Robot-assisted surgery for benign distal ureteral strictures: step-by-step technique using the SP ® surgical system

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Step-by-Step

Robot-assisted surgery for benign distal ureteral strictures: step-by-step technique using the SP® surgical system

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Objectives

To describe the step-by-step techniques for robot-assisted ureteric reimplantation performed using the Vinci SP® surgical system (Intuitive Surgical, Sunnyvale, CA, USA), including different case scenarios with an educational purpose.

Materials and Methods

Three consecutive patients diagnosed with distal benign ureteric strictures were counselled for ureteric reimplantation and consented to undergo surgery performed using the da Vinci SP surgical system. Demographics and peri-operative outcomes were collected after institutional review board approval (IRB 13-780). Patients provided informed consent having received an explanation for the adoption of the novel platform. The first patient was a woman referred to our institution for a left distal ureteric stricture after total hysterectomy for uterine fibroids with ureteric injury. The second patient was a man with BPH and recurrent UTIs, who was diagnosed with a 1.5-cm bladder stone and a large bladder diverticulum compressing the left distal ureter. The third patient was a man diagnosed with bilateral uretero-enteric anastomoses stricture status after radical cystectomy with orthotopic ileal neobladder urinary diversion for bladder cancer.

Results

The procedures were successfully completed. An extra port through a separate skin incision for the bedside assistant was placed for the first two procedures. In such cases, this additional port was used electively from the start of the procedure and did not represent a change in the treatment plan. Moreover, the port wound was used to accommodate the drainage. The bilateral ureteric reimplantation, however, was completed according to a pure single-site approach (no extra ports were placed out of the GelSeal cap). The mean operating times were 165, 150 and 180 min, respectively. Blood loss was 50 mL in all cases. No intra-operative complications occurred. Patients were discharged on postoperative days 1, 1 and 2, respectively, with normal serum creatinine levels. Neither transfusions nor major complications occurred.

Conclusion

Robot-assisted reconstructive surgery for benign distal ureteric strictures is feasible and safe using the da Vinci SP surgical system.

Keywords

robot, single-site, single-port, reconstructive, reimplantation, ureter

Introduction

Open surgery is the 'gold standard' approach for complex ureteric reconstructive surgery [1]. Endoscopic treatments are often used first-line, but they are associated with poor long-term success rates [2]. During the last decade, the increasing adoption of minimally invasive approaches has included the field of ureteric reconstructive procedures. Ureteric strictures still represent a challenging scenario. Although the pure laparoscopic approach has been described as a treatment option, its diffusion has remained limited because of technical issues.

The advent of robot-assisted surgery has offered a more reliable minimally invasive alternative to open surgery, thanks to the undoubted advantages of the da Vinci system (Intuitive Surgical, Sunnyvale, CA, USA), including the facilitated intracorporeal suturing and three-dimensional vision of the surgical field. Several techniques have been reported describing the robot-assisted technique for ureteric repair of benign ureteric strictures [3]. Buffi et al. [4] reported a large case series of ureteric reconstructive surgeries for benign ureteric strictures. In their multicentre experience, 21 patients underwent robot-assisted ureteric reimplantation for distal ureteric stricture and the authors reported an overview of

Table 1 Patient demographics, clinical scenarios, and peri-operative and pathology data.

Case no.	Age	Sex, race	Clinical scenario	Intraoperative data	Postoperative data	Pathology	Discharge
Robot-assisted ureteric reimplantation							
1	45	Female, black	Left ureteric stricture Status post hysterectomy in 2015, managed with nephrostomy tube, SCr 1.2 mg/dL	OT 165 min, EBL 30 mL	SCr 1.19 mg/dL No complications	Benign ureter with submucosal edema and chronic inflammation	On POD 1
2*	54	Male, non-Hispanic white	BPH, recurrent UTIs, large bladder diverticulum compressing the left ureter, SCr 0.8 mg/dL	OT 150 min, EBL 50 mL	SCr 0.79 mg/dL Nausea/vomiting after discharge (Clavien I)	Benign urothelial mucosa with squamous metaplasia	On POD 1
3†	67	Male, non-Hispanic white	Bilateral ureteric strictures status post cystectomy for BCa with ileal neobladder in 2013, SCr 1.0 mg/dL	OT 180 min, EBL 50 mL	SCr 0.9 mg/dL No complications	Intestinal-type glandular mucosa with chronic inflammation Negative for BCa	On POD 2

*BCa, bladder cancer; EBL, estimated blood; OT, operating time; POD, post-operative day; SCr, serum creatinine. *With bladder diverticulectomy and litho-lapaxy. †Bilateral procedure.*

techniques, with compelling results. The recent introduction to the market of a novel purpose-built single-port robotic system prompted us to duplicate the principles of robotic ureteric reconstructive surgery in a single-site philosophy, in an attempt to further reduce the invasiveness of this surgery [5,6].

