MÆDICA - a Journal of Clinical Medicine

REVIEW

MAEDICA – a Journal of Clinical Medicine
2025; 20(4): 840-850
https://doi.org/10.26574/maedica.2025.20.4.840

# The Role of Laparoscopic Surgery in Gynecological Congenital Anomalies

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## ABSTRACT

***Background:*** *Müllerian duct anomalies (MDAs) comprise a heterogeneous group of congenital malformations of the uterus, cervix and vagina that can impair menstruation, sexual function and fertility. Over the past three decades, minimally invasive techniques have largely replaced laparotomy for their surgical management; yet, data remain fragmented across small series and diverse anomaly types.*

***Objective:*** *To synthesize contemporary evidence on laparoscopic and robotic management of MDAs, highlighting indications, key surgical techniques and reproductive and functional outcomes, while addressing psychosocial and ethical considerations.*

***Methods:*** *A comprehensive narrative review was conducted in PubMed, Scopus and Google Scholar (January 1995–June 2024) using predefined Boolean combinations for specific anomalies and minimally invasive procedures. We included English-language, peer-reviewed clinical studies and sizable case series ($n \geq 3$) reporting laparoscopic, laparoscopic-assisted, or robotic management of congenital uterine, cervical, or vaginal anomalies. The review was designed and reported in accordance with SANRA guidelines for narrative reviews.*

***Results:*** *Laparoscopy has become central to the management of fusion and obstructive anomalies. Laparoscopic Strassman metroplasty in selected bicornuate uteri and laparoscopic excision of rudimentary horns in unicornuate uteri achieve high rates of symptom relief, reduction in miscarriage risk, and subsequent term pregnancies, with fewer adhesions than open surgery. In uterus didelphys and obstructed hemivagina and ipsilateral renal anomaly (OHVIRA), combined vaginal and laparoscopic approaches effectively relieve obstruction while preserving the functional uterus. For vaginal agenesis in Mayer–Rokitansky–Küster–Hauser syndrome, laparoscopic Vecchietti, Davydov and sigmoid vaginoplasties consistently provide anatomically adequate neovaginas and satisfactory sexual function. Robotic assistance facilitates complex suturing in selected reconstructions, but clear superiority over conventional laparoscopy has not been demonstrated.*

***Conclusions:*** *Minimally invasive surgery has transformed the management of MDAs by enabling effective correction of complex malformations with reduced morbidity and favorable reproductive and functional outcomes in appropriately selected patients. However, the evidence base is dominated by observational studies from specialized centers, with limited standardized reporting of fertility and psychosexual endpoints. Future multicenter, prospective research integrating uniform classification, core outcome sets and long-term psychosocial follow-up is needed to refine patient selection and optimize care pathways.*

**Keywords**: Müllerian duct anomalies, laparoscopy, minimally invasive surgery, robotic surgery, reproductive outcomes.

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*Article received on the 19th of November 2025 and accepted for publication on the 10th of December 2025*

## INTRODUCTION

Müllerian duct anomalies (MDAs) are disorders of development that arise from defects in organogenesis and subsequent differentiation of the Müllerian ducts (paramesonephric ducts), which are the embryonic origin of most of the female reproductive tract (FRT). Therefore, MDAs can cause abnormalities anywhere along the FRT, including the fallopian tubes, uterus or uterine horns, and the upper two-thirds of the vagina.

Despite the clinical significance of this topic, we still do not have a thorough understanding of the etiology and pathogenesis of MDAs, not only because it is considered a complex topic, but also because the number of studies and patient samples is limited.

The prevalence of MDAs among the normal female population is estimated to be around 6.7%. However, those numbers change when we investigate specific subtypes of the female population: infertile females show an MDA prevalence of 7.3% and women with repeated miscarriages show a prevalence of 16.7% (1).

The female reproductive system develops through differentiation, migration, fusion, and canalization of the Müllerian ducts. The absence of the Y chromosome, testosterone and AMH in females leads to the regression of the Wolffian ducts and the development of the Müllerian ducts into the female reproductive organs, such as the fallopian tubes, uterus, and upper vagina. Fusion with the urogenital sinus forms the vaginal plate, which canalizes into the lower vagina. MDAs occur when there is a disruption at any stage during this process. Complex MDAs can result from disturbances at multiple developmental stages, which explains the wide anatomical variability (2).

Several classification systems have been developed to group and study MDAs, starting with the Buttram & Gibbons (1979), then the ASRM/AFS (1988), which is still widely used, followed by the two most recent systems: the ESHRE/ESGE (2013) and the updated ASRM (2021), which will be discussed in our paper. The ESHRE/ESGE system categorizes anomalies based on uterine anatomy, with independent classifications for the cervix and vagina, using a structured coding system (U0–U6 for the uterus, C0–C4 for the cervix, and V0–V4 for the vagina) to capture the wide spectrum of phenotypes (3). The updated ASRM classification organizes Müllerian anomalies into nine clinically oriented categories, including Müllerian agenesis/hypoplasia, cervical agenesis/hypoplasia, unicornuate uterus, uterus didelphys, bicornuate uterus, septate uterus, longitudinal and transverse vaginal septa and a final group of complex combined anomalies (4).

Although laparoscopy and hysteroscopy are the gold standards for the detection of MDAs, they are considered invasive. Therefore, less invasive imaging modalities have been developed over the years. Three-dimensional transvaginal ultrasound provides coronal views of the internal and external uterine contours and is now considered the imaging gold standard for detecting and classifying most uterine abnormalities (2). Magnetic resonance imaging (MRI) offers multiplanar imaging, excellent soft tissue detail, and a wide field of view, which allows accurate assessment of uterine morphology and associated renal or pelvic anomalies and is particularly useful in complex cases or when ultrasound findings are inconclusive (2). Hysteroscopy is reserved as a more invasive technique that provides direct visualization of the uterine cavity and is often combined with laparoscopy when a complete evaluation and operative management are planned (2).

