Obstetrics & Gynecology Science

Robotic single-site staging operation for early-stage endometrial cancer: initial experience at a single institution

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Objective

The aims of this study were to introduce surgical guidelines, and to evaluate the feasibility and safety of a robotic single-site staging (RSSS) operation for early-stage endometrial cancer.

Methods

Patients with a preoperative diagnosis of endometrial cancer (International Federation of Gynecology and Obstetrics stages IA to IB) from endometrial curettage and preoperative imaging studies were selected at Dongsan Medical Center from March 2014 to November 2015. All surgical procedures, including hysterectomy, salpingo-oophorectomy, bilateral pelvic node dissection, and cytology aspiration, were performed by robotic single-site instruments (da Vinci Si® surgical system; Intuitive Surgical, Sunnyvale, CA, USA).

Results

A total of 15 women with early-stage endometrial cancer underwent the RSSS operation. The median patient age and body mass index were 53 years (range, 37–70 years) and 25.4 kg/m^2 (range, 18.3–46.4 kg/m^2). The median docking time, console time, and total operative time were 8 minutes (range, 4–15 minutes), 75 minutes (range, 55–115 minutes), and 155 minutes (range, 125–190 minutes), respectively. The median retrieval of both pelvic lymph nodes was 9 (range, 6–15). There were no conversions to laparoscopy or laparotomy.

Conclusion

The RSSS operation is feasible and safe in patients with early-stage endometrial cancer. In this study, operative times were reasonable, and the surgical procedure was well-tolerated by the patients. Further evaluation of patients with early-stage endometrial cancer should be performed in large-scale comparative studies using the laparoendoscopic, single-site staging operation to confirm the safety and benefits of the RSSS operation for early-stage endometrial cancer.

Keywords: Single site; Single port; Robotic; Staging operation; Endometrial cancer

Introduction

Current trends in minimally invasive surgery are focused on decreasing surgical trauma through the elimination of incisions, which results in less postoperative discomfort, decreased hospital stays, improved cosmetic results, and less wound-related complications [1,2]. Laparoendoscopic single-site surgery (LESS) utilizes a minimal number of skin incisions to gain access to the abdominal or pelvic cavity. There has been an increase in the use of LESS for the management of gynecologic disease, even for the most advanced oncologic procedures. Park et al. [3] described the feasibility and efficacy of LESS on patients with early-stage endometrial cancer. In addition, some retrospective, multi-institutional studies described the use of single-incision laparoscopy for endometrial cancer staging and early-stage cervical cancer [4,5]. Advances in instrumentation are providing solutions to the technical challenges of LESS and encouraging reconsideration of the use of a single incision for laparoscopic surgery. However, despite being a more advanced surgical method, LESS presents various surgical challenges, including a limited range of motion due to the parallel angle of the surgical instruments, and the difficulty in manipulating a flexible camera and surgical instruments in a limited space through a small skin incision [6-8]. Therefore, robotic technology applied to LESS has been postulated to overcome these limitations [9,10]. In 2009, Kaouk et al. [11] reported the first successful series of single-site robotic procedures in humans; they noted an improved ability in intracorporeal dissecting and suturing because of the robotic semi-flexible instrument and the triangulation achieved by crossing the curved cannulas. A less-recognized benefit was the reduction in fatigue and strain for the operating surgeon [12]. These studies show that advanced technology used to perform operations in various surgical fields can be successful.

Many studies have reported the feasibility, safety, and efficacy of robotic-assisted, single-site surgery in benign gynecologic diseases [13-15]. However, few studies have used robotic-assisted, single-site surgery in gynecologic oncology. Preliminary studies that have evaluated the use of this technique for the management of malignant disorders in gynecology have demonstrated the feasibility of this approach [16].

Endometrial cancer is the most common malignancy of the female genital tract in the United States [17] and the third most common malignancy of the female genital tract in South Korea, and its incidence is rapidly increasing [18]. The standard surgical management for early-stage endometrial cancer is surgery, including a total hysterectomy, bilateral salpingo-oophorectomy, and pelvic and/or para-aortic lymph node dissection [19]. As mentioned previously, only a few reports about robot-assisted, single-site surgery in gynecologic oncology have been published. This study is a preliminary evaluation of a robotic single-site staging (RSSS) operation including pelvic node dissection at a single institution by a single surgeon. The aims of our preliminary study are to introduce surgical guidelines, and to evaluate the feasibility and safety of the RSSS operation on patients with early-stage endometrial cancer.