The aim of the present paper was to describe the step-by-step techniques for robot-assisted ureteric reimplantation performed using the da Vinci SP® surgical system (Intuitive Surgical). Different case scenarios were included with an educational purpose.

Materials and Methods

Patients and Case Scenarios

Three consecutive patients diagnosed with distal benign ureteric strictures were counselled to undergo ureteric reimplantation and consented to surgery performed using the da Vinci SP surgical system. Demographics and peri-operative outcomes were collected after institutional review board approval (IRB 13-780). Patients were provided with an explanation for the adoption of the novel surgical platform before giving their informed consent. No specific inclusion/ exclusion criteria were considered.

The first patient was a woman referred to our institution for a left distal ureteric stricture status after undergoing total hysterectomy for uterine fibroids with ureteric injury. The second patient was a man with BPH and recurrent UTIs, who was diagnosed with a 1.5-cm bladder stone and a large bladder diverticulum compressing the left distal ureter. The third patient was a man diagnosed with bilateral uretero-enteric anastomoses stricture status after radical cystectomy with orthotopic ileal neobladder urinary diversion for bladder cancer. The case scenarios are summarized in Table 1.

da Vinci SP surgical system

The da Vinci SP platform includes three, multi-jointed, wristed instruments and a fully wristed three-dimensional high-definition camera. The instruments and camera all emerge through a single multi-channel port. The SP instruments incorporate an additional joint, providing an ‘elbow’ so that instruments can be triangulated around the target anatomy. This feature represents the main advance with respect to existing systems that are not dedicated to a single port, reducing the external instrument clashing that can occur in narrow surgical workspaces. Another important feature enabled by the system is the 360° of anatomical access allowed by the single arm, which facilitates the accomplishment of single-docking, multi-quadrant surgery [6].

Patient Positioning, Port Placement and Docking

The patients were placed in the modified lithotomy position, with the legs in stirrups but relatively straight and midline to avoid pressure on the calves. This allowed access for sterile Foley catheter placement and eventual sterile urethral access later in the case.

All the surgeries were completed via a 2.5–3-cm incision through which a GelPOINT advanced access platform (Applied Medical, Rancho Santa Margarita, CA, USA) and a dedicated 25-mm multi-channel port (accommodating a 12 × 10-mm articulating robotic camera, three 6-mm double-jointed articulating robotic instruments and a 6-mm accessory laparoscopic instrument) were placed. An additional 12-mm port for the bedside assistant was placed through the GelSeal cap or transabdominally, as previously described in our pre-clinical experience (Fig. 1) [7]. Patients were moved to a 15° Trendelenburg position. The robot was docked aside.

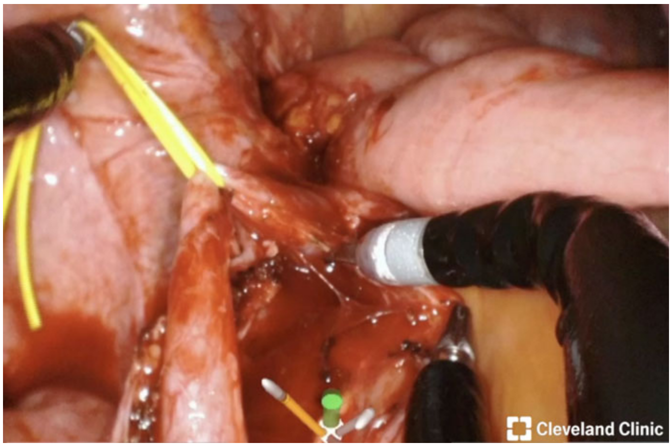
Surgical Techniques

Robot-Assisted Ureteric Reimplantation after Hysterectomy

The patient who had undergone total hysterectomy was noted to have significant adhesions from the bowel to the abdominal wall both in the midline underneath her prior scar as well as in both sides of the pelvis. These attachments were taken down sharply with robotic scissors, with care taken to avoid the bowel. After sufficient adhesiolysis had been performed, the 12-mm assistant port was placed on the right para-rectal line.