Management of MDAs has shifted towards a minimally invasive approach in recent decades, as they are now managed mostly by laparoscopy. The first true laparoscopy on a human was performed in 1910 to inspect the human peritoneal, thoracic, and pericardial cavities. After about 40 years, gynecological laparoscopy was introduced and performed extensively in Europe. This technique reached a large number of English speakers when Patrick Steptoe published an English textbook describing laparoscopic surgical techniques. At first, laparoscopy was used for diagnosis and simple procedures such as tubal ligation, and then developments were gradually made to cover more complex cases. Today, minimally invasive surgery is the standard of care for the treatment of many gynecological conditions, and it is widely used all over the world. Many benefits have made this type of surgery more favorable among surgeons, such as decreased blood loss, decreased postoperative pain, decreased perioperative complications,

shorter hospitalization, and faster recovery when compared to laparotomy (5). Given this shift towards minimally invasive surgery, this narrative review synthesizes the available evidence on laparoscopic and robotic management of Müllerian duct anomalies, with a focus on indications, surgical techniques, and reproductive or functional outcomes. ❑

## METHODOLOGY

A comprehensive literature search was conducted to capture relevant publications on the minimally invasive (laparoscopic and robotic) management of Müllerian anomalies. We queried multiple databases – PubMed, Scopus and Google Scholar – using Boolean combinations of keywords such as "laparoscopy AND Müllerian anomalies", "laparoscopic metroplasty", "laparoscopic vaginoplasty", "robotic Müllerian anomaly" and specific terms for each congenital condition (e.g., "OHVIRA syndrome laparoscopy", "unicornuate uterus rudimentary horn"). Additional references were identified by handsearching the bibliographies of key review articles (2015–2024) in *Human Reproduction Update*, *Fertility and Sterility* and *Journal of Minimally Invasive Gynecology*.

**Inclusion criteria** – We focused on human female patients of all ages (emphasizing adolescents and reproductive-age) with congenital Müllerian anomalies of the uterus, cervix and/or vagina. Eligible conditions included septate, bicornuate, didelphys and unicornuate uteri, including variants like obstructed hemivagina and ipsilateral renal anomaly (OHVIRA), as well as vaginal outflow tract anomalies (imperforate hymen, transverse vaginal septum) and agenesis syndromes (Mayer–Rokitansky–Küster–Hauser (MRKH) and cervicovaginal agenesis). Studies had to involve a minimally invasive intervention – primarily laparoscopic or laparoscopically-assisted surgical management (including robotic-assisted cases) – either as the sole approach or in comparison to open or hysteroscopic methods. Both outcome studies (reporting surgical results such as symptom relief, fertility outcomes, complications) and significant technical series were included. We included prospective and retrospective cohort studies, case–control studies, clinical trials, and sizable case series (n ≥ three patients). Systematic or narrative reviews were used for background context.

**Time frame** – January 1995 up to June 2024 (to capture the modern laparoscopic era).

**Language** – English (or full English translations); publication types: full-text, peer-reviewed journal articles (no abstracts, dissertations, or non-peer-reviewed reports).

**Exclusion criteria** – We excluded studies focusing on acquired uterine/vaginal pathology (fibroids, Asherman's syndrome, etc) rather than congenital anomalies, and those with no laparoscopic component (purely open or hysteroscopic procedures without a minimally invasive arm). Diagnostic imaging studies without surgical outcomes were excluded from the treatment analysis (though we used some for epidemiology/diagnosis background). We also excluded animal or cadaveric simulations and single-patient case reports unless they described an exceedingly rare anomaly or novel technique not otherwise represented in larger series. In instances of multiple publications from the same center/cohort, the most comprehensive or recent study was used to avoid double-counting.

Our narrative review methodology was designed in accordance with best practices for scientific reviews. In particular, we adhered to the SANRA guidelines (Scale for the Assessment of Narrative Review Articles) to ensure a high-quality synthesis (6). This included clearly defining the review's scope and aims, performing a thorough literature search and critically appraising and referencing the evidence. By following these principles, we aimed to provide a transparent and reproducible methodology for this narrative review (6). All included sources were cross-checked for relevance to the research question, and findings were synthesized qualitatively given the heterogeneity of study designs and outcomes.

### Laparoscopic management of uterine anomalies

Müllerian anomalies of the uterus encompass defects in lateral fusion or septal resorption that can impact menstruation and fertility. Table 1 summarizes the classification of these anomalies by ASRM and ESHRE/ESGE. The uterine anomalies that require laparoscopic intervention primarily include septate uterus, bicornuate and

**TABLE 1.** Classification of Müllerian anomalies – comparison of ASRM 2021 (Müllerian Anomaly Classification, MAC) with ESHRE/ESGE 2013 system