Materials and methods

1. Patients and basic characteristics

A total of 15 patients who underwent the RSSS operation between March 2014 and November 2015 in the Department of Obstetrics and Gynecology at the Keimyung University Dongsan Medical Center (Daegu, Korea) were included in this study. Prior to their operations, all patients were informed about the RSSS techniques, benefits, and related risks of possible laparoscopic or laparotomic conversion, and signed a written consent form.

Patients with a preoperative diagnosis of endometrial cancer (International Federation of Gynecology and Obstetrics stage IA and IB) by endometrial curettage or biopsy were selected. Inclusion criteria were as follows: 1) No evidence of metastasis to other organs in the preoperative imaging, 2) a uterus size smaller than 14 gestational weeks, and 3) well (G1) and moderately (G2) differentiated endometrioid endometrial cancer diagnosed by preoperative endometrial curettage or biopsy. The standard exclusion criteria used for any laparoscopic cancer surgery were applied, but there were no restrictions related to body mass index (BMI) or previous abdominal surgeries.

Perioperative and postoperative data were collected prospectively. Operative times were recorded electronically and were defined as the interval between the start of the incision to closure. In addition, the time it took to perform the following was recorded: 1) umbilical incision and single-port placement, 2) robotic docking, 3) surgeon console time, and

Obstetrics & Gynecology Science

Hyewon Chung, et al. Robotic surgery in endometrial cancer

4) vaginal cuff closure. The total operation time was calculated from setting time to console time. Intraoperative parameters included estimated blood loss, requirement for blood transfusion, conversion to multiport laparoscopy or laparotomy, and presence of drainage. Postoperative parameters included length of hospital stay, postoperative hemoglobin changes after 4 hours, and complications and presence of postoperative therapy according to the permanent biopsy. All patients were followed up at the outpatient clinic 2 weeks and 6 weeks after discharge.

2. Surgical technique

All RSSS operations were performed using a da Vinci Si® Surgical System (Intuitive Surgical, Sunnyvale, CA, USA). The surgical team consisted of the primary surgeon, the bedside assistant, and a robot system-dedicated scrub technician and circulating nurse. This single-site instrument is a multiple-channel single port composed of: a robotic, 8.5-mm, high-definition, and 3-dimensional (3D) endoscope; 2 types of curved robotic cannulas; and one 5-mm accessory cannula.

The patient was placed in the typical low-lithotomy position after induction of general anesthesia. The body of the patient was then positioned in the Trendelenburg position (at a 30-degree angle). A single 2.5-cm vertical periumbilical incision was usually made to the left of the umbilicus using an open Hasson approach. The left periumbilical incision provided an easier approach and resulted in less postoperative scarring. The lubricated single-site port was inserted into the abdominal cavity, and the lower rim of the single-site port was clamped using a traumatic Kelly forceps (AliMed, Dedham, MA, USA). After checking the other organs, a pneumoperitoneum was made with carbon dioxide at a pressure of 12 mmHg. A trocar for the camera and a 3D, 8.5-mm endoscope (30 degrees) were inserted carefully along the endoscopic cannula. The abdominal cavity was inspected to confirm the feasibility of the RSSS operation, and to verify any adhesion and/or obstacle for node dissection. The operator coagulated both salpinges before the uterine manipulation device was inserted to prevent the possibility of metastasis to other organs. After coagulating both salpinges, the 3D, 8.5-mm endoscope was removed. A Rumi® uterine manipulation device (Cooper Surgical, Trumbull, Connecticut, USA) was inserted to hold the cervix tight and enable efficient movement during the operation.

One 5×250-mm curved cannula (arm 2) was inserted through the designated lumen until the end of the cannula was visible in the visible field of the endoscope. While the other cannula (arm 1) was inserted using the same method as arm 2, the already inserted cannula was held by the assistant to prevent displacement. Lastly, the 2 curved cannulas were positioned in a cross position to avoid collision, and a monopolar hook (arm 2) and fenestrated bipolar grasper (arm 1) were placed in each arm of the cannulas for the right-handed surgeon (Fig. 1).