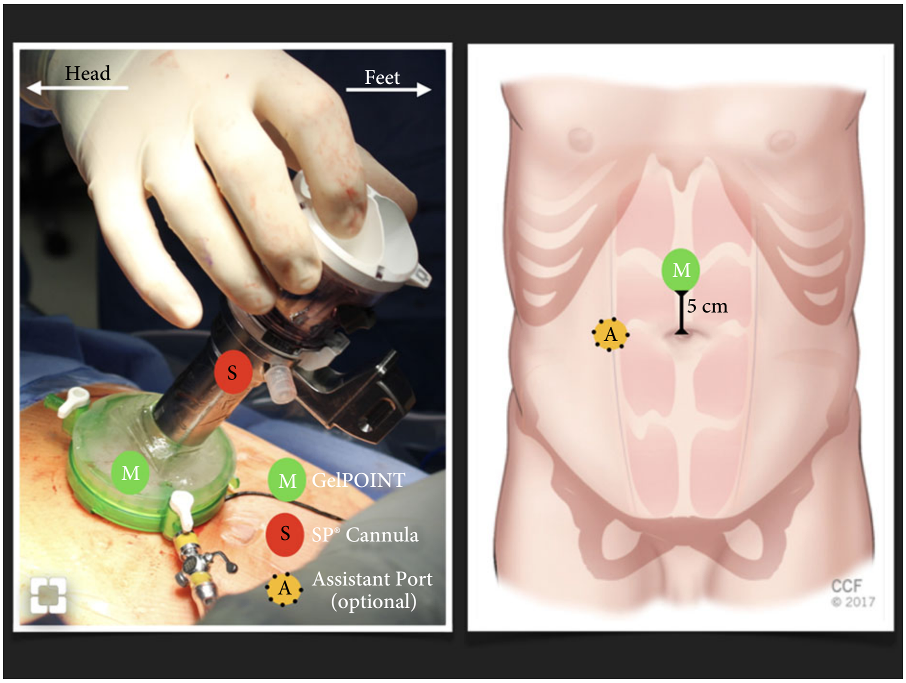
In the left pelvis, the ureter was identified adjacent to the iliac vessels. After sharp dissection and proper mobilization, a vessel loop was placed around the ureter. This was used to assist in retraction as the ureter was dissected proximally and distally to gain sufficient length for reimplantation (Fig. 2). Again, extensive adhesions between the bowel and the pelvic/abdominal sidewall were divided to allow adequate mobilization of the ureter. The bowel was examined, and no injuries were noted. The ureter was traced distally until it entered an area of dense fibrotic scar likely at the site of prior injury.

Fig. 2 Placement of vessel loop around the ureter. The loop was used to assist in retraction as the ureter was dissected proximally and distally to gain sufficient length for reimplantation.



At this point, the ureter was clipped and sharply cut, with the distal portion sent for frozen section. Attention was then turned to mobilizing the bladder off the anterior abdominal wall in order to perform a psoas hitch. The bladder was filled with sterile saline solution. Once the bladder was sufficiently mobilized, the peritoneum was opened cephalad to the iliac vessels where the psoas tendon could be visualized and the perivesical tissue was secured on the left side to complete the psoas hitch. The nearest area of bladder was dissected off the perivesical fat, and the bladder was sharply incised. The

Fig. 1 Port Placement for Single-Port Robotic Ureteral Reimplantation using the SP Surgical System.



incision was extended through the mucosa, and a 4/0 polyglactin 910 stay suture was placed in the cephalad apex of the bladder incision. The ureter was spatulated, and the anastomosis performed with two 3/0 polysorb sutures according to the Lich–Gregoir technique. Prior to completing the anastomosis, a 7-F × 26 cm ureteric JJ stent was placed using a guidewire. The distal end of the JJ stent was placed in the bladder and the anastomosis completed. Water-tightness was tested. A Jackson–Pratt drain was placed through the incision accommodating the 12-mm assistant port. The midline incision was closed.