| Anomaly category | ASRM 2021 classification | ESHRE/ESGE 2013 classification |
|---|---|---|
| Müllerian agenesis (uterine ± vaginal agenesis) | "Müllerian agenesis" (complete uterovaginal aplasia) | U5 – Aplastic uterus (often with C4 cervical aplasia and V4 vaginal aplasia) |
| Cervical agenesis (isolated absence of cervix) | "Cervical agenesis" (normal uterus, no cervix) | Classified as C4 – Cervical aplasia (uterus often normal shape, ± upper vaginal agenesis V3) |
| Unicornuate uterus (single hemi-uterus) | "Unicornuate uterus" (one-sided development with or without rudimentary horn) | U4 – Hemi-uterus (subclass U4a with rudimentary horn (communicating or not); U4b without horn) |
| Uterus didelphys (double uterus & cervix) | "Uterus didelphys" (complete bilateral non-fusion) | U3 – Bicorporeal uterus (complete separation) + C2 – double cervix (often with longitudinal vaginal septum) |
| Bicornuate uterus (partial fusion defect) | "Bicornuate uterus" (partial uterine fundal separation) | U3 – Bicorporeal uterus (partial fusion) (usually single cervix, C0 normal cervix) |
| Septate uterus (midline resorption defect) | "Septate uterus" (internal septum dividing cavity, partial or complete) | U2 – Septate uterus (classified by length of septum; normal external fundus contour) |
| Longitudinal vaginal septum | "Longitudinal vaginal septum" (double vagina ± double cervix) | V1 – Longitudinal vaginal septum (non-obstructive or obstructive; often associated with didelphys or septate cervix) |
| Transverse vaginal septum | "Transverse vaginal septum" (horizontal partition in vagina) | V3 – Transverse vaginal septum (location specified as upper, mid, or lower vagina) |
| Complex or mixed anomaly | "Complex anomaly" (multiple components) | Combination of classes (*e.g.*, U + C + V codes for each affected organ; *e.g.*, MRKH type II: U5 + C4 + V4) |

ASRM: American Society for Reproductive Medicine; ESHRE: European Society of Human Reproduction and Embryology; ESGE: European Society for Gynecological Endoscopy. The ASRM MAC 2021 system uses descriptive categories including uterine, cervical and vaginal anomalies in one framework. The ESHRE/ESGE system (2013) separately classifies uterine (U), cervical (C), and vaginal (V) anomalies; *e.g.*, a didelphys uterus with double cervices and a vaginal septum would be coded U3 C2 V1. Normal variants (*e.g.*, minor arcuate indentations) are considered normal (ASRM) or "dysmorphic" (ESHRE U1) rather than true anomalies (7).

didelphic uteri (lateral fusion defects) and the unicornuate uterus with a rudimentary horn.

### Septate uterus (septum removal *vs.* metroplasty)

A septate uterus results from failed resorption of the midline wall between the fused Müllerian ducts, creating a fibrous or fibromuscular partition. It is the most common Müllerian anomaly and is strongly associated with adverse reproductive outcomes – notably the highest miscarriage rate among uterine anomalies (8). Historically, septate uteri were treated *via* abdominal metroplasty (*e.g.*, Jones or Strassmann procedure) to incise the septum. Today, hysteroscopic septum resection is the gold-standard treatment, given its minimally invasive nature and high success in restoring normal uterine cavity anatomy. Hysteroscopic metroplasty significantly improves live birth rates in women with septate uteri and prior infertility or pregnancy losses (9). In contrast, laparoscopy has a limited direct role in pure septate uterus management. Laparoscopic observation can be used concurrently to confirm an external fundal contour (to distinguish a septate uterus from a bicornuate uterus) or to monitor for perforation during hysteroscopic cutting (9). However, laparoscopic excision of a uterine septum is generally unnecessary given the hysteroscopic access to the uterine cavity. Current guidelines emphasize hysteroscopic treatment for septate uteri, with studies suggesting improved obstetrical outcomes post-septoplasty despite a lack of randomized trials (9). Thus, the clinical role of laparoscopy is adjunctive for diagnosis or treating coexistent pelvic pathology, rather than for the primary correction of a septate uterus.

### Bicornuate and didelphys uterus (fusion anomalies and obstructed hemivagina and ipsilateral renal anomaly)

Bicornuate and didelphys uteri arise from partial or complete failure of lateral fusion of the

Müllerian ducts. A bicornuate uterus has two horned cavities that share a single cervix (partial fusion defect), whereas a uterus didelphys represents a complete non-fusion resulting in dual uterine bodies each with its own cervix (often accompanied by a longitudinal vaginal septum). These anomalies are associated with reproductive challenges such as miscarriage, malpresentation and preterm birth (8). Not all bicorporeal uteri require surgery – many women can carry pregnancies (albeit with higher preterm risk), so intervention is reserved for those with recurrent adverse outcomes or an obstructive component. In appropriately selected patients (*e.g.*, recurrent second-trimester losses attributable to a bicornuate uterus), a Strassman metroplasty can be performed laparoscopically to unify the two cavities. Case series have demonstrated that laparoscopic Strassman metroplasty is feasible and yields improved obstetric outcomes, converting a bicornuate uterus into a near-normal cavity (10, 11). In one report, women with bicornuate uteri and recurrent miscarriage who underwent laparoscopic metroplasty subsequently achieved term pregnancies and had resolution of prior infertility (10). Laparoscopic suturing and optical magnification allow precise approximation of the myometrial walls, mimicking the open technique but with less postoperative pain and adhesion formation.

For a uterus didelphys, surgical unification is seldom attempted – each uterus is often smaller, but can function independently. Historically it was thought didelphys uteri had normal reproductive outcomes, but research shows an increase in miscarriage and preterm birth rates in these patients as well (8). Unlike bicornuate uteri, a didelphys anomaly typically has two separate cervices and often a vaginal septum; thus, there is no simple way to surgically "unify" the fundi without extensive reconstruction. Instead, management focuses on treating any obstructive component and optimizing use of the existing uteri.