The assistant's 5-mm accessory cannula was inserted to perform several functions in the procedure: 1) suction and irrigation, 2) coagulation and cutting simultaneously by the LigaSure 5-mm blunt tip (Covidien, Minneapolis, MN, USA), and 3) insertion of V-loc™ 2-0 sutures (Covidien), which are unidirectional barbed sutures used exclusively with a straightened needle.

All steps of the RSSS operation were performed sequentially, from cytology aspiration to bilateral pelvic node dissection, type I hysterectomy (classification of radical hysterectomy by the Surgeons Committee of the Gynecologic Cancer Group, which was part of the European Organization of Research and Treatment of Cancer in 2007), and salpingo-oophorectomy. For the pelvic lymphadenectomy, the peritoneal space, located between the external iliac arteries and the round ligament and infundibulopelvic ligament, was opened by an incision along the external iliac vessel. After dissection of the internal and external iliac artery bifurcations, the ureter was retracted to the infundibulopelvic ligament site to prevent ureter injury. The external pelvic lymph nodes parallel to the

Fig. 1. Full view after completion of docking.

external iliac artery were carefully removed, avoiding injury to the external iliac vessel and the genitofemoral nerve beside the psoas muscle. For the internal pelvic lymphadenectomy, the obturator area was opened by retraction of the external iliac vein and medial dissection of the lymphatic tissues. The obturator nerve was identified downward of the lymphatic tissue, and the internal pelvic lymph nodes were carefully removed, avoiding obturator nerve injury. In the retroperitoneal space, careful dissection of the lymph nodes away from the ureter and vessels was accomplished using the monopolar hook and the fenestrated bipolar grasper (Fig. 2A). At this point in the operation, energy was used sparingly to avoid thermal injury of the ureter, vessels, and nerves. All retrieved pelvic lymph nodes remained in the ipsilateral retroperitoneal space until the hysterectomy was finished. The paravesical and pararectal spaces were gently opened. The round and infundibulopelvic ligaments were cut and coagulated with the 5-mm LigaSure via the assistant port. The uterine artery was ligated and secured by an endoclip. A colpotomy was circumferentially performed with the monopolar hook, and the specimen was delivered vaginally. After the hysterectomy, the remaining nodal tissue was placed in a sterile endoscopic bag through the vagina by the second assistant and extracted. Robotic instruments were then exchanged with the fenestrated bipolar grasper placed on the left arm (arm 1) and the needle driver on the right arm (arm 2), which was replaced with a long cannula (5×300 mm) for a stronger and more rigid suture. The vagina cuff was repaired with a continuous suture by V-Loc™ (Covidien), which is a unidirectional barbed suture, with a straightened needle in all patients (Fig. 2B and C). After all steps of the RSSS operation were completed, the peritoneum and fascia were repaired using absorbable sutures. The skin was closed using a liquid topical skin adhesive agent to lessen the scarring.

3. Statistical analyses
Statistics were primarily descriptive. The median and range were utilized for skewed data. Categorical data were presented as the number of patients and a percentage.

Results

A cytology aspiration, bilateral pelvic lymph node dissection, type I hysterectomy, and salpingo-oophorectomy were performed on all patients who underwent the RSSS operation.

The basic characteristics of the patients, and the perioperative and postoperative parameters are shown in Table 1. The median age of the women was 53 years (range, 37–70 years), and the median BMI was 25.4 kg/m^2 (range, 18.3–46.4 kg/m^2). Four of 15 (27%) patients had a history of previous abdominal surgery, which included cesarean sections, but there were no conversions to laparoscopy or laparotomy. In this study, no additional ports were used for the RSSS operation.

The median total operation time was 155 minutes (range, 125–190 minutes), and the total operation time was measured separately according to the time it took to perform each procedure. Table 2 shows each procedural time. The median console time was 75 minutes (range, 55–115 minutes), and the console time gradually shortened as the RSSS operations were performed (Fig. 3).

