THERAPEUTIC ADVANCES in
Urology

Original Research

The role of the surgical robot in gender-affirming surgery: a scoping review

Ther Adv Urol

2025, Vol. 17: 1–14

DOI: 10.1177/17562872251336639

Karen M. Doersch, Lily Kong, Christodoulos Kaoutzanis and Ty Higuchi

Abstract

Background: Gender-affirming surgery is a growing field to address gender dysphoria, which is an increasingly recognized condition. The surgical robot is an excellent tool for performing some gender-affirming procedures and has been utilized extensively in both feminizing and masculinizing surgery.

Objectives: To provide an overview for the use of the surgical robot in gender-affirming surgeries.

Design: This is a scoping review.

Methods: A literature search was conducted by the authors via PubMed and Google Scholar.

Results: The ability of the robot to operate within the pelvis makes it an excellent platform for performing colpectomy with colpocleisis, hysterectomy, and vaginoplasty. A variety of grafts and flaps are amenable to robotic employment in the setting of gender-affirming surgeries. Finally, many revisions can be performed via the robotic approach, regardless of the approach of a patient's primary surgery.

Conclusion: The surgical robot is a useful tool for performing gender-affirming surgeries, including primary surgeries and revisions. Future research will continue to define roles for the robot in the setting of gender-affirming surgery, improve outcomes, and develop novel techniques.

Plain language summary

A scoping review of the use of a robot to perform surgery to affirm an individual's gender

Gender dysphoria is defined as the distress that can occur when the sex an individual is assigned at birth is different from that person's gender identity. Patients who present with gender dysphoria may be offered medications and/or surgery if these treatments are congruent with their goals. This manuscript represents a scoping review of currently available literature discussing the use of the surgical robot in gender affirming surgery. Surgery for gender affirmation takes a variety of forms. The surgical robot has emerged as a useful tool in performing minimally invasive gender affirming surgery due to its increasing availability and greater surgeon familiarity with this operative platform. The surgical robot is especially helpful for gender affirming surgeries performed in the deep pelvis, such as removing the native uterus, ovaries, or vagina, or in forming a new vagina, called a neovagina. The surgical robot can also be used to revise or manage complications from previously performed surgeries. As the field continues to develop, there will likely be increasing employment of this surgical platform for gender affirming care.

Keywords: gender-affirming care, robotic gender-affirming surgery, robotic surgery, vaginoplasty

Correspondence to:
Karen M. Doersch
Division of Urology, Department of Surgery, University of Colorado Anschutz Medical Center, 13001 E 17th Pl, Aurora, CO 80045, USA

Department of Urology, University of Rochester Medical Center, 601, Elmwood Avenue, Rochester, NY, USA
karen.doersch@cuanschutz.edu

Lily Kong
Ty Higuchi
Division of Urology, Department of Surgery, University of Colorado Anschutz Medical Campus, Aurora, CO, USA

Christodoulos Kaoutzanis
Division of Plastic & Reconstructive Surgery, Department of Surgery, University of Colorado Anschutz Medical Campus, Aurora, CO, USA

Received: 31 July 2024; revised manuscript accepted: 28 March 2025.

Introduction

Gender-affirming surgeries performed by urologists, plastic surgeons, and other pelvic surgeons include a broad variety of masculinizing and feminizing surgeries based upon patients' aesthetic and functional goals. The robotic approach can be used for many gender-affirming surgeries due to its familiarity to urologists, the ability to reach the structures of the deep pelvis, the ability to perform both perineal and abdominal aspects of a surgery simultaneously, and ergonomic considerations for the surgeon. Robotic approaches for many gender-affirming surgeries have been described, including gender-affirming hysterectomy, oophorectomy, colpectomy with colpocleisis, and vaginoplasty.[1–3] Furthermore, in the revision setting, the surgical robot is invaluable in performing difficult pelvic dissections.[4–6] The main limitations of the use of the robotic platform in gender-affirming surgeries may be due to financial barriers, the lack of accessibility or availability of the robot in certain settings, and the learning curve associated with use of the robot.[7]

In this scoping review, we discuss the role of robotic surgery in gender-affirming surgery, including a discussion of masculinizing and feminizing surgeries, revisions and complication management, and the development of future techniques. The uses of the robotic platform in gender-affirming surgery detailed in this review can be summarized in Figure 1.

Methods

The authors conducted a search on PubMed and Google Scholar. All resulting articles were reviewed by two authors for content and applicability. See Table 1 for a detailed summary of the search strategy. The reporting of this study conforms to the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews statement.

Results

Feminizing genital reconstructive surgery for gender affirmation

Use of the robotic platform has been increasingly prevalent in feminizing gender-affirming surgery, particularly gender-affirming vaginoplasty (GAV). There are two common applications for the robotic platform in GAV: primary robotic-assisted penile inversion vaginoplasty

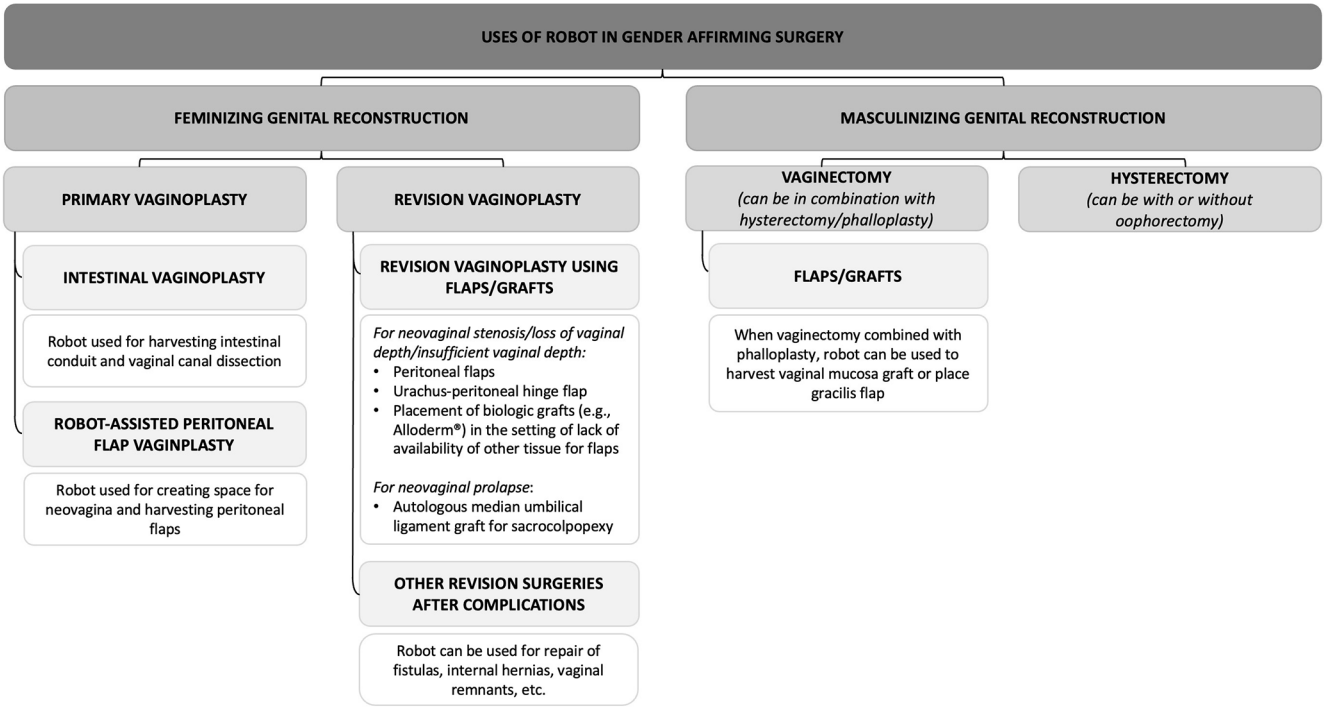

Figure 1. Summary of uses of robotic platform in gender-affirming surgery.