A key subtype is the OHVIRA (obstructed hemivagina and ipsilateral renal anomaly) syndrome, usually occurring in the setting of uterus didelphys. In OHVIRA, one vaginal hemichannel is blocked (due to a transverse septum or blind hemivagina) leading to hematocolpos and cyclic pain, while the contralateral side is normal; a unilateral renal agenesis is classically associated. The first-line treatment in OHVIRA is to relieve the outflow obstruction, typically by resecting or fenestrating the vaginal septum to drain the hematocolpos (12). Laparoscopy serves as an important adjunct in complex OHVIRA cases – it allows confirmation of the anatomical relationships and can address complications like endometriosis or adhesions secondary to chronic reflux menstruation. If the obstructed hemi-uterus is severely damaged or if diagnosis is delayed until significant infection (*e.g.*, abscess, pyometra) has occurred, a laparoscopic hemihysterectomy (removal of the affected uterus and ipsilateral cervix) may be indicated (12). Case reports document successful laparoscopic removal of a non-communicating infected uterine horn in OHVIRA, with resolution of pain and preservation of the normal uterus for future fertility (12). In one such case, after a laparoscopic hemihysterectomy the patient had complete relief of symptoms and no recurrence of pelvic infection at three-month follow-up (12). Overall, for bicornuate/didelphys anomalies, laparoscopy offers a minimally invasive route to perform metroplasty or excise a pathologic uterine unit, with the benefits of reduced adhesion formation and faster recovery compared to traditional laparotomy. Hybrid approaches are commonly employed (combining vaginal septum resection with laparoscopic guidance) to ensure complete treatment of all anatomic components.

**Unicornuate uterus with rudimentary horn**

A unicornuate uterus results from unilateral Müllerian development: one side forms a normal or hypoplastic uterus while the other side is absent or vestigial. In many cases a fibrous or rudimentary horn is present; if this horn contains functional endometrium and is not in communication with the main uterus, it can cause significant problems. Patients often present in adolescence with severe dysmenorrhea due to trapped menses in the rudimentary horn (acting like a "blind pouch"), and there is a risk of ectopic pregnancy implanting in the small horn, which can rupture given the horn's limited distensibility. For these reasons, the recommended management for a unicornuate uterus with a functional rudimentary horn is prophylactic removal of that horn (and its fallopian tube) *via* laparoscopy (13). Early laparoscopic excision of a non-communicating horn effectively alleviates pain and prevents future catastrophic events (such as a

**TABLE 2.** Key minimally invasive surgical interventions for Müllerian anomalies and outcomes

| Anomaly | Minimally invasive procedure | Outcome/benefit |
|---|---|---|
| Septate uterus (Class V, septum in cavity) | Hysteroscopic septum resection (± laparoscopic guidance) | ~80–90% term pregnancy rate post-resection in those with prior miscarriage; significant reduction in miscarriage risk (8, 9). Laparoscopy mainly to confirm diagnosis. |
| Bicornuate uterus (Class IV, partial fusion) | Laparoscopic Strassman metroplasty (fundal unification) | ~75% subsequent term delivery rate in women with recurrent pregnancy loss (10, 11); improved obstetric outcomes (reduced miscarriage/preterm birth) compared to uncorrected. Minimal adhesions and quick recovery versus open metroplasty. |
| Uterus didelphys ± OHVIRA (Class III, complete duplication) | Vaginal septum resection (hysteroscopic or vaginal) ± laparoscopic hemihysterectomy | Resolution of obstructed hemivagina symptoms (cyclic pain, hematocolpos) in >95% (12). If hemihysterectomy performed for OHVIRA, pain relief and prevention of recurrent infection (12); preservation of contralateral normal uterus for fertility. Didelphys without obstruction typically requires no surgery (normal fertility in separate uteri). |
| Unicornuate uterus with rudimentary horn (Class II) | Laparoscopic excision of rudimentary horn (and ipsilateral tube) | Near 100% prevention of future rudimentary horn rupture or ectopic pregnancy. Excellent symptom relief (no more hematometra) and reduced endometriosis incidence (13). Preserves fertility in the main uterus; patients have carried pregnancies in the remaining unicornuate uterus (though high-risk obstetrics). |
| Transverse vaginal septum (complete) | Combined vaginal septum incision & laparoscopic guidance (septoplasty) | Restores normal menstrual outflow and alleviates pain in ~100%. High anatomic success; subsequent normal sexual function. Fertility potential preserved (though some need C-section due to scar). Laparoscopy reduces risk of missed septal tissue and assures patency. |
| Vaginal agenesis (MRKH syndrome) | Laparoscopic neovagina creation (Vecchietti or Davydov vaginoplasty) | >90% anatomical success (neovagina length ~8–10 cm) (17). Over 95% of patients able to have intercourse; sexual function scores in normal range (18). No abdominal incisions (faster recovery) *vs*. older skin graft methods. First-line is dilation; surgery reserved for dilation failures. |
| Cervical agenesis (uterus present, no cervix) | **Experimental:** robotic/laparoscopic uterovaginal anastomosis (cervical canal creation) | Extremely low success – only isolated case reports of term pregnancy (21). High risk of re-obstruction and infection; most patients require hysterectomy or uterine transplant for definitive management. |

Note: Class designations refer to traditional AFS/ASRM categories for context. Minimally invasive approaches result in shorter recovery and fewer adhesions than open surgery in all the above. Robotic assistance can be used for complex suturing (*e.g.*, metroplasty or cervico-uterine anastomosis) in specialized centers (23).

horn rupture), with minimal impact on the normal hemilateral uterus. Studies have shown that endometriosis is very common (up to 75%) in patients with a unicornuate uterus and a functioning, obstructed horn (13), underscoring the importance of early intervention to remove the ectopic endometrial source. Once the rudimentary horn is removed, the remaining unicornuate uterus often can sustain pregnancies, though careful obstetric management is required due to its smaller size and potential cervical insufficiency. Case series of laparoscopic rudimentary horn resection report high rates of symptom resolution and subsequent uneventful intrauterine pregnancies in the dominant horn (12, 13). Importantly, laparoscopic technique allows excellent visualization of the sometimes aberrant vascular and ureteric anatomy in these cases, minimizing intraoperative risks during horn resection.