The median retrieval of both pelvic lymph nodes was 9 nodes (range, 6–15 nodes), and estimated blood loss was
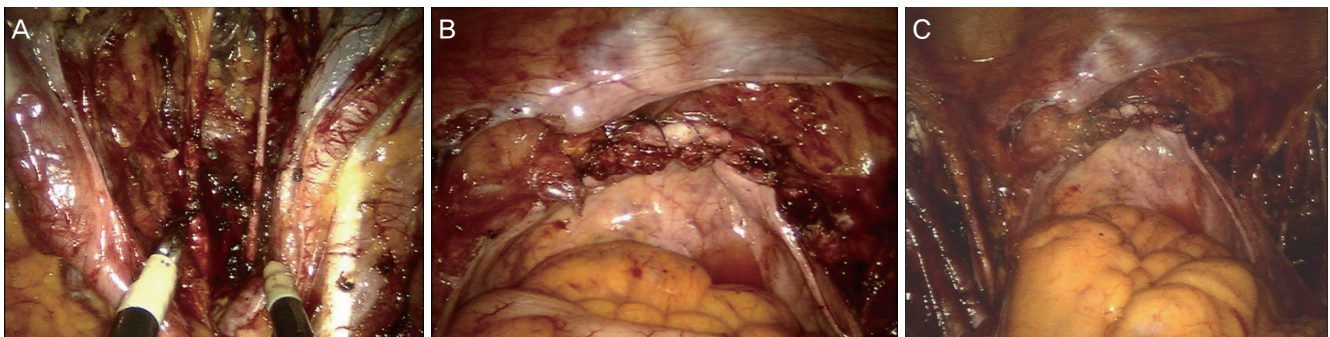

Fig. 2. (A) Careful dissection of the lymph nodes away from the ureter and vessels accomplished by the monopolar hook and the fenestrated bipolar grasper at the retroperitoneal space. (B) Completion of vagina cuff repair by continuous suture of V-Loc™ (Covidien, Minneapolis, MN, USA). (C) Full view after completion of full staging operation.

145 mL (range, 100–200 mL). Drainage was inserted into the pelvic cavity for the first 3 patients due to the possibility of postoperative bleeding. However, for the remaining patients, drainage was not inserted, and there were no complications associated with postoperative bleeding irrespective of the drainage insertion.

Table 1. Basic characteristic of patients and operative parameters of the study population

Parameter	RSSS operation (n=15)
Age (yr)	53 (37–70)
BMI (kg/m^2)	25.4 (18.3–46.4)
Previous abdominal surgery	4 (26.7)
Node retrieval	9 (6–15)
Biopsy confirmed surgical staging	
IA	13 (86.6)
IB	1 (6.7)
Over II	1 (6.7)
Estimated blood loss (mL)	145 (100–200)
Blood transfusion	0 (0)
Postoperative hospital stay (days)	3 (2–9)
Conversion to laparoscopy or laparotomy	0 (0)
Complications	
Major[a]	1 (6.7)
Minor[b]	0 (0)

Data are presented as medians (ranges) or number (%) unless otherwise specified.

BMI, body mass index; RSSS, robotic single-site staging.

[a]Major complications include hernia, bowel injury or ileus, vaginal cuff dehiscence, vaginal cuff infection, and vaginal bleeding and require surgical intervention or hospital readmission; [b]Minor complications include any event other than the major complications listed above.

Table 2. Procedural times

Duration of procedures (min)	RSSS operation (n=15)
Setting time	25 (15–35)
Preparation time	10 (4–20)
Docking time	8 (4–15)
Console time	75 (55–115)
Vaginal cuff closure time	11 (8–18)
Total operation time	155 (125–190)

Data are presented as medians (ranges).
RSSS, robotic single-site staging.

The median postoperative hospital stay was 3 days (range, 2–9 days). None of the patients required a transfusion. One patient had an incisional hernia diagnosed by a physical exam and computed tomography 5 months after the surgery. This patient was transferred to the general surgery department and received surgical treatment using bilayer mesh. The patient is now free of any symptoms regarding the incisional hernia.

According to the histological biopsy results, 4 patients required adjuvant therapy due to risk factors for recurrence and upstaging after the surgery. Among these, 3 patients received concurrent chemoradiation therapy with 6 cycles of cisplatin, and 1 patient received radiation therapy. These 4 patients finished all adjuvant therapy and continue to be disease free (Table 3).

Discussion

The RSSS operation is a new platform that has been used for benign gynecologic diseases. Compared with laparoscopic single-site surgery, the RSSS operation provides easier manipulation and makes an enhanced approach possible for the operator.