Table 1. Search strategy summary.

Items	Specification
Date of search (specified to date, month, and year)	A PubMed and Google Scholar search was conducted on December 14, 2023 by KMD. A separate PubMed search was conducted on December 28, 2023 by LK.
Databases and other sources searched	PubMed, Google SCholar
Search terms used (including MeSH and free text search terms and filters)	KMD's search terms included "gender affirming surgery" AND "robotic;" "transgender" AND "robotic." LK's search terms included "gender affirming vaginoplasty," "revision vaginoplasty," "transgender vaginoplasty, "robotic vaginoplasty."
Timeframe	As search results did not yield a large number of studies, all studies that resulted were considered.
Inclusion and exclusion criteria (study type, language restrictions, etc.)	Only studies conducted in the English language were included.
Selection process (who conducted the selection, whether it was conducted independently, how consensus was obtained, etc.)	KMD and LK conducted the selection and reviewed all resulting articles for content and applicability. Resulting articles were discussed with CK and TH to obtain consensus.
Any additional considerations, if applicable	N/A

(PIV) with peritoneal flaps and revision robotic-assisted vaginoplasty with peritoneal flaps.

Three main techniques are currently used for GAV, with technical variations that differ by surgeon: PIV via a perineal approach, robotic-assisted PIV with peritoneal flaps, and intestinal vaginoplasty. Perineal PIV is the most common vaginoplasty technique[8]; however, there has been increasing literature describing peritoneal vaginoplasty using the robotic platform, also called robotic peritoneal gender-affirming vaginoplasty (RPGAV) or robotic-assisted peritoneal flap vaginoplasty.

Intestinal vaginoplasty. Historically, intestinal vaginoplasty, also called enteric or bowel vaginoplasty, was utilized as an alternative to PIV in patients with insufficient penoscrotal skin. Intestinal vaginoplasty can be performed laparoscopically or with the assistance of the robot. In this procedure, a portion of the intestine, usually sigmoid colon or ileum, is used to create the neovaginal canal. The role of the robot is typically in harvesting the intestinal conduit and dissecting the vaginal canal.[9] Advantages of using intestine include the ability to create sufficient neovaginal depth, the inherent self-lubricating quality of the intestinal segments, its resemblance to vaginal lining in texture, and rare contraction or shrinkage of the neovagina (theoretically eliminating the need for lifelong dilation).[10,11] However, intestinal vaginoplasty necessitates intra-abdominal surgery with intestinal anastomosis, and risks include the development of diversion colitis and malignancy of the intestinal segment. Disadvantages for patients include excessive mucus production and malodor.[11] For these reasons, the trend in GAV has generally been away from intestinal vaginoplasty.[12] In a study that interviewed 17 high-volume surgeons performing GAV, none of the surgeons offered intestinal vaginoplasty for routine, primary vaginoplasties. Some surgeons did offer intestinal vaginoplasty as an option for revision vaginoplasty, which is discussed below, or in patients who had undergone pubertal blockade with insufficient penoscrotal tissue.[8]

Robotic-assisted peritoneal flap vaginoplasty. The use of peritoneal flaps for vaginal lining can be traced back to 1912, when Walter Stoeckel described his technique for using peritoneal flaps for colpopoesis in a cisgender female patient.[13–15] This technique, initially used for patients with vaginal agenesis, became more widely known after S.N. Davydov published his case series using

this technique in cisgender women.[8,13] The Davydov procedure has continued to be utilized for patients with vaginal agenesis, Mayer–Rokitansky–Küster–Hauser syndrome, and androgen insensitivity.[9]

In 2017, the first robotic-assisted peritoneal flap vaginoplasty using a modified Davydov technique was performed by Lee C. Zhao and Rachel Bluebond-Langner in conjunction with PIV as a means to increase vaginal depth in patients with insufficient genital skin and minimize donor site morbidity[13,16] In this procedure, the robotic platform is used to perform a transabdominal dissection between the rectum and prostate in Denonvilliers fascia to create a space for the neovagina. The vaginal apex and canal are created by mobilizing peritoneal flaps from the anterior rectum and posterior bladder. The robotically harvested peritoneal flaps are then anastomosed to the penile skin to create the resulting neovagina. Sometimes, if the penile skin is not long enough to reach the peritoneal flaps, scrotal skin is also utilized.[17] This technique incorporates the rectovesical pouch into the neovagina, allowing for creation of vaginal depth beyond the peritoneal reflection.[3] In the initial series of 41 patients who underwent RPGAV using the da Vinci Xi platform (Intuitive Surgical Inc., Sunnyvale, CA, USA), follow-up vaginal depth and width was measured to be 14.2 ± 0.7 cm and 3.6 ± 0.2 cm, respectively, compared to a preoperative average penile length of 8.7 ± 2.5 cm. All patients reported erogenous sensation postoperatively, and minor wound complications were noted in 20% of patients.[18] A separate series of eight subjects who underwent a vaginoplasty using scrotal and penile skin with augmentation from robotically harvested peritoneal flap noted an average operative time of 6 h and no complications.[17] A separate study of RPGAV in 33 subjects noted a median operative time of 406 min, a median length of stay of 7 days and complications in 33% of subjects, all of which were Clavien-Dindo grade I or II.[19] Thus, mounting evidence demonstrates the success of the robotic approach to peritoneal flap vaginoplasty.