In summary, laparoscopy has become integral to managing major uterine malformations when surgical intervention is needed. It offers a superior view of pelvic anatomy and allows surgeons to correct anomalies (septal, lateral fusion, or rudimentary horn) with less morbidity than open surgery. Across various studies, outcomes such as relief of cyclic pain, reduction in miscarriage rates and improved chances of term pregnancy have been achieved with laparoscopic procedures for Müllerian anomalies (8,10). Table 2 provides an overview of these uterine anomaly interventions and their outcomes.

## Laparoscopic management of vaginal and cervical anomalies

Congenital anomalies of the vaginal outlet and cervix require timely intervention to relieve obstruction and create functional anatomy. The

goals are to establish normal menses drainage, enable sexual function and preserve fertility when possible – all with minimal invasiveness and psychosocial sensitivity.

**Imperforate hymen**

Imperforate hymen is a common outflow obstruction presenting with primary amenorrhea, cyclic pain and hematocolpos. Treatment is a simple cruciate hymenotomy (excision of the hymenal membrane) to evacuate retained blood. This procedure is traditionally done *via* a perineal approach and is curative in the vast majority of cases. Laparoscopy is rarely needed in isolated imperforate hymen, since correction is straightforward and extraperitoneal (14). Only in unusual cases (*e.g.*, diagnostic uncertainty or suspected coexistent pathology) would one perform laparoscopy – for example, to check for endometriosis or confirm that the obstruction is fully relieved (15). Once the hymen is opened, symptoms resolve and reproductive prognosis is normal.

**Transverse vaginal septum**

A transverse vaginal septum is a horizontal partition that can block the vaginal canal. Complete septa cause menstrual retention similar to an imperforate hymen, whereas partial septa may cause dyspareunia or infertility. Surgical management involves resecting the septum and anastomosing the upper and lower vaginal segments. A combined vaginal–abdominal approach is often used for higher septa: the septum is incised vaginally, and laparoscopy guides the procedure by delineating the cervix and ensuring a patent tract is created (13). Laparoscopic assistance is invaluable for thick septa near the cervix to help mobilize the uterus, provide illumination and minimize injury to adjacent organs. After septum resection, normal menstruation is restored and patients can have normal sexual function. Fertility is generally preserved, though scarring from a high septum may necessitate delivery *via* Cesarean section in some cases. Compared to historic abdominal operations, laparoscopy-assisted septum surgery offers less morbidity and a clearer view to confirm complete septum removal.

**Vaginal agenesis (MRKH syndrome)**

Mayer–Rokitansky–Küster–Hauser (MRKH) syndrome is characterized by congenital absence of the uterus and upper vagina (uterovaginal agenesis) in 46,XX females. Ovarian function is normal, but affected individuals have primary amenorrhea and a vaginal dimple. Management focuses on creating a neovagina to allow sexual function. Non-surgical vaginal dilation is the first-line therapy and can successfully create a functional vagina in most patients (16). If dilation fails or the patient prefers a faster result, surgical vaginoplasty is indicated. Minimally invasive techniques have largely replaced older open methods:

- **laparoscopic Vecchietti procedure** – uses gradual traction on vaginal tissue and peritoneum (*via* an intra-abdominal device) to form a neovagina over about 7–10 days; modern laparoscopic Vecchietti series report >90% anatomical success, with neovaginal lengths around 8–10 cm and high patient satisfaction (17);
- **laparoscopic Davydov procedure** – creates a vagina by pulling down pelvic peritoneum to line a new canal; this technique is done entirely laparoscopically (with a perineal incision for the vaginal opening); it avoids external devices but typically involves longer operative time than Vecchietti.

Notably, a 2024 systematic review by Martens *et al* (18) found that Vecchietti and Davydov techniques had equivalent outcomes. The average neovagina length (~8–9 cm) and sexual function scores after either procedure were similar, with no evidence of sexual dysfunction in either group. Complication rates (stenosis, dyspareunia) were low for both. The main difference was operative time: Vecchietti was significantly faster (mean ~40 minutes) than Davydov (~two hours). Thus, both laparoscopic approaches are effective, and choice depends on surgeon expertise and patient preference.

- **McIndoe vaginoplasty** – an older technique involving an open vaginal dissection and skin graft to line the neovagina. It does not typically involve laparoscopy. McIndoe has good success but requires a skin graft and diligent postoperative dilation to prevent contraction. In experienced centers, minimally invasive vaginoplasties (Vecchietti/Davydov) have largely superseded McIndoe due to quicker recovery and no external scarring, though McIndoe remains an option where laparoscopic resources are limited (19).
- **Intestinal (sigmoid) vaginoplasty** uses a segment of sigmoid colon to create a neovagina

and can be performed entirely laparoscopically. The sigmoid segment provides a well-lubricated mucosa, stable caliber, and low risk of stenosis, with high functional and sexual satisfaction rates reported in case series. Because it is a bowel procedure, it requires appropriate expertise and bowel preparation, but laparoscopic approaches have minimized morbidity and hospital stay, making sigmoid vaginoplasty a widely accepted surgical option for MRKH in experienced centers (20).

**Cervical agenesis and complex cases**

In rare cases, a patient has a uterus but no cervix or vagina (cervicovaginal agenesis). Here the menstrual outflow is completely obstructed. Surgical attempts to connect the uterus to a constructed vagina (uterovaginal anastomosis) have a high failure and complication rate (re-obstruction, infection). Many experts recommend hysterectomy in complete cervical agenesis to prevent complications like hematometra and endometriosis. A few exceptional successes have been reported; for instance, one patient underwent neovagina creation and laparoscopic uterine reimplantation into the vaginal apex, eventually achieving a term pregnancy (21). Such cases are exceedingly rare and no robust series exists – they underscore that fertility can be theoretically preserved, but the surgical burden and risks are high. In practice, if a functional uterus is present without a cervix, management must be individualized at specialized centers, often with consideration of uterine transplant or surrogacy if genetic parenthood is desired.

