2020) [20]	225.7	NR	1	23.3	None	None	1
Lee SR, *et al.* (2021) [19]	141.8	2.31	NR	71.25	None	2 (25%)	12
Lee JH, *et al.* (2022) [18]	149.9	2.1	4.5	NR	None	15 (24.6%)	NR
Kwak YH, *et al.* (2022) [8]	245 (median)	5 (median)	2.8	50 (median)	None	1 (1%)	NR

LPT, Laparotomy; MP, Multi-port laparoscopy; NR, not recorded.

3.2 Synthesis of Results

Six articles have been published about the use of da Vinci SP1098 robot in gynecologic surgery, yielding a total of 211 patients. Detailed patient demographics and operative results are presented in Table 1,2 (Ref. [8,18–22]). In all studies, except one [8], the data were reported as mean. The mean/median age of patients ranged from 37 to 67.6 years while the mean/median body mass index ranged from 21.5 to 27.85 kg/m^2. 47/203 women (23.1%) had a history of abdominal or pelvic surgery. Data regarding previous surgery was not reported in a study with a sample size of eight patients. In terms of operative outcomes, the mean/median docking time varied from 2.1 to 5 min while mean/median operating time from 86.5 to 245 min. The estimated blood loss was inferior to 100 mL in all series. The mean/median hospitalization time was reported in five manuscripts, and it was shorter than five days in all studies. Da Vinci SP1098 surgical system was used to perform single-port robotic surgery in both benign and malignant gynecologic disorders. Pelvic organ prolapse, uterine fibroid or abnormal uterine bleeding were the most common indications. The most commonly performed procedures were myomectomy, hysterectomy, adnexal surgery and sacrocolpopexy. Myomectomy was performed in 149 patients (70.6%), alone or in combination with other surgical procedures (6 cases). In many cases, the surgeons preferred to add one ancillary trocar to the single-port one. In most cases, the SP cannula as well as an additional assistant trocar was inserted through the GelSeal cap (Applied Medical, Rancho Santa Margarita, CA, USA). These studies demonstrated that da Vinci SP1098 gynecologic surgery was feasibile in 211 patients: no case of conversion to multi-port laparoscopy or laparotomy and major complications related to SP surgery were recorded. Only two (0.9%) intraoperative complications were recorded: a superficial bowel laceration due to severe adhesion from prior surgery [9] and an accidental bladder injury [19] that were both intraoperatively repaired. 21 (9.95%) postoperative complications were reported: one abdominal pain, one vaginal bleeding and two transient ileus, that were managed expectantly (Clavien-Dindo grade I); seven postoperative fevers and one wound complication that resolved with the use of antibiotics (Clavien-Dindo grade II); in 8 women, postoperative blood transfusions were needed (Clavien-Dindo grade II); in one patient, posterior vaginal wall mesh underwent erosion (Clavien-Dindo grade IIIa) and it was repaired under local anesthesia. The exposed mesh and the surrounding vaginal wall were excised wall, and then the vaginal wall was sutured. Only one postoperative wound complication (0.5%) was recorded. Precisely, the patient that had undergone myomectomy, was visited approximately one week after discharge and a small quantity of yellow discharge from the umbilical wound was noted. The wound was dressed using betadine and the women was treated with oral antibiotics for 5 days [8]. No case of incisional hernia was reported.

4. Discussion

The present review provides a summary of the available studies on single-port robotic surgery using da Vinci SP1098 system in gynecologic field. Robotic single site surgery was introduced in order to combine the advantages of LESS and robotic surgery. However, instruments clashing, and the unfavorable ergonomics of robotic single site surgery can be an issue for the surgeon [23]. Robotic single site surgery is characterized by several advantages compared to conventional LESS: better triangulation at the surgical site and improved ergonomics during surgery. In addition, the robotic platform provides three-dimensional visualization, a stable camera platform, fine movement, and tremor control [20–22]. Reducing number of ancillary trocars should decrease port site complications, such as herniation of the small bowel and obstruction through the 8 mm robotic port sites. However, robotic single site surgery still presents some drawbacks, that are mainly the collision and clashing of instruments [24]. The da Vinci SP1098 platform is the last technologic development in single port surgery, and it presents innovative characteristics that overcome the limitations above-mentioned and expand the range of surgical applications. Indeed, this platform offers to the surgeon similar functionality as the da Vinci multiport platform, with the exception that 3 multiarticular wrist instruments and a hree dimensional high resolution (3D-HD) articulated scope are introduced through a single port. This technology

permits distal triangulation of the instrument, excellent internal and external range of movement and 360° access to multiple quadrants through a unique 2.5 cm skin incision [7,25,26] The da Vinci SP1098 system uses the same console of the da Vinci X and Xi systems. This console is already well known by many gynecologic sugeons, and this allows an easy transition to the da Vinci SP [25]. This system increases dexterity and range of motion, camera mobility and intracorporeal instrument triangulation [21], maintaining benefits of robotic single site surgery, i.e., a single scar with better cosmetic result and the potential for decreased pain. Even if our systematic review is based on a limited number of preliminary results, it suggests the technical feasibility of da Vinci SP1098 system in gynecologic surgery. Moreover, the available literature suggests that standard robotic and LESS skills are highly transferrable to the robotic single-port platform. According to these data, there was no conversion to alternative surgical modality and there were no complications related to SP1098 platform.