RPGAV has since successfully been performed using the da Vinci Xi and Single Port (SP) systems. In a comparison between the da Vinci Xi and SP systems, Dy et al.[16] found that the two systems yielded comparable vaginal depths and similar intraoperative and postoperative complication rates. The authors also noted a lower rate of vaginal stenosis in the SP group; however, the follow-up time was shorter in the SP group compared to the Xi group. In adapting the Xi technique to the SP system, Dy et al. described multiple benefits to using the SP robot for RPGAV, including decreased operative time (220 min vs 254 min in the Xi group), which decreases the risk for positioning-related complications; improved surgical visualization and mobility due to a single robotic arm, as seen in Figure 2; and fewer abdominal incisions compared to the Xi system.[16] In a study done at a different institution with a smaller cohort of both cisgender and transgender patients who underwent primary and revision vaginoplasties, the authors stated that they transitioned to using the SP robot as their preferred platform for robotic vaginoplasty for similar reasons.[20]

In examining the role of robotics in GAV, an important consideration is comparing RPGAV to perineal PIV, which is the gold standard for GAV. RPGAV has a number of proposed advantages, including the ability achieve greater vaginal depth, avoidance of extragenital skin grafts or intestinal vaginoplasty, especially in patients with limited penile or scrotal skin, and an antegrade dissection approach with which urologic surgeons may be more familiar.[8] RPGAV may also have an advantage in producing more aesthetically desirable results as it does not require as much genital skin to be used for the neovaginal lining, allowing for more penile skin to be used for vulvoplasty and construction of the labia minora[16] (Figure 3). However, entry into the abdominal cavity in RPGAV carries inherent associated risks, including bowel obstruction, intra-abdominal adhesions, and injury to deep pelvic structures (vasculature, rectum, bladder, ureters, and urethra).[16,18] Risks associated with using the robotic platform include complications related to positioning (e.g., neuropathy), port site hernias, and equipment malfunction. Additionally, the use of the robotic platform is typically more costly.[18] To our knowledge, there is no literature directly comparing outcomes from perineal PIV and RPGAV; however, this may be because the decision to pursue one technique over the other is driven more by patient and surgeon circumstances. Peters et al.[21] have described a framework for considerations when choosing perineal versus robotic vaginoplasty. In this framework, perineal vaginoplasty is favorable in patients with gastrointestinal disease and major prior abdominal surgery, while RPGAV is preferred in patients

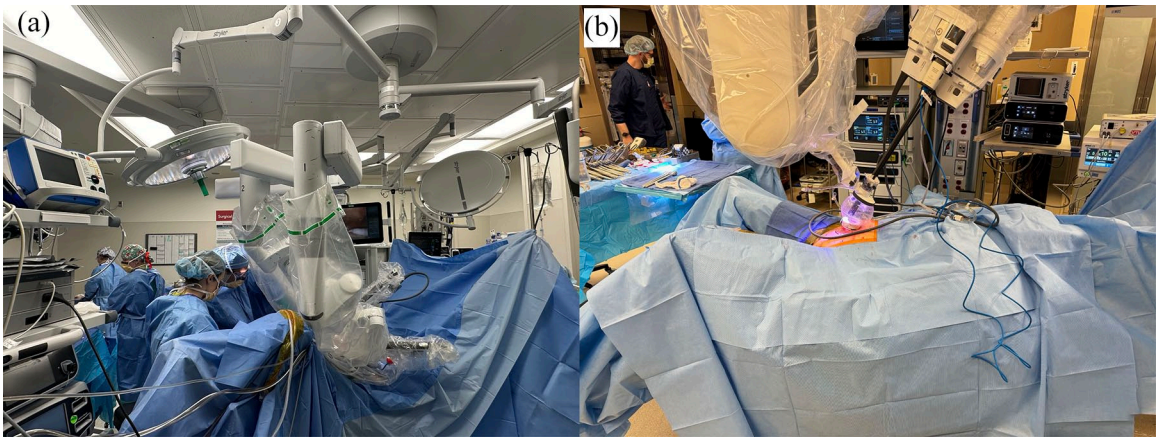

Figure 2. Comparison of lateral view of da Vinci Xi versus SP. (a) Lateral view of da Vinci Xi during gender-affirming surgery showing perineal surgeon with limited mobility from multiport robot. (b) Lateral view of da Vinci SP showing the amount of space potentially available for perineal surgeons to operate due to robotic arm rotating away from the perineal surgeons.

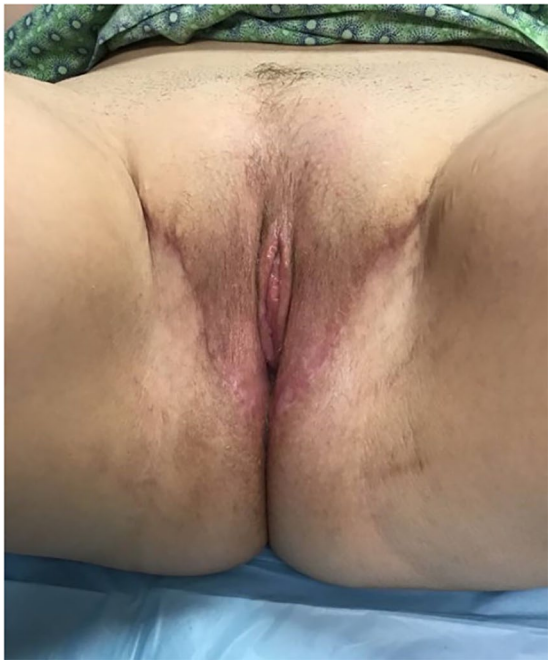

Figure 3. The appearance of the external genitalia following a robotic-assisted gender-affirming full-depth vaginoplasty.

with limited genital tissue.[16,22,23] RPGAV has been shown to have equivalent results in subjects with and without genital hypoplasia.[23] Body mass index (BMI) is another consideration in which practice differs based on institution. Some institutions prefer perineal PIV in patients with high BMI as central and truncal obesity may preclude safe RPGAV, while other surgeons prefer RPGAV in patients with high BMI due to an increased risk of having inadequate genital skin for perineal PIV or limited visibility due to body habitus.[24] Skin grafting may be required at the introitus to overcome the inadequacy of genital skin in this setting. It is important to note that RPGAV is a relatively new technique, and future studies are necessary to elucidate long-term success and satisfaction.

Robotic-assisted prostatectomy. The prostate typically remains *in situ* after feminizing gender-affirming surgery. While individuals in this patient population have a low risk of prostate cancer, it can occur. One case report described a transgender female with prostate cancer who underwent a successful robotic-assisted radical prostatectomy with preservation of the neovagina.[25] Thus, the robot can be used to successfully manage prostate cancer in the setting of prior gender-affirming feminizing surgery.

Masculinizing genital reconstructive surgery for gender affirmation

Hysterectomy. Gender-affirming hysterectomy with or without oophorectomy is a common application of the surgical robot for masculinizing surgery.[1] Gynecologists trained in robotic hysterectomy for cisgender patients are easily able to adapt this approach to the transgender population. In this setting, the robotic approach has the advantage of access to the pelvis and good visualization to prevent ovarian remnant syndrome, wherein ovarian tissue left behind causes pelvic pain or a mass.[1] Furthermore, for transgender male patients on testosterone therapy,