**Fertility and psychosocial considerations**

Because MRKH patients lack a uterus, they have absolute uterine-factor infertility. Historically, the only path to a genetic child was *in vitro* fertilization (IVF) and gestational surrogacy. Recently, uterus transplantation (UTx) has emerged: the first live birth after UTx in an MRKH patient occurred in 2014 (16). UTx, still experimental, offers hope that women with uterine agenesis may carry their own pregnancies in the future.

Lastly, the psychosocial impact of Müllerian anomalies is profound. Adolescents facing vaginal agenesis or infertility often experience distress, depression, and body-image issues (22). Incorporating psychological support and counseling into management is essential. Studies show that when patients receive appropriate counseling and are involved in decision-making (such as choosing dilation *vs* surgery), their long-term sexual and emotional outcomes are very favorable (22). Thus, a multidisciplinary approach combining minimally invasive surgery with mental health support ensures these young women achieve not only anatomical success but also a healthy psychosexual adjustment. ❑

## DISCUSSION

The evolution from open surgery to minimally invasive techniques has significantly improved the management of Müllerian anomalies. Laparoscopic surgery offers well-documented advantages over laparotomy: smaller incisions, less pain, shorter hospital stay and faster recovery. Patients who formerly faced large abdominal incisions for procedures like metroplasty or vaginoplasty can now often be treated with laparoscopy and go home the next day. Moreover, laparoscopy is associated with reduced adhesion formation compared to open surgery (24), which is particularly important in these typically young patients for whom postoperative fertility is a key concern. Less adhesion burden translates into lower rates of chronic pelvic pain and bowel obstruction and may preserve future fertility by minimizing tubal damage. For example, studies in infertility surgery have shown laparoscopy to result in significantly fewer adhesions than laparotomy when performing adhesiolysis or myomectomy (24).

When comparing laparoscopy to the purely vaginal or hysteroscopic approaches, each modality has its role. Hysteroscopic surgery (e.g., for septate uteri) is extremely effective and minimally invasive for intrauterine septa, but it cannot address external structures or associated pathology in the pelvis. Laparoscopy, on the other hand, can tackle extensive or complex anomalies that extend beyond the uterine cavity – such as excising a non-communicating horn or mobilizing a high vaginal septum – which are not accessible hysteroscopically. In many cases a combined approach yields the best outcome (for instance, hysteroscopic septum resection with concurrent laparoscopy to inspect the fundus, or vaginal septum excision with laparoscopic guidance). This interdisciplinarity maximizes the strengths of each route while minimizing patient morbidity.

From a clinical outcomes perspective, minimally invasive management has shown excellent results. For obstructive anomalies, laparoscopic-assisted procedures relieve outflow obstruction and resolve pain in the vast majority of patients, with low complication rates as seen in numerous case series. In terms of reproductive outcomes, studies suggest that correcting a uterine anomaly laparoscopically (when indicated) can reduce miscarriage rates and improve live birth rates in subsequent pregnancies (9, 11). For example, women with recurrent pregnancy loss due to a bicornuate uterus have had successful term pregnancies after laparoscopic metroplasty (10). Similarly, excision of a rudimentary horn or transverse septum *via* laparoscopy virtually eliminates the risk of future ectopic gestation in that horn or accumulation of menses, thereby protecting fertility and reproductive health.

Despite these benefits, technical challenges exist with minimally invasive surgery in this domain. Müllerian anomaly surgeries can be complex, often requiring advanced suturing and reconstruction of unusual anatomy. There is a learning curve for procedures like laparoscopic metroplasty or neovagina creation. Surgeons must be adept in laparoscopic dissection of fused or distorted structures and comfortable operating in adolescents or virginal patients where working space is limited. In the early years of laparoscopic reproductive surgery, concerns were raised about the potential for higher complication rates when performing such delicate reconstructions. Over time, as skills and instruments improved, laparoscopy has proven equal to the task, but it remains true that these cases should be managed by experienced gynecologic surgeons. The learning curve means that outcomes in high-volume centers or by specialized surgeons tend to be better (*e.g.*, shorter operative times, fewer conversions to open surgery). The use of simulation training and mentorship in advanced minimally invasive gynecology can help flatten this curve.

One innovation that has helped surgeons overcome some technical hurdles is robotic-assisted laparoscopy. Robotic surgical systems provide enhanced three-dimensional visualization and wristed instruments that improve dexterity. For complex Müllerian anomaly surgeries – such as suturing during a Strassman metroplasty or performing a precise cervico-uterine anastomosis – the robot can offer greater precision (23). Case reports have described robotic-assisted excisions of non-communicating uterine horns and even robotic repair of a congenital cervical atresia (23, 25). The improved ergonomics may shorten the learning curve for difficult maneuvers. However, robotic surgery comes with downsides: longer setup time, significantly higher costs and the need for specialized equipment. In resource-limited settings, robotics may not be accessible, and conventional laparoscopy has achieved excellent outcomes in most Müllerian anomaly cases. To date, there is no evidence of superior patient outcomes with robotics *versus* standard laparoscopy in this field, so the cost–benefit must be considered. Robotic surgery is best reserved for select cases where its advantages (fine suturing, tremor reduction) can truly be leveraged.