Robot-Assisted Bladder Diverticulectomy and Ureteric Reimplantation

In the patient who underwent robot-assisted bladder diverticulectomy and ureteric reimplantation, the pneumoperitoneum was induced, and the 12-mm assistant port was placed on the right para-rectal line. The bladder was dropped and dissected to expose the diverticulum.

Flexible cystoscopy was performed, and access to the diverticulum was gained. The robotic camera light was turned off for visualization of the boundaries of the diverticulum by transillumination (Fig. 3). The light was then turned on, and the dissection of the diverticulum was started circumferentially up to the diverticulum infundibulum. During the dissection, the left ureter was found to be closely adherent to the diverticulum. The complete excision of the diverticulum was not possible without transecting the ureter. The ureter was then dissected distally as much as possible before it was sharply cut. Then, the excision of the diverticulum infundibulum was started, and the diverticulum was completely separated from the bladder. The bladder defect was repaired with 2/0 polyglactin 910 sutures.

The bladder was then distended with sterile saline solution. A psoas hitch was performed with a 1/0 polysorb suture, carefully avoiding nerve injury. The ureter was then spatulated, and a JJ stent was placed. The uretero-vesical anastomosis was performed with two 4/0 polysorb sutures in a running fashion, according to the Lich–Gregoir technique. A Jackson–Pratt drain was inserted into the pelvis through the assistant port. The robot was undocked. The specimen was retrieved through the main incision, and the surgical wound was then closed.

Robot-Assisted Bilateral Ureteric Reimplantation

In the man diagnosed with bilateral uretero-enteric anastomoses stricture status after radical cystectomy, the SP multichannel port was introduced through the GelSeal cap of the GelPOINT advanced access platform, and the assistant port was then placed adjacently (Fig. 4). After sufficient adhesiolysis was performed, the chimney of the neobladder was identified by distending the neobladder. The caudal end of the chimney was dissected to reach the site of the uretero-enteric anastomoses. The right and left ureter appeared fused together at their insertion (Fig. 5). The right ureter was then sharply incised from around the stent, separating it from the ileal neobladder. Careful sharp dissection was used to separate both the ureters for a sufficient length. The left ureter was similarly sharply divided from the neobladder. The old ileostomy accommodating the left ureter was closed using a 3/0 polyglactin 910 running suture. The JJ stent in the left ureter was positioned in the ileostomy of the right ureter after frozen section was negative for fibrosis. The ureter was spatulated for a sufficient length. The left uretero-enteric anastomosis was then performed using two 4/0 polysorb sutures. A new ileal opening was made lateral to the old one for the right uretero-enteric anastomosis. The right ureter

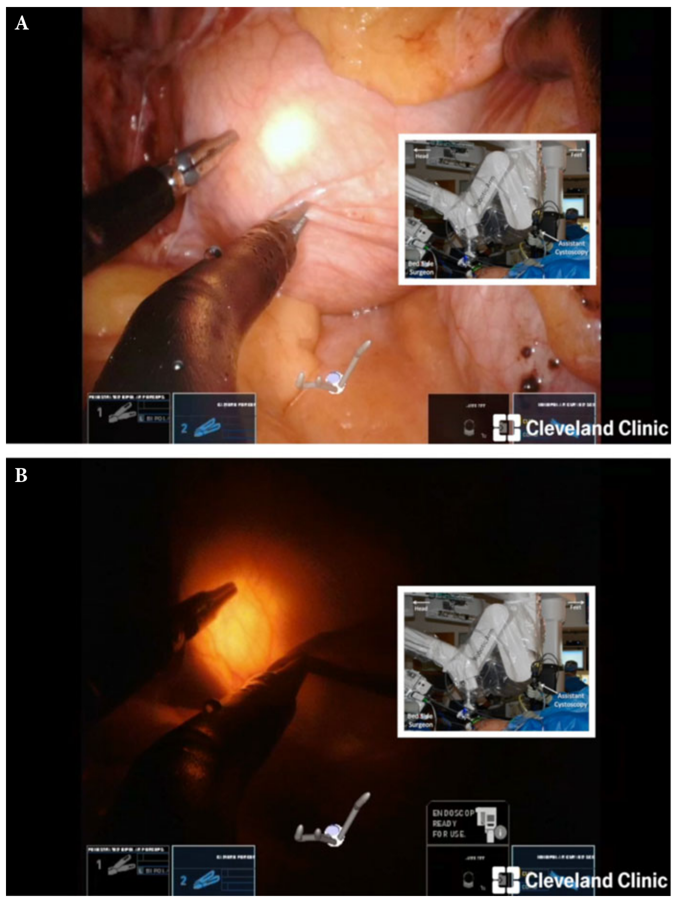
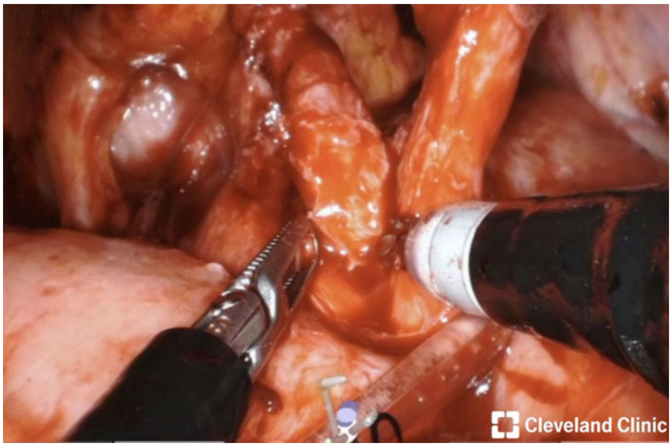