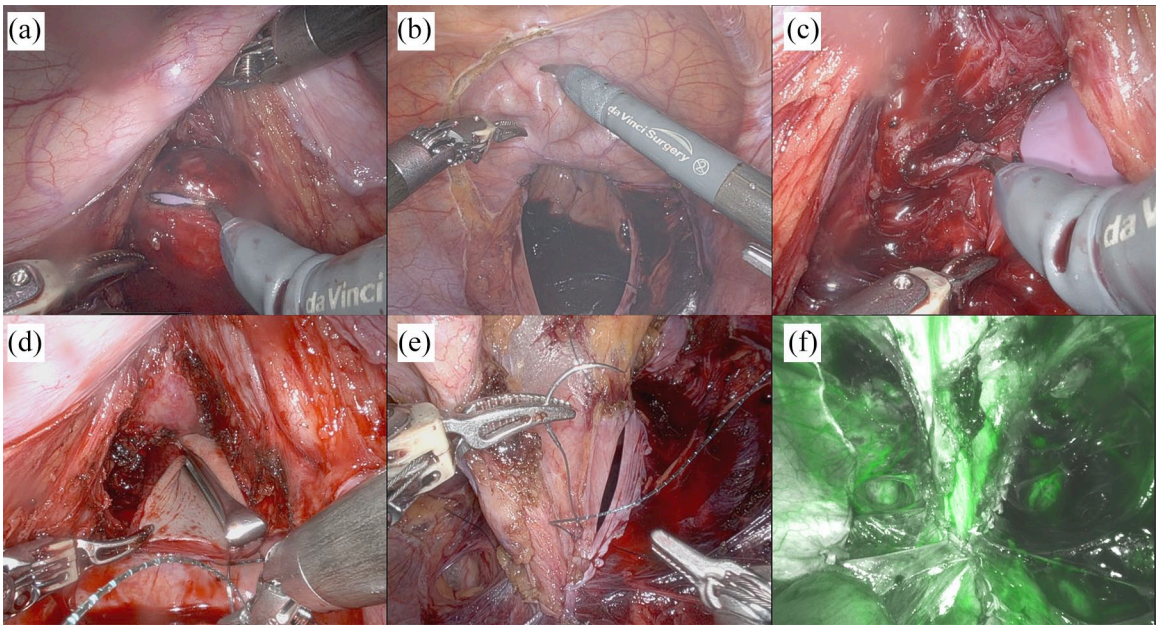

Figure 4. The creation of the neovaginal canal on the da Vinci platform. (a) Dissection of canal onto dilator. (b) Creation of the peritoneal flap. (c) Incision and extension of incision into levator ani tissue. (d) Passage of neovaginal flap via the perineum. (e) Closure of the neovaginal. (f) Final view of closed neovaginal canal with indocyanine green to demonstrate health and perfusion of the flap.

vaginal atrophy may be present due to low estradiol, making the vaginal approach to hysterectomy challenging.[26,27] Hysterectomy for gender affirmation can be performed with the Xi or SP platforms.[28,29]

Studies comparing outcomes between transgender male and cisgender females undergoing robotic-assisted laparoscopic hysterectomy have demonstrated no difference in outcomes between the two groups, including complication rate, estimated blood loss, or conversion to the open approach.[30] Additionally, a study of 10 subjects undergoing SP robotic-assisted hysterectomy demonstrated good results with only one minor complication and a median hospital length of stay of 2.4 days, indicating the success of this approach.[29] A different single-center study of 20 subjects who underwent robotic-assisted total hysterectomy and bilateral salpingo-oophorectomy showed similar results—in this study, there were no intraoperative or postoperative complications and the average hospital length of stay was 2.5 days.[27]

Colpectomy with colpocleisis. Removal of the vagina is amenable to the robotic approach and can be combined with hysterectomy, phalloplasty, or can be performed in a separate setting.[2,31] The robot allows for good visualization of the bilateral ureters and the rectovaginal septum to prevent injury to these pelvic structures.[31] Colpectomy with colpocleisis can be performed with either the SP or the Xi platforms.[2] Additionally, a transperineal approach to colpectomy with colpocleisis using the robot has been described.[32]

One study of patients undergoing a combined gender-affirming hysterectomy and colpectomy with colpocleisis demonstrated an approximately 25% complication rate with only one major complication (postoperative bleeding requiring transfusion).[31] Additionally, operative times were acceptable and improved over the learning curve from a median of 278 min in the first 18 cases to a median of 197 min in the second 18 cases.[31] Of note, postoperative urinary retention was common in this cohort, with six of 36 subjects requiring a prolonged catheterization.[31] Another study of 42 subjects undergoing robotic-assisted laparoscopic colpectomy with colpocleisis demonstrated a 13% rate of complications attributable to the colpectomy with colpocleisis portion of the case, all of which were Clavien-Dindo Grade 1 or 2.[2] Another study comparing robotic-assisted colpectomy with colpocleisis with hysterectomy to transvaginal colpectomy noted lower estimated blood loss, shorter hospital lengths of stay, and

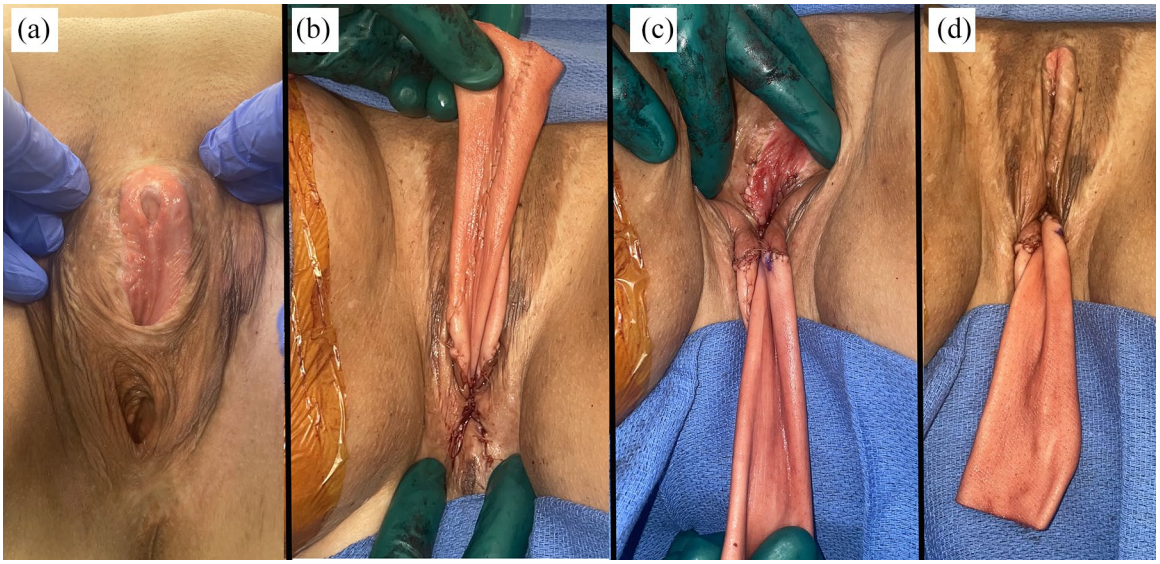

Figure 5. The use of acellular dermal matrix, in this case Alloderm®, in revision vaginoplasty to improve vaginal depth after standard penile inversion vaginoplasty performed at an outside hospital that was complicated by almost complete loss of depth. (a) Appearance of external genitalia at presentation. (b) Perineoplasty required to improve the appearance of the introitus. (c) and (d) Placement of Alloderm® to form the neovaginal canal. Note the minimal amount of residual penile skin from the initial surgery.

fewer intraoperative complications when the robotic approach was used.[33] Thus, it is evident from the current literature that patients do well following robotic colpectomy with colpocleisis and, with further corroboration of the evidence that outcomes are improved during robotic colpectomy with colpocleisis, this approach will likely become more common.