Beyond the surgical mechanics, ethical and psychosocial considerations are paramount when treating congenital reproductive anomalies. Many of these interventions occur in adolescence, which is a time when patients are developing their sense of identity and bodily autonomy. As such, obtaining informed consent/assent is delicate: the patient (and often her parents) must understand the goals and limitations of surgery. For example, creating a neovagina or performing a uterine surgery in a teenager has implications for her future sexual and reproductive life, which must be discussed openly and with sensitivity. Multidisciplinary care including pediatric/adolescent gynecologists, psychologists, and ethicists is recommended to support young patients. Attention to timing is crucial; surgeons generally wait until an adolescent is emotionally ready and, in the case of neovagina creation, motivated (often around the age when peers begin sexual activity) rather than rushing into an operation during childhood.

Psychosocial support should extend through the perioperative period. Conditions like MRKH syndrome can carry a heavy psychosocial burden – patients often report feelings of inadequacy, depression and isolation upon learning of their anomaly (22). Addressing these issues is as important as the surgery itself. Support groups and counseling can drastically improve coping. Involving mental health professionals has been shown to reduce psychological distress and improve sexual outcomes in these patients (22).

Culturally sensitive counseling is also important, as taboos and family dynamics can influence how a young woman experiences her anomaly and its treatment. Surgeons must be mindful of not only the physical but also the emotional "scar". For instance, ensuring the patient has realistic expectations (*e.g.*, a neovagina will require regular dilation, or a reconstructed uterus might still carry obstetric risks).

In summary, laparoscopy (and related minimally invasive techniques) has transformed the care of Müllerian anomalies by providing surgical solutions that are effective yet less morbid. Patients benefit from quicker recovery, fewer adhesions and often improved reproductive outcomes. However, success in this field is defined not just by anatomical correction but by the patient's overall well-being – requiring skilled surgical execution, careful patient selection and comprehensive psychosocial care. As technology and training continue to advance (including the potential wider use of robotic assistance), the threshold to safely correct these anomalies will likely further decrease, making minimally invasive reproductive surgery available to more patients worldwide. The continuing challenge is to ensure equitable access to these advances and to maintain a patient-centered, ethical approach in treating anomalies that strike at the core of young women's reproductive identity.

### Study limitations

Several limitations of this review should be acknowledged. First, the evidence base consists mainly of observational studies and small case series, usually from single high-volume tertiary centers, with very few comparative trials between laparoscopic, robotic, vaginal, and open approaches. This heterogeneity in design, inclusion criteria, and outcome reporting limits any firm conclusions about the superiority of one minimally invasive technique over another. Second, reproductive and psychosexual outcomes are inconsistently reported: some series focus only on anatomical success, whereas others provide short follow-up or use non-standard definitions of satisfaction, miscarriage, or live birth. Third, rare anomalies such as cervicovaginal agenesis or complex combined malformations are represented almost exclusively by case reports, so the techniques described may not be generalizable. Fourth, most studies originate from centers with advanced minimally invasive expertise, introducing selection and publication bias and making it difficult to extrapolate results to low-resource settings. Finally, this narrative review is restricted to English-language publications from the modern laparoscopic era, so some earlier or non-English work may have been missed.

### Future directions

Future research should move beyond descriptive single-center experiences towards more standardized, collaborative data collection. Multicenter registries using uniform definitions of Müllerian anomalies (ASRM 2021 and/or ESHRE/ESGE) and core outcome sets for pain, sexual function, fertility and quality of life would allow more meaningful comparison across techniques. Prospective studies comparing laparoscopic, vaginal, and, where available, robotic procedures for specific anomalies are needed to clarify which patients benefit most from each approach. Longer-term follow-up of adolescents into adulthood is essential to capture durability of reconstructions, obstetric outcomes, and late complications such as stenosis, prolapse, or endometriosis recurrence. In parallel, cost-effectiveness analyses and implementation studies in low- and middle-income settings are required to determine how minimally invasive techniques can be safely disseminated beyond highly specialized centers. Finally, future work should integrate psychological and sexual health endpoints and evaluate models of multidisciplinary care, including structured counseling pathways for patients with MRKH and other anomalies. ❑

## CONCLUSION

Minimally invasive surgery has transformed the management of Müllerian duct anomalies, allowing correction of complex uterine, cervical, and vaginal malformations with less morbidity than open approaches. Laparoscopy now plays a central role, while hysteroscopy remains the gold standard for isolated septate uterus and robotics serves as an adjunct for selected complex reconstructions. Across the available literature, laparoscopic and laparoscopic-assisted techniques achieve high rates of symptom relief, restoration of menstrual outflow and satisfactory sexual function, with encouraging fertility out-

comes in appropriately selected patients. However, most data derive from small observational series, and the incremental benefit of robotic assistance over conventional laparoscopy remains uncertain. Optimal management of Müllerian anomalies requires not only technical expertise in minimally invasive surgery, but also individualized counseling, attention to psychosocial impact, and long-term follow-up. As classification systems, imaging and surgical technology continue to evolve, patient-centered use of these tools offers the best chance of aligning anatomical correction with the reproductive and quality-of-life goals of affected women. ❑