We performed the RSSS operation with pelvic node dissection on patients with gynecologic malignancies, especially those with low-risk early-stage endometrial cancer. Sinno et al. [20] reported a single-site robotic sentinel lymph node biopsy and hysterectomy in endometrial cancer and discussed the possibility of using the RSSS operation in this type of cancer. In a large-scale study, Vizza et al. [21] described the
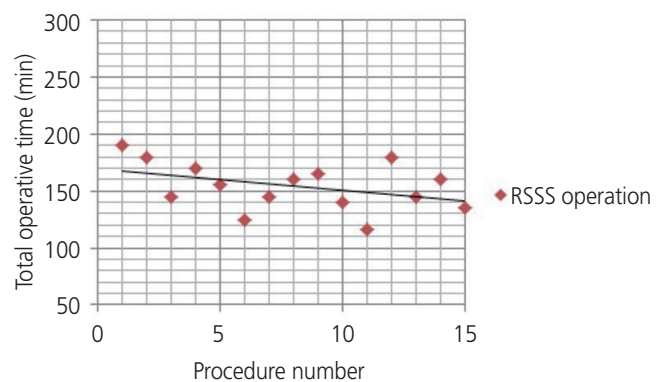

Fig. 3. Total operative time by chronological procedure number. RSSS, robotic single-site staging.

feasibility of a robotic single-site hysterectomy in 15 patients with low-risk endometrial cancer. However, their internal protocol showed that a lymph node dissection was not performed. The aims of our study were to evaluate the feasibility of the RSSS operation with lymph node dissection in patients with early-stage endometrial cancer, and to suggest surgical guidelines for node dissection using a robotic single-site platform.

All RSSS operations were accomplished successfully without additional port insertions or conversions to a laparotomy or laparoscopy. There was no exclusion criterion related to BMI in the selection of patients, since the robotic surgical platform was developed for obese patients. There were no perioperative complications regarding patient 12, who had a BMI of 46.44 kg/m².

We believe that there are 2 surgical difficulties in performing the RSSS operation on patients with endometrial cancer. The first is efficient node dissection. In this study, a bilateral pelvic lymphadenectomy was performed without the firefly system for sentinel node mapping. The median number of nodes retrieved was 9 (range, 6–15). This may appear to be a small number, but considering that node involvement and

Table 3. Case series of robotic single-site staging operation

Case No.	Age (yr)	BMI (kg/m²)	Operative times (min)	Hospital days	PLN	Tumor histology	FIGO	Depth (mm)	LVI	Stage	Postoperative treatment
1	58	25.3	190	5	0/6	Endometrioid	G1	4/15	None	II	CCRT (#6) c CDDP[b]
2	45	28.6	180	9	0/6	Endometrioid	G1	E[a]	None	IA	
3	60	23.4	145	7	0/6	Papillary serous	G3	5/17	None	IA	CCRT (#6) c CDDP
4	53	20.4	170	5	0/14	Endometrioid	G2	1/15	None	IA	
5	65	25.9	155	7	0/9	Endometrioid	G1	2/14	None	IA	
6	70	22.6	125	3	0/8	Endometrioid	G1	E	None	IA	
7	56	26.6	145	2	0/15	Endometrioid	G3	5/14	Present	IA	RTx
8	65	22.2	160	9	0/10	Endometrioid	G1	E	None	IA	
9	53	27.9	165	3	0/9	Endometrioid	G1	E	None	IA	
10	47	25.7	140	3	0/6	Endometrioid	G1	1/29	None	IA	
11	57	18.3	116	3	0/14	Endometrioid	G1	2/6	None	IA	
12	37	46.4	180	3	0/8	Endometrioid	G1	8/18	None	IA	
13	46	27.3	145	2	0/13	Endometrioid	G1	2/24	None	IA	
14	45	21.8	160	7	0/9	Endometrioid	G1	E	None	IA	
15	53	24.3	135	3	0/12	Endometrioid	G2	9/13	None	IB	CCRT (#6) c CDDP