Phalloplasty. The Symani Surgical System (MMI, DE, Jacksonville, FL, USA) is a microsurgical robot that can be used to perform phalloplasty. One case study described the use of this robotic system to perform the phalloplasty portion of a masculinizing gender-affirming surgery without complications.[34] This novel robotic system thus demonstrates promise in improving the performance of phalloplasty by providing an alternative to traditional microsurgical approaches.

Use of grafts and flaps

The use of flaps and grafts is a fundamental strategy for gender-affirming surgery, regardless of patient gender, in both the primary and revision setting. Numerous techniques have been described to employ grafts and flaps to augment available tissue for optimizing functional and aesthetic outcomes.

Grafts and flaps in feminizing genital reconstructive surgery. Peritoneal flaps are widely used in GAV. Recently, some institutions have described techniques for revision vaginoplasty with peritoneal flaps that utilize the robotic platform. Dy et al. first described their technique in 24 patients who received robotic peritoneal flap revision vaginoplasty after primary PIV or vulvoplasty. To perform this technique, the robot (either the Xi or SP platform) is used to create a plane between the prostate and the rectum for the neovaginal space, as seen in Figure 4.[4] The dissection is continued toward the perineum until the apex of the stenotic neovagina is encountered, which is then incised horizontally. The anterior peritoneal flap is raised from the posterior aspect of the bladder, while the posterior flap is raised lateral to the rectum on either side. The robot then assists in suturing the posterior peritoneal flap to the posterior aspect of the neovagina and the anterior peritoneal flap to the anterior aspect of the neovagina, creating a circumferential anastomosis.[3,20] Short-term outcomes of this study demonstrated a mean neovaginal depth and width of 13.6 cm and 3.6 cm, respectively, which was comparable to other revision techniques.

Smith et al.[35] have described an alternative option for robotic revision vaginoplasty using a urachus-peritoneal hinge flap. In their technique, a long

pedicle-flap of peritoneum, urachus, and transversalis fascia is raised from the dome of the bladder at the level of the umbilicus. The flap is flipped back on itself, and the end closest to the umbilicus is sutured to the posterior wall of the stenosed or shortened neovaginal canal. The flap remains in a collapsed state unless it is in use (i.e., when the patient is using a vaginal dilator or engaging in receptive vaginal intercourse). The proposed advantages of this technique are the ability to avoid involvement of the rectum and the lack of resting tension on the lateral suture lines of the neovaginal canal pouch.[35] In their cohort of 10 patients who underwent this technique, Smith et al. found a mean neovaginal depth of 12.5 cm at final follow-up with high patient satisfaction. For both techniques, data on long-term outcomes and satisfaction are not yet available.

A jejunal free flap using a the greater saphenous vein anastomosed to the femoral artery as its blood supply has been described to aid in formation of a neovagina.[36] In this study, six subjects underwent this procedure and the median length of the jejunal segment was 18 cm. In this study, no bowel complications were noted, although several subjects required return to the operating room for hematoma evacuation, confirming vascularity of the flap, ventral hernia, or introital stenosis. Despite these further operative interventions, the gender-affirming surgeries based upon the jejunal flap were overall a success.

Acellular dermal matrices, such as Alloderm®, are commercially available biologic products that have been described as graft material in gender-affirming surgery, especially in the revision setting.[6,37] Such products can easily be placed through robotic ports and utilized intraperitoneally via a robotic approach. These products can be especially useful when there is a lack of other tissue available, such as in the setting of prior graft loss, or a history of multiple revisions which have used the other available options for grafting. Thus, in situations in which there is a lack of tissue available, such products may improve the feasibility of a desirable repair. Future work will likely define further roles for this type of biologic graft materials in gender-affirming surgeries. Additionally, future histopathologic studies could yield better understanding into how acellular dermal matrix products are incorporated into tissues in the setting of its use in gender-affirming surgery.

Grafts and flaps in masculinizing genital reconstructive surgery. When colpectomy with colpocleisis is combined with phalloplasty, a graft of vaginal mucosa can be harvested via the robotic approach and used to form the glans or the urethra of the neophallus.[2] The gracilis muscle flap is also amenable to placement via a robotic approach during colpectomy with colpocleisis and phalloplasty. While one surgeon is performing the robotic-assisted colpectomy with colpocleisis, a second surgeon can isolate the gracilis muscle and use it as a pedicled flap by passing it under the groin skin to the perineal region, where it serves as the support and blood supply to the neourethra and to obliterate the dead space following colpectomy with colpocleisis.[38] Following this technique performed in 16 subjects, no major complications were noted at a median follow-up of 361 days.[38]

Use of robot in managing complications from gender-affirming surgery

Patients who have undergone gender-affirming surgery may desire revision for aesthetic and/or functional reasons. Complications are common after genital reconstruction for gender affirmation and can include complications related to the neovagina, neophallus, flap sites, or intraabdominal complications. Reported neovaginal stenosis rates range from 1% to 12%.[4] Studies have demonstrated an approximately 2% rate of intraabdominal complications, such as postoperative hematoma, abscesses, bowel obstruction, and internal hernias.[39] The following section will discuss common complications from both masculinizing and feminizing gender affirmation surgeries, as well as the utility of the robotic platform in managing such complications where applicable.

Complications from feminizing genital reconstructive surgery

Neovaginal stenosis, insufficient vaginal depth, or vaginal depth loss. Ideal transfeminine surgery includes adequate vaginal depth and a non-stenotic vaginal opening. Neovaginal stenosis or shortening is a complication that may arise from primary GAV, either from granulation tissue or nonadherence to vaginal dilation. Stenosis is common following intestinal vaginoplasty, and occurs at a rate of about 20%.[10] Multiple options exist for canal reconstruction to treat neovaginal stenosis; however, the literature is sparse. These options include a perineal approach using full thickness skin grafts from the abdomen or lower extremities, extracellular matrix grafts, open

or laparoscopic/robotic intestinal vaginoplasty (as described above), or the use of peritoneal flaps.[4,40–42] Vaginal canal reconstruction can be difficult due to challenging surgical exposure, lack of tissue, and risk of injury to the urinary tract, bowel, and rectum.[4,5,41,43] Currently, no optimal approach has been established for revision vaginoplasty in these circumstances.