Fig. 3 (**A**) Image showing flexible cystoscopy and gaining of access to the diverticulum. (**B**) Visualization of the boundaries of the diverticulum by transillumination; the robotic camera light was turned off for this.

Fig. 4 Pure single-site approach for bilateral ureteric reimplantation. The SP multichannel port is introduced through the GelSeal cap of the GelPOINT advanced access platform. The assistant port is placed adjacently without need of additional transabdominal incisions (A= assistant port; S= SP Cannula; M= Multiaccess advanced platform).

Fig. 5 Dissection of Ureter using the SP Surgical system.

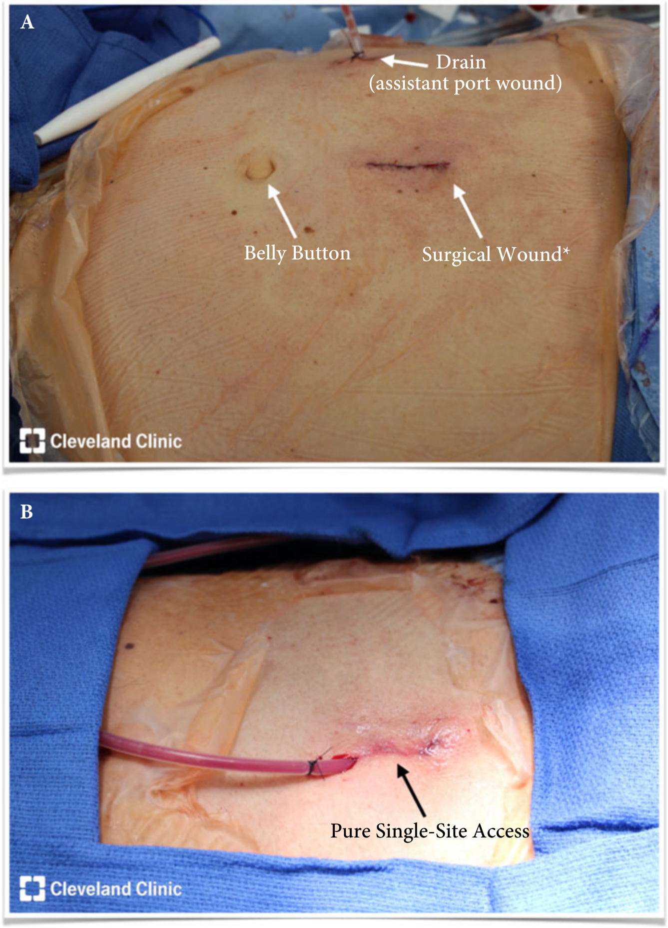


was spatulated, and the uretero-enteric anastomosis was performed using two 4/0 polysorb sutures over the existing nephron-stent. The fascia was closed using a running suture. A Jackson–Pratt drain was brought up through the lower part of the skin incision but through a separate fascial incision.