In our review, we analyzed five retrospective studies and only one prospective report. Lee *et al.* [18] conducted a prospective observational pilot study to evaluate the robotic-single port myomectomy using da Vinci SP platform. In our systematic review, the surgeries incorporated were heterogeneous with mean/median operating time from 86.5 to 245 min, so it was difficult to directly compare them with surgeries performed with different approaches. According to our review, the most commonly perfomed surgery with da Vinci SP1098 was myomectomy. Only in a few cases da Vinci SP1098 was used to treat oncological cases.

The only study that compares da Vinci SP1098 to other robotic platforms is the manuscript of Lee *et al.* [19]. They compared 40 cases of single site robotic sacrocolpopexy, using the da Vinci Xi or Si system, with 8 cases of sacrocolpopexy, using da Vinci SP. There were no differences in the mean operative time and in the console time between the two groups (135.3 $\pm$ 31.6 min *vs.* 141.8 $\pm$ 23.5 min; 94.6 $\pm$ 32.2 min *vs.* 89 $\pm$ 9.5 min, respectively). while the docking time and cervix suturing time were shorter in the da Vinci SP group ($p < 0.05$). However, after analyzing the initial 8 cases in each of the two groups, all surgical times except the cervix suturing time were shorter in the da Vinci SP group ($p < 0.05$) [19]. The docking time was decreased because placing a single multichannel robotic port reduced the port placement and docking time in comparison with deploying multi-arms Si and Xi robotic platforms [22]. Although a slightly larger skin incision of 2.7 cm was made in the SP group for the insertion of metallic trocar, there was no case of incisional hernia. Instead, there were two cases of incisional hernia in the single site group, but both patients were obese [19] and obesity is a well known risk factor for incisional hernia [26]. Kwak *et al.* [8] reported that the umbilical wound following single-port robotic surgery appeared similar to what they have observed for single-port laparoscopic surgery, although the incision was bigger (2.5 cm *vs.* 1.5 cm). Risk of incisional hernia might potentially be higher in patients that underwent single port robotic surgeries because of the larger fascial incision that is required for the port placement. However, data from the available literature do not show a higher incisional hernia risk in patients that underwent single port surgery compared to patients that underwent standard laparoscopy. In particular, the incidence of incisional hernia after single port laparoscopy ranges from 1.4% [27] to 7.2% [28]. However, it is important to note that the true incidence of incisional hernias remains largely unknown because most patients are asymptomatic and therefore do not seek medical evaluation. Moreover, no large data are available in the literature regarding the incidence of incisional hernia after robotic single site surgery. In our review, we recorded only one case of minor postoperative wound complication but no case of incisional hernia was reported. Perhaps, the short follow up did not allow this complication to be diagnosed.

Concerning the limitations of the SP1098 platform compared to the multiport robotic platform, as highlighted by Ganesan *et al.* [20], they are the limited surgical field (about 10–25 cm from the port), and restriction of possible movements when all the instruments are deployed. Other drawbacks are that the right angle produced by the elbow joint requires more workspace than the straight instruments, and this could be an obstacle when operating on large-sized uteri. Moreover, although an ancillary trocar can be used for procedures such as suctioning and irrigation, there is still difficulty with the movements of the assistant [22]. Most recently, a new single-port entry system, designed only for da Vinci SP1098, was introduced: the Uni-Port. It has four entry ports of different sizes that can accommodate one da Vinci SP cannula, one 10–15 mm-sized laparoscopic instrument, and two 5 mm-sized laparoscopic instruments at the same time [8].

The main limit of our review is that the data available in the literature are limited and they consist mainly of pilot studies, case series and case reports with a small number of cases and with a short follow-up. Moreover, only one comparative study has been conducted in gynecological surgery and no randomized control studies are present in the literature. Although a small number of cases were included in this review, the heterogenous patients' characteristics and miscellaneous surgeries performed are reflective of high-volume gynecology practices. Randomized prospective studies that compare da Vinci SP1098 system with conventional LESS or robotic multi-port surgeries are needed to evaluate the possible benefits of this innovative platform. Additional studies examining postoperative outcomes, surgical costs and prospective studies comparing this modality to traditional robotic surgery are needed.

5. Conclusions

The preliminary and limited data available in the literature on the use of da Vinci SP Surgical System (SP1098) seem to suggest its technical feasibility and safety for gynecologic surgery, with minimal alteration in surgical techniques.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

Conceptualization, MA and SC; methodology, GV; validation, AE, RG and LD; formal analysis, MA and SR; investigation, PR and GS; writing—original draft preparation, PR; writing—review and editing, SR and MA; supervision, GV. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

Not applicable.

Acknowledgment

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Conflict of Interest

The authors declare no conflict of interest. Stefano Cianci is serving as one of the Editorial Board members and Guest editors of this journal. Roberta Granese are serving as one of the Editorial Board members of this journal. We declare that Stefano Cianci and Roberta Granese had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to Christos Iavazzo.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/j.ceog5008158.

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