Septate Uterus: Diagnosis and Management

4

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Objectives

- Describe the developmental formation of a uterine septum and review different variations that can occur
- Explain the classification systems used to define a uterine septum and the imaging modalities available to identify and diagnose this anomaly
- Discuss the literature evaluating the prevalence of this anomaly and the potential impact on reproductive outcomes
- Review the available methods and techniques used for uterine septum incision

Introduction

A septate uterus is a müllerian anomaly that is commonly encountered during an evaluation for infertility or adverse pregnancy outcome. This anomaly is the most common of the müllerian anomalies, though the true prevalence is unknown because in many women, this anomaly is asymptomatic. Many aspects of the diagnosis and treatment of septate uteri are debated among experts including what defines a uterine septum, whether the septum causes abnormal reproductive outcomes, whether surgical treatment of the septum improves reproductive outcomes, and what technique is best for septum correction. In this chapter, these topics will be reviewed to provide a foundation for how to diagnose and manage patients with a uterine septum.

Development

A uterine septum occurs when there is incomplete uterine septum resorption during fetal development. In female fetuses, by the tenth week of gestation, the two müllerian ducts fuse in the midline to create a Y-shaped luminal structure that is destined to become the fallopian tubes, uterine cavity, cervical cavity, and upper third of the vagina [1]. The midline fusion creates a thick septum, composed of fibromuscular tissue, attached to the upper pole of the uterus which resolves by the twentieth week of gestation in normal development [2, 3].

Alternatively, the uterine septum will persist if resorption fails or is incomplete. There is great variability in the structure and appearance of septate uteri. This relates to the developmental stage of the uterus achieved during organogenesis prior

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to cessation of septum resorption. Developmental variations may be viewed as a continuum. The feature that distinguishes a uterine septum from other müllerian anomalies is the presence of a single fundus with normal external contour and internal fundal indentation. The etiology of this anomaly is not well understood and is most likely multifactorial. There are no consistently reported gene mutations or epigenetic alterations that lead to the formation of a uterine septum [3].

Septate uteri have been classified as either partial or complete. Partial septate uterus refers to a single outer uterine body with an indentation in the endometrial cavity. There is a spectrum of length and width that can occur ranging from a small internal indentation at the fundus to a thick septum from the fundus that extends down to the level of the external cervical os. A septum is considered partial if it extends towards but does not reach the internal cervical os (Fig. 4.1).

A complete septate uterus refers to a single external uterine cavity with an internal septum that extends through the cervical canal resulting in a septate cervix or duplicated cervices often seen in association with a longitudinal vaginal septum (Fig. 4.2). It is important to differentiate a