BMI, body mass index; PLN, pelvic lymphnode dissection; FIGO, International Federation of Gynecology and Obstetrics; LVI, lymphovascular invasion; CCRT, concurrent chemoradiotherapy; CDDP, cisplatin; RTx, radiotherapy.
[a] Only in endometrium; [b] Concurrent chemoradiation therapy with Cisplatin for 6 cycles.
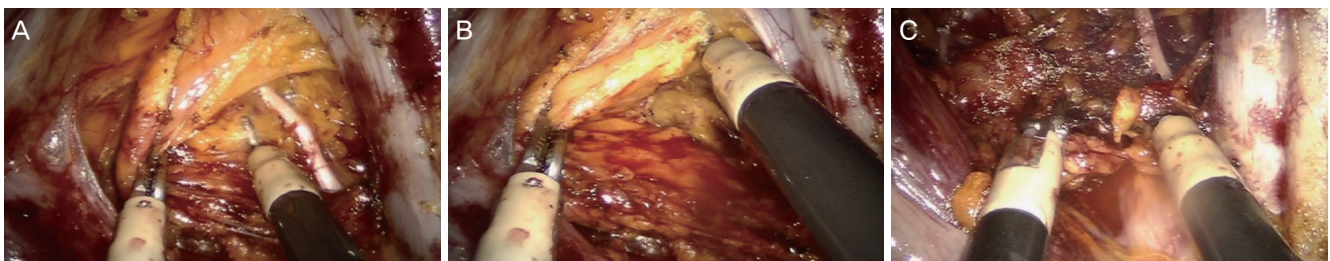

Fig. 4. (A) Safe dissection of the retroperitoneal space by unipolar hook which a tip of the unipolar hook faces upwards by rotation. (B) Dissected nodes as *en bloc*. (C) Careful coagulation of the small branches of vessels by the bipolar grasper to decrease any unnecessary bleeding.

Obstetrics & Gynecology Science

Hyewon Chung, et al. Robotic surgery in endometrial cancer

grade are risk factors in endometrial cancer, lymph node sampling rather than the total number of nodes retrieved may play a more pivotal role in the prognosis and overall survival. None of the patients in this study reported a recurrence. Even though limitations of the instruments and movements caused a narrow surgical angle from a single port and collision from each robotic arm, the pelvic lymphadenectomy was performed on all patients and was found to be equivalent or better than single-site laparoscopic staging operations [4]. With a full understanding of the unipolar hook characteristics, efficient and safe node dissections can be performed without injury to the adjacent nerves and vessels. The angle of the unipolar hook must be used appropriately, because it may cause blind thermal injury. A rotation of the unipolar hook so that the tip faces upwards ensures a safe dissection without any complications (Fig. 4A). The lymph nodes were dissected *en bloc* and lifted upward to maintain their characteristics (Fig. 4B), and the small branches of vessels were carefully coagulated by the bipolar grasper to avoid unnecessary bleeding (Fig. 4C).

The second surgical difficulty was obtaining a firm vaginal cuff suture. To pass through the vaginal tissue with semi-rigid, robotic, single-site instruments and secure the vaginal cuff in full depth was difficult. To overcome this difficulty, we changed the curved needle of the V-Loc™ (Covidien) into a straight needle. As a result, the surgeon could pass the vaginal cuff more easily and perform suturing with less difficulty, because it is much easier to suture a full thickness layer uniformly when using the horizontal strength of a straightened needle [22]. In addition, the replacement of the cannula on the right arm (arm 2) with a long cannula (5×300 mm) added more strength to the suture in full length with semi-rigid instruments. Altogether, these modifications effectively decreased the total operative time, operative blood loss, and surgical difficulty.

One incisional hernia was seen among all our patients, which was identified 5 months after the operation. Even though the periumbilical incision is a single cut, the incision length is longer than that needed for a multiport laparoscopy. When an incision of more than 10 mm is present at the port, the incidence of an incisional hernia has been reported to be 1% [23]. Compared with multiport surgery, this single-site process must include careful intraoperative closure of the peritoneum and fascia.

A limitation of our study is the small number of patients.

However, our results demonstrate that the RSSS operation is safe and feasible for early-stage endometrial cancer. Further evaluations should be performed in large-scale comparative studies with LESS to confirm our conclusion. If large-scale studies acknowledge the feasibility and safety of using the RSSS operation for patients with early-stage endometrial cancer, our surgical guidelines will apply to a wide range of gynecologic cancers.

In conclusion, we have reported the first series of RSSS operations for patients with early-stage endometrial cancer using the da Vinci Si® single-site platform and have introduced surgical guidelines for successful surgical staging. Our results establish that the RSSS operation is a feasible and safe procedure with reasonable operative times and favorable outcomes.

Acknowledgements

Conflict of interest

No potential conflict of interest relevant to this article was reported.

Ethical approval

The study was approved by the Institutional Review Board of Dongsan Medical Center (IRB No. 2016-02-045) and performed in accordance with the principles of the Declaration of Helsinki. Written informed consents were obtained.

Patient consent

The patients provided written informed consent for the publication and the use of their images.

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