Vaginal depth can be inadequate immediately following surgery or can be lost over time due to lack of blood supply to the vaginal canal or insufficient dilation during the follow-up period.[4] One study of nine subjects with symptomatic loss of vaginal depth demonstrated a median remnant vaginal depth of 3 cm, with three subjects reporting absence of the neovagina.[6] Another study of subjects who required revision of feminizing surgery on their external genitalia noted that 34.3% of subjects also required vaginal canal revision, which may indicate that similar factors contribute to both of these complications.[5] Revisions can be performed via an abdominal, perineal, or combined approach, and the use of the robot to perform the abdominal portion of the surgery can be advantageous.[4,6,43]

Revision vaginoplasty can be performed to revise a stenotic or collapsed vaginal canal, which often requires the use of flaps. Surgeons must first remove the stenotic or collapsed vaginal canal from the remaining patent portion. Then, peritoneal flaps, remnant scrotal skin, or lower abdominal grafts are used to reconstruct the proximal neovagina.[4,6] The use of a urachus-peritoneal hinge flap to form the neovagina in the revision setting has also been described.[44] In one study, a stenotic neovagina was repaired with a combined perineal and robotic approach, including the advancement of a flap of native urethra to form the anterior wall of the revised neovagina and use of remnant scrotal flaps to create the posterior neovagina.[43] These flaps were formed into a tubular neovagina and secured to the peritoneum robotically.[43]

Alloderm®, a decellularized scaffold of extracellular matrix, can also be used to form a neovagina, as seen in Figure 5.[6] To perform a revision vaginoplasty using the latter technique, the Alloderm® is sutured to the peritoneal flaps instead of utilizing a scrotal skin graft.[6] Parker et al. evaluated nine subjects undergoing revision vaginoplasty using Alloderm® to deepen the canal, finding that median depth improved from 3 to 12 cm. In this study, no subjects experienced an intraoperative complication from the revision vaginoplasty.[6]

Several studies of revision vaginoplasty report complications. Following neovaginal revision, granulation tissue formed at the peritoneal portion of the vaginal canal in 3 of 9 subjects in one study (Parker et al.) and two of 24 subjects in another study (Dy et al.) following robotic-assisted revision vaginoplasty, which were treated with excision in the office.[4,6] Parker et al. also noted vaginal restenosis in a subject who was unable to perform routine dilations, a pelvic fluid collection in one subject, and postoperative incontinence in one subject, which resolved with improved diabetes control.[6] Thus, complications requiring further management can occur in the setting of revision vaginoplasty and must be discussed with patients prior to proceeding with the revision.

Neovaginal prolapse. Prolapse of the neovagina has been described following feminizing gender-affirming surgery, which can lead to pain and difficulty with dilation.[45] Multiple techniques for management have been described, including the use of the medial umbilical ligament as an autologous graft via the robotic approach to perform a sacrocolpopexy.[45] To perform this procedure, a Y-shaped tissue graft is created and secured to the sacral promontory and the neovagina, after which the peritoneum is closed over the operative sites.[45] Neovaginal prolapse can also occur for individuals undergoing intestinal vaginoplasty.[10] To reduce the risk of this complication, the neovagina can be sutured to the sacral promontory with permanent sutures.[10]

Fistula. Following vaginoplasty, fistulae can form between the neovagina and the bowel, bladder, or prostate. One abstract presented at the American Urological Association meeting in 2021 evaluated a subject that developed a fistula between the prostate and neovagina following feminizing PIV.[46] To repair the fistula, the subject underwent a robotic-assisted revision vaginoplasty using a sigmoid flap to form the neovagina.[46] Outcomes were excellent with continence, no fistula recurrence, and a vaginal depth of 6 inches at 6 months of follow-up.[46] A separate group also repaired a fistula between the rectum and neovagina using a sigmoid vaginoplasty after attempted management with colonic diversion failed.[47]

Intraabdominal hematoma or fluid collection. Subjects can develop fluid collections or abscesses following robotic vaginoplasty due to the complex nature of the abdominal operation. In one study, Robinson et al. noted 1 subject out of 247 vaginoplasties developed a hematoma, which required a return to the operating room for hematoma drainage and transfusion of 8 units of blood.[39] Intraoperatively, no source of bleeding was identified and the subject recovered uneventfully. The same study demonstrated intraabdominal abscesses in 2 of 247 subjects following robotic-assisted peritoneal flap vaginoplasty, requiring drain placement or diagnostic laparoscopy to manage.[39] Both subjects recovered and were successfully able to dilate their neovagina.

Internal hernia. In the study by Robinson et al. evaluating complications after peritoneal flap vaginoplasty, 2 of 247 subjects experienced an internal hernia resulting in small bowel obstruction.[39] One subject had herniation of bowel through a dehiscence of the neovagina, which was managed with laparoscopic hernia reduction and neovagina repair.[39] The second subject had bowel herniation at the peritoneal flap donor site, which was repaired robotically.[39]

Complications from masculinizing genital reconstructive surgery

Cuff dehiscence. Breakdown of the vaginal cuff after hysterectomy is an established complication, both for the transgender and cisgender populations. One study compared outcomes for cisgender and transgender subjects out of 166 subjects who underwent minimally invasive hysterectomy, 49 of whom were transgender, with one subject having undergone robotic-assisted hysterectomy in the transgender cohort.[48] In this study, 6.1% of subjects in the transgender group and 1.7% of subjects in the cisgender group experienced a vaginal cuff dehiscence, which was statistically significant.[48] The authors of this study concluded that preoperative testosterone therapy may have contributed to the risk of vaginal cuff dehiscence, but this relationship remains to be established with prospective studies.[48]

Vaginal remnant. Previous studies have reported that approximately 47% of individuals will experience a symptomatic vaginal remnant following colpectomy with colpocleisis for gender affirmation.[49] When a vaginal remnant is incompletely excised in transgender male patients, it can cause incontinence due to pooling of urine.[49] Other symptoms include urine leak, urinary tract infections, and pain.[49] A combined robotic and perineal approach has been described to excise a vaginal remnant, with a high degree of success and no recurrences described in one study.[49] In this study, two of three subjects who desired to stand to void were able to do so and only one of four subjects had spraying with urination.[49]

Voiding dysfunction. Voiding dysfunction can be a concern following colpectomy with colpocleisis that can serve as a barrier to further genital reconstruction. In one study of subjects who had undergone colpectomy with colpocleisis, 67% of whom had their surgery via a robotic approach, and 5% of subjects were unable to undergo a subsequent urethral lengthening surgery due to voiding dysfunction.[50] Among subjects with persistent voiding dysfunction, 4 of 6 had had surgery via the robotic approach, indicating that this issue is not unique to robotic colpectomy with colpocleisis. Thus, it is worthwhile to council patients regarding the possibility of voiding dysfunction after vaginoplasty regardless of approach.

Use of the single port platform in gender-affirming surgery

Multiple authors have described the use of the SP robotic surgical platform to perform gender-affirming surgery; however, few studies have compared the SP to the Xi, limiting the ability to compare the techniques within this review.[4,16,29,30] One study that did compare the SP to the Xi in the performance of vaginoplasty noted that the SP decreased operative time by allowing the perineal surgeon and robotic surgeon to work more effectively simultaneously.[16] In this study, several outcomes, such as need for transfusions, vaginal depth, and occurrence of vaginal stenosis favored the SP platform.[16] Other advantages of the SP platform include the single incision site, which may be associated with improved cosmesis, and the ability to perform extraperitoneal surgery when desired. Disadvantages of the SP platform include the learning curve required to master the instrumentation, which many practicing surgeons were not trained to use during residency. Furthermore, insufflation and suction can be more difficult with this platform compared to the Xi. While this technique has clearly shown substantial promise in gender-affirming surgery, more studies are needed to further evaluate the optimal use of the SP robotic system for

gender-affirming surgery and identify unique strengths and challenges of this approach.