Results

The procedures were successfully completed. An extra port through a separate skin incision for the bedside assistant was placed in the first two procedures. In such cases, this additional port was used electively from the start of the

Fig. 6 (**A**) Cosmetic result after bladder diverticulectomy and ureteric reimplantation. An extra port through a separate skin incision for the bedside assistant was placed. The assistant port's wound was used to accommodate the drainage. (**B**) Cosmetic result after bilateral ureteric reimplantation. The procedure was completed according to a pure single-site approach (no extra ports were placed out of the GelSeal cap).



procedure and did not represent a change in the treatment plan. Moreover, the port's wound was used to accommodate the drainage (Fig. 6A).

By contrast, the bilateral ureteric reimplantation was completed according to a pure single-site approach (no extra ports were placed out of the GelSeal cap [Fig. 6B]). Results are summarized in Table 1. The mean (range) operating time was 165 (150–180) min. Blood losses were 50 mL in all cases. No intra-operative complications occurred. Benign pathology was confirmed in all cases. The three patients were discharged on postoperative days 1, 1 and 2, respectively, with normal serum creatinine levels. The patient who underwent concurrent diverticulectomy reported self-limited nausea and vomiting after discharge, managed by common medications (Clavien grade I).

Discussion

The recent advances in surgical robotics, paired with the pursuit of reducing the invasiveness of laparoscopic surgery, has led to the development of novel robotic platforms specifically designed for single-port surgery [5]. Among the latest developments in the field, the da Vinci SP1098 system figured as a purpose-built robotic platform dedicated to single-site, single-port surgery [6]. Kaouk et al. [8] described the first clinical application of its earlier version, the SP999, and successfully completed major urological procedures. The compact profile of the platform's working element allows operations to be performed within narrow spaces so that the feasibility of unconventional approaches to various urological interventions has been investigated in a pre-clinical setting [9], including extraperitoneal renal surgery [10], transperineal and transvesical prostate surgery [11,12] and transperineal bladder surgery with intracorporeal urinary diversion [13,14]. The latest release, the Da Vinci SP® Surgical System, was approved on 31 May 2018 by the US Food and Drug Administration. In the present paper, we report the first case series of ureteric reconstructive surgeries in patients diagnosed with benign distal ureteric strictures.

In the two surgeries performed at the very beginning of the experience, an extra port for the bedside assistant was placed through a separate skin incision from the start of the procedure, to give the assistant more space during the surgery.

By contrast, one procedure was performed using a pure single-site approach. The cosmetic result was encouraging. We underline that the da Vinci SP boom can be rotated more than 360° around the remote centre of the cannula. Moreover, the instrument cluster can be turned over 360° within the cannula. Such technical aspects might stimulate the concept of a multi-quadrant, single-docking surgery that could be a bespoke indication for kidney autotransplant in the future.

Nevertheless, challenges related to bedside assisting represent a major issue during laparo-endoscopic single-site surgery, as previously reported [15]. We acknowledge this issue is not completely resolved with the SP surgical system because, in the case of a pure single-site approach, the access to the surgical field remains challenging for the assistant. Good coordination between the console surgeon and the assistant is mandatory because of the limited working space as well as when using the SP platform.

In addition, a learning curve exists when embarking on this type of surgery, particularly when intracorporeal suturing is included, as in the case of ureteric reconstructive surgery. The instruments of the SP surgical system allow seven degrees of freedom, similarly to those of the standard multi-port da Vinci platforms, but differences are perceived in the suturing dynamic: the novel elbow is introduced at the expense of the loss of the EndoWrist™ technology experience. We believe the expert robotic surgeon (with a consistent number of procedures performed using the earlier multi-arm Da Vinci platforms) might particularly perceive such modification.

In conclusion, robot-assisted reconstructive surgery for benign distal ureteric strictures is feasible and safe using the da Vinci SP surgical system. This novel technology could represent a viable tool for achieving a pure single-site approach. The definition of the optimal indications of the SP system will be the goal of future clinical studies. The potential perspective of a single-docking universal access for performing multi-quadrant surgery is promising for the future of the platform.

Conflict of Interest

Jihad H. Kaouk certifies that all conflicts of interest including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (e.g. Employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patent filed, received or pending) are the following: Intuitive Surgical. Juan Garisto, Riccardo Bertolo and Mohamed Eltemamy have nothing to disclose.

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Abbreviations: SP, single-port.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article:

Video S1. Robot-assisted surgery for benign ureteral strictures: Step-by-step Using the SP Surgical System.