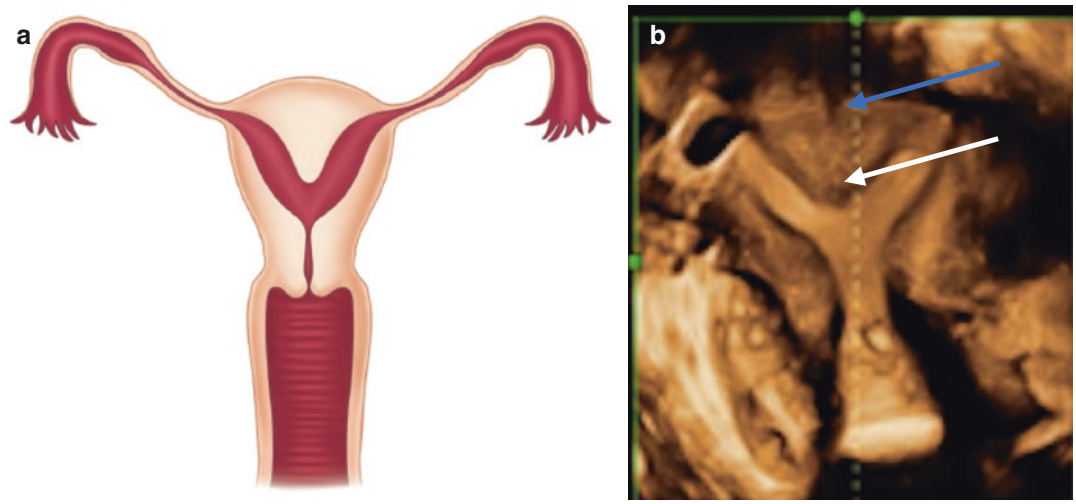

Fig. 4.1 Partial uterine septum. (**a**) Depiction of partial uterine septum. (**b**) 3D ultrasound image of partial uterine septum (Blue arrow: Normal fundal uterine contour) (White arrow: Partial uterine septum)

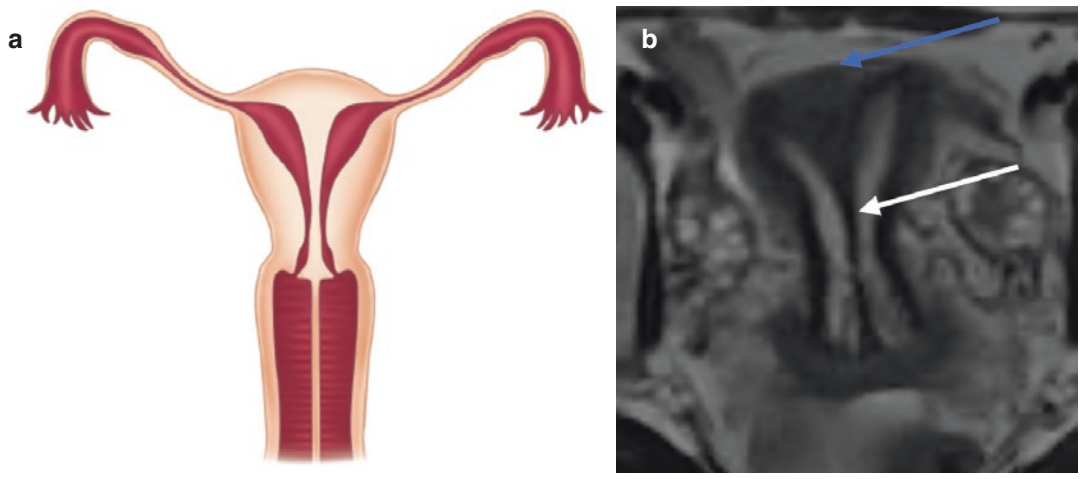

Fig. 4.2 Complete uterine septum**.** (**a**) Depiction of complete uterine septum. (**b**) MRI of complete uterine septum (Blue arrow: Normal fundal uterine contour) (White arrow: Complete uterine septum)

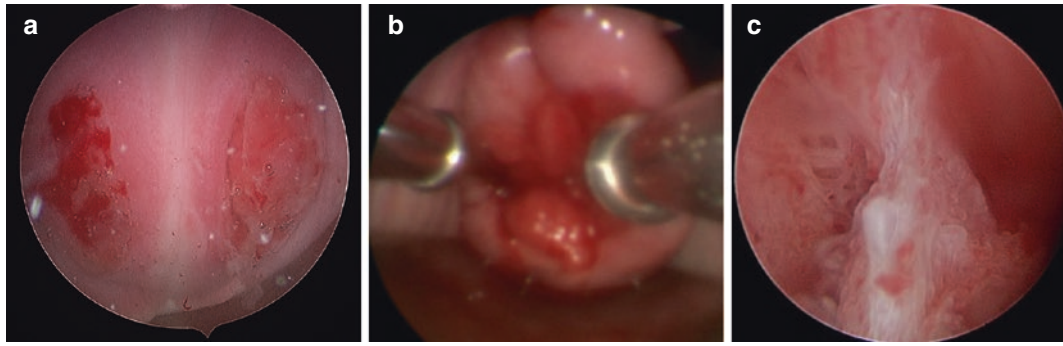

Fig. 4.3 (**a**) Cervical septum seen at vaginoscopy. (**b**) Cervical septum – dilator