Strengths and limitations

Though gender-affirming surgery has become increasingly prevalent in the past few decades, literature surrounding this field of surgery is still relatively lacking. Due to the paucity of studies on gender-affirming surgery and its outcomes, the authors were able to undergo a thorough and comprehensive review of the existing literature.

This review has some notable limitations. Given the aforementioned lack of research on gender-affirming surgery, the studies included had relatively small sample sizes, and many studies were performed as a single institution, which may decrease the generalizability of the results. The review also did not include any studies that were not published in English, limiting the scope of our review. Additionally, many of the modern techniques in gender-affirming surgery have emerged in the last decade; thus, long-term outcomes are yet to be described.

Conclusion

The surgical robot is a useful tool to perform many gender-affirming surgeries, including both primary surgeries and revisions. In both the primary and revision settings, the surgical robot is able to reach the deep pelvis with excellent visualization, which can be advantageous in performing complex gender-affirming procedures. With more reconstructive urologic surgeons receiving robotic training and further technique development, robotic approaches to gender-affirming care will increasingly be adopted.

Future directions

The surgical robot is highly amenable to the deep pelvic surgeries required for hysterectomy, colpectomy with colpocleisis, and vaginoplasty. The technical approaches to performing these cases will continue to develop. The robotic placement of gracilis flaps and the robotic procurement of vaginal mucosal graft tissue in the setting of colpectomy with colpocleisis and phalloplasty are well described.[2,38] However, when these tissues are insufficient, there are opportunities to further develop strategies to fill the space left during the colpectomy with colpocleisis, create the neourethra, or construct the glans. Additionally, when the peritoneal flaps typically used for vaginoplasty are insufficient, for example, due to prior surgeries, alternatives must be developed. One recent example is the use of Alloderm® to form the superior aspect of the neovagina.[6] Further biologic or synthetic materials would assist in providing needed tissue in the primary or revision settings to facilitate cosmesis and function.

Declarations

Ethics approval and consent to participate

The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Photographs used for figures were completely unidentified and no details on persons are mentioned within the text. There was no direct human subject involvement in this work.

Consent for publication

Written informed consent was obtained from all patients included in the study.

Author contributions

Karen M. Doersch: Conceptualization; Investigation; Project administration; Writing – original draft; Writing – review & editing.

Lily Kong: Conceptualization; Investigation; Writing – original draft; Writing – review & editing.

Christodoulos Kaoutzanis: Conceptualization; Visualization; Writing – original draft; Writing – review & editing.

Ty Higuchi: Conceptualization; Methodology; Writing – original draft; Writing – review & editing.

Acknowledgements

None.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Competing interests

All authors have completed the ICMJE uniform disclosure form. The authors have no conflicts of interest related to this manuscript to declare.

Availability of data and materials
Not applicable.

ORCID iD
Karen M. Doersch https://orcid.org/0000-0001-8374-9639

References

1. Lee A, Cruz J, Nahas S, et al. Hysterectomy with or without oopherectomy for transgender male patients: preoperative and intraoperative considerations. *J Minimally Invasive Gynecol* 2022; 29: S87–S88.
2. Jun MS, Shakir NA, Blasdel G, et al. Robotic-assisted vaginectomy during staged gender-affirming penile reconstruction surgery: technique and outcomes. *Urology* 2021; 152: 74–78.
3. Jun MS, Gonzalez E, Zhao LC, et al. Penile inversion vaginoplasty with robotically assisted peritoneal flaps. *Plast Reconstr Surg* 2021; 148(2): 439–442.
4. Dy GW, Blasdel G, Shakir NA, et al. Robotic peritoneal flap revision of gender affirming vaginoplasty: a novel technique for treating neovaginal stenosis. *Urology* 2021; 154: 308–314.
5. Dy GW, Salibian AA, Blasdel G, et al. External genital revisions after gender-affirming penile inversion vaginoplasty: surgical assessment, techniques, and outcomes. *Plast Reconstr Surg* 2022; 149(6): 1429–1438.
6. Parker A, Brydges H, Blasdel G, et al. Mending the gap: AlloDerm as a safe and effective option for vaginal canal lining in revision robotic assisted gender affirming peritoneal flap vaginoplasty. *Urology* 2023; 173: 204–208.
7. Weinstein B, Govekar H, Cherullo E, et al. Robotics in genital gender-affirming surgery. *Plast Aesthet Res* 2023; 10: 61.
8. Coon D, Morrison SD, Morris MP, et al. Gender-affirming vaginoplasty: a comparison of algorithms, surgical techniques and management practices across 17 high-volume centers in North America and Europe. *Plast Reconstr Surg Glob Open* 2023; 11(5): e5033.
9. Boztosun A and Olgan S. Robotic sigmoid vaginoplasty in an adolescent girl with Mayer-Rokitansky-Kuster-Hauser syndrome. *Female Pelvic Med Reconstr Surg* 2016; 22(5): e32–e35.
10. van der Sluis WB, Tuynman JB, Meijerink W, et al. Laparoscopic intestinal vaginoplasty in transgender women: an update on surgical indications, operative technique, perioperative care, and short- and long-term postoperative issues. *Urol Clin North Am* 2019; 46(4): 527–539.
11. Bouman MB, van Zeijl MCT, Buncamper ME, et al. Intestinal vaginoplasty revisited: a review of surgical techniques, complications, and sexual function. *J Sex Med* 2014; 11(7): 1835–1847.
12. Pariser JJ and Kim N. Transgender vaginoplasty: techniques and outcomes. *Transl Androl Urol* 2019; 8(3): 241–247.
13. Zilavy AJ, Santucci RA and Gallegos MA. The history of gender-affirming vaginoplasty technique. *Urology* 2022; 165: 366–372.
14. Stoeckel W. V. Zur operativen Herstellung einer künstlichen Vagina. *Monatsschrift für Geburtshilfe und Gynäkologie* 2010; 50(2): 129–140.
15. Davydov SN and Zhvitiashvili OD. Formation of vagina (colpopoiesis) from peritoneum of Douglas pouch. *Acta Chir Plast* 1974; 16(1): 35–41.
16. Dy GW, Jun MS, Blasdel G, et al. Outcomes of gender affirming peritoneal flap vaginoplasty using the Da Vinci Single Port versus Xi Robotic systems. *Eur Urol* 2021; 79(5): 676–683.
17. Morelli G, Zucchi A, Ralph D, et al. A single pedicled robotic peritoneal flap in penile inversion vaginoplasty augmentation. *BJU Int* 2023; 131(1): 125–129.
18. Jacoby A, Maliha S, Granieri MA, et al. Robotic Davydov peritoneal flap vaginoplasty for augmentation of vaginal depth in feminizing vaginoplasty. *J Urol* 2019; 201(6): 1171–1176.
19. Johnston AW, Soyster ME, Koch MO, et al. Gender-affirming robotic tubularized peritoneal vaginoplasty: feasibility and outcomes. *Urology* 2025; 195: 191–198.
20. Acar O, Sofer L, Dobbs RW, et al. Single port and multiport approaches for robotic vaginoplasty with the Davydov technique. *Urology* 2020; 138: 166–173.
21. Peters BR, Martin LH, Butler C, et al. Robotic peritoneal flap vs. perineal penile inversion techniques for gender-affirming vaginoplasty. *Curr Urol Rep* 2022; 23(10): 211–218.
22. Dy GW, Dugi DD and Peters BR. Skin management during robotic peritoneal flap vaginoplasty for penoscrotal hypoplasia secondary to pubertal suppression. *Urology* 2023; 173: 226–227.
23. Blasdel G, Kloer C, Parker A, et al. Genital hypoplasia before gender-affirming vaginoplasty: does the robotic peritoneal flap method create

equivalent vaginal canal outcomes? *Plast Reconstr Surg* 2023; 151(4): 867–874.

24. Acar O, Alcantar J, Millman A, et al. Outcomes of penile inversion vaginoplasty and robotic-assisted peritoneal flap vaginoplasty in obese and nonobese patients. *Neurourol Urodyn* 2023; 42(5): 939–946.
25. Blasdel G, Borah L, Navarrete R, et al. Prostatectomy after gender-affirming vaginoplasty for a transgender woman with prostate cancer. *Urol Case Rep* 2024; 56: 102819.
26. Makhija N and Mihalov L. Hysterectomy as gender-affirmation surgery in female-to-male transgender persons. *Obstet Gynecol* 2017; 129: 173S.
27. Giampaolino P, Della Corte L, Improda FP, et al. Robotic hysterectomy as a step of gender affirmative surgery in female-to-male patients. *J Invest Surg* 2021; 34(6): 645–650.
28. Bogliolo S, Cassani C, Babilonti L, et al. Robotic single site hysterectomy with bilateral salpingo-oophorectomy in female to male transsexualism. *J Sex Med* 2014; 11(1): 313.
29. Bogliolo S, Cassani C, Babilonti L, et al. Robotic single-site surgery for female-to-male transsexuals: preliminary experience. *ScientificWorldJournal* 2014; 2014: 674579.
30. Gardella B, Dominoni M, Bogliolo S, et al. Surgical outcome for robotic-assisted single-site hysterectomy (RSSH) in female-to male reassignment compared to its use in benign gynecological disease: a single center experience. *J Robot Surg* 2021; 15(4): 579–584.
31. Groenman F, Nikkels C, Huirne J, et al. Robot-assisted laparoscopic colpectomy in female-to-male transgender patients; technique and outcomes of a prospective cohort study. *Surg Endosc* 2017; 31(8): 3363–3369.
32. Hougen HY, Shoureshi PS and Sajadi KP. Gender-affirming vaginectomy-transperineal approach. *Urology* 2020; 144: 263–265.
33. Nikkels C, Vestering A, Huirne JAF, et al. Robotic-assisted laparoscopic colpectomy combined with a hysterectomy and bilateral salpingo-oophorectomy versus a vaginal colpectomy in trans masculine individuals. *Int J Transgend Health* 2024; 25(4): 878–887.
34. Wellenbrock S, Ozturk M, Sohn M, et al. Robotic-assisted microsurgery in gender-affirming phalloplasty. *Ann Plast Surg* 2025; 94(1): 2–4.
35. Smith SM, Yuan N, Stelmar J, et al. An alternative option for gender-affirming revision vaginoplasty: the tubularized urachus-peritoneal hinge flap. *Sex Med* 2022; 10(6): 100572.
36. Del Corral GA, Chang BL, Lava CX, et al. The robotic-assisted free jejunal flap for neovaginal canal creation in gender-affirming vaginoplasties. *Microsurgery* 2024; 44: e31202.
37. Alba B, Weinstein B, Arnold SH, et al. The use of acellular tissue matrices in gender-affirming surgery: review of the literature and institutional experience. *Adv Biol (Weinh)* 2024; 8(9): e2300507.
38. Cohen O, Stranix JT, Zhao L, et al. Use of a split pedicled gracilis muscle flap in robotically assisted vaginectomy and urethral lengthening for phalloplasty: a novel technique for female-to-male genital reconstruction. *Plast Reconstr Surg* 2020; 145(6): 1512–1515.
39. Robinson IS, Blasdel G, Bluebond-Langner R, et al. The management of intra-abdominal complications following peritoneal flap vaginoplasty. *Urology* 2022; 164: 278–285.
40. van der Sluis WB, Bouman MB, de Boer NKH, et al. Long-term follow-up of transgender women after secondary intestinal vaginoplasty. *J Sex Med* 2016; 13(4): 702–710.
41. Van der Sluis WB, Bouman MB, Buncamper ME, et al. Revision vaginoplasty: a comparison of surgical outcomes of laparoscopic intestinal versus perineal full-thickness skin graft vaginoplasty. *Plast Reconstr Surg* 2016; 138(4): 793–800.
42. Gupta A, Francis S, Stewart R, et al. Repair of colonic neovaginal stenosis using a biological graft in a male-to-female transgender patient. *Int Urogynecol J* 2019; 30(4): 661–663.
43. Pinkhasov A, Bratslavsky G, Upadhyaya P, et al. Manuscript- revision vaginoplasty with robotic assistance for obliterated neovagina. *Urol Video J* 2023; 20: 100241.
44. Yuan N, Gupta A and Garcia M. An alternative option for gender-affirming revision vaginoplasty: the tubularized urachus-peritoneal hinge flap. *J Urol* 2021; 206: 100572.
45. Egbe A, Issa R, Walker R, et al. Robotic sacrocolpopexy with medial umbilical ligament autologous graft to treat neovaginal prolapse in a transgender woman. *Urol Case Rep* 2023; 51: 102580.
46. Young J, Kent M, Wiklund P, et al. Robotic sigmoid vaginoplasty and urethral reconstruction for prostatoneovaginal fistula. *J Urol* 2021; 206: e551.

47. Fouche D, Boissieras L, Marichez A, et al. Robotic sigmoid colon vaginoplasty for rectovaginal fistula after gender affirming surgery by penile inversion technique: a video vignette. *Colorectal Dis* 2024; 26(5): 1074–1075.

48. O'Connor RM, Scott ME and Rimel BJ. Vaginal cuff dehiscence in transgender patients after minimally invasive hysterectomy. *J Minim Invasive Gynecol* 2024; 31(2): 138–146.

49. Cohen OD, Dy GW, Nolan IT, et al. Robotic excision of vaginal remnant/urethral diverticulum for relief of urinary symptoms following phalloplasty in transgender men. *Urology* 2020; 136: 158–161.

50. de Rooij FPW, Ronkes BL, Groenman FA, et al. The effect of colpectomy on lower urinary tract function in transgender men. *Int J Transgend Health* 2023; 24(4): 510–518.