*Conflicts of interest: none declared.*
*Financial support: none declared.*

## References

1 **González LS, Artibani M, Ahmed AA.** Studying Müllerian duct anomalies – from cataloguing phenotypes to discovering causation. *Dis Model Mech* 2021;14:dmm047977. doi: 10.1242/dmm.047977.
2 **Jayaprakasan K, Ojha K.** Diagnosis of Congenital Uterine Abnormalities: Practical Considerations. *J Clin Med* 2022;11:1251. doi: 10.3390/jcm11051251.
3 **Grimbizis GF, Gordts S, Di Spiezio Sardo, et al.** The ESHRE/ESGE consensus on the classification of female genital tract congenital anomalies. *Hum Reprod* 2013;28:2032-2044.
4 **Pfeifer SM, Attaran M, Goldstein J, et al.** ASRM Müllerian anomalies classification 2021. *Fertil Steril* 2021;116:1238-1252. doi: 10.1016/j.fertnstert.2021.09.025.
5 **Levy L, Tsaltas J.** Recent advances in benign gynecological laparoscopic surgery. *Faculty Reviews* 2021;10:60. doi: 10.12703/r/10-60.
6 **Baethge C, Goldbeck-Wood S, Mertens S.** SANRA-a scale for the quality assessment of narrative review articles. *Res Integr Peer Rev* 2019;4:5. doi: 10.1186/s41073-019-0064-8.
7 **Dixit R, Duggireddy CS, Pradhan GS.** Mullerian anomalies: revisiting imaging and classification. *Insights Imaging* 2025;16:40. doi: 10.1186/s13244-024-01879-2.
8 **Lin PC.** Reproductive outcomes in women with uterine anomalies. *J Womens Health* (Larchmt) 2004;13:33-39. doi: 10.1089/154099904322836438.
9 **Spanish Infertility SWOT Group (SISG), Checa MA, Bellver J, et al.** Hysteroscopic septum resection and reproductive medicine: A SWOT analysis. *Reprod Biomed Online* 2018;37:709-715. doi: 10.1016/j.rbmo.2018.09.013.
10 **Karthik SDS, Kriplani A, Mahey R, Kachhawa G.** Successful Reproductive Outcome After Laparoscopic Strassmann's Metroplasty. *J Hum Reprod Sci* 2017;10:231-234. doi: 10.4103/jhrs.JHRS_11_17.
11 **Pisat S, Tas B, van Herendael B.** Laparoscopic Strassman's metroplasty for bicornuate uterus. *Gynecol Surg* 2009;6:153-158. https://doi.org/10.1007/s10397-008-0463-1.
12 **Huseyin K, Lale TS, Burak Y, et al.** A case of obstructed hemivagina and ipsilateral renal anomaly syndrome complicated with pyometra: tips and tricks for laparoscopic hemihysterectomy. *Fertil Steril* 2019;112:177-179. doi: 10.1016/j.fertnstert.2019.04.016.
13 **Kapczuk K, Zajączkowska W, Madziar K, Kędzia W.** Endometriosis in Adolescents with Obstructive Anomalies of the Reproductive Tract. *J Clin Med* 2023;12:2007. doi: 10.3390/jcm12052007.
14 **Dane C, Dane B, Erginbas M, Cetin A.** Imperforate hymen-a rare cause of abdominal pain: two cases and review of the literature. *J Pediatr Adolesc Gynecol* 2007;20:245-247. doi: 10.1016/j.jpag.2006.12.003.
15 **Harris HR, Wieser F, Vitonis AF, et al.** Early life abuse and risk of endometriosis. *Hum Reprod* 2018;33:1657-1668. doi: 10.1093/humrep/dey248.
16 **Herlin MK, Petersen MB, Brännström M.** Mayer-Rokitansky-Küster-Hauser (MRKH) syndrome: a comprehensive update. *Orphanet J Rare Dis* 2020;15:214. doi: 10.1186/s13023-020-01491-9.
17 **Wang YY, Duan H, Zhang XN, Wang S.** Neovagina Creation: A Novel Improved Laparoscopic Vecchietti Procedure in Patients with Mayer-Rokitansky-Küster-Hauster Syndrome. *J Minim Invasive Gynecol* 2021;28:82-92. doi: 10.1016/j.jmig.2020.04.006.
18 **Martens L, Tannenbaum L, Van Kuijk SMJ, et al.** Laparoscopic Davydov vs. laparoscopic Vecchietti neovaginoplasty in women with Mayer-Rokitansky-Küster-Hauser syndrome; a systematic review and meta-analysis. *Fertil Steril* 2024;121:679-692. doi: 10.1016/j.fertnstert.2023.12.015.
19 **Shah NA, Yadav M, Verma S, et al.** McIndoe Vaginoplasty in MRKHS: Case Report and Literature Review. *Clin Case Rep* 2024;12:e70009. doi: 10.1002/ccr3.70009.
20 **Yang L, Xu G, Tao K, et al.** Laparoscopic Sigmoid Vaginoplasty for the Treatment of Mayer-Rokitansky-Kuster-Hauser Syndrome in a Single Center: 20 years' Experience. *Int Urogynecol J* 2024;35:1503-1510. doi: 10.1007/s00192-024-05829-w.
21 **Acién P, Acién MI, Quereda F, Santoyo T.** Cervicovaginal agenesis: spontaneous gestation at term after previous reimplantation of the uterine corpus in a neovagina: Case Report. *Hum Reprod* 2008;23:548-553. doi: 10.1093/humrep/dem420.
22 **Davoudian T, Hills E.** The need to integrate mental health treatment into the care of Mayer-Rokitansky-Küster-Hauser. *F S Rep* 2025;6:116-119. doi: 10.1016/j.xfre.2025.03.008.
23 **Sareri MI, Bonanno GM, Sarpietro G, Cianci A.** Robotic-assisted laparoscopic cervicouterine anastomosis in a patient with agenesis of the uterine isthmus. *Fertil Steril* 2022;117:463-465. doi: 10.1016/j.fertnstert.2021.10.001.
24 **Schäfer M, Krähenb hl L, Büchler MW.** Comparison of adhesion formation in open and laparoscopic surgery. *Dig Surg* 1998;15:148-152. doi: 10.1159/000018609.
25 **Zakaria MA, Hemstreet M, Silva C, Glazerman L.** Robotic-assisted excision of Mullerian anomaly. *J Minim Invasive Gynecol* 2012;19(suppl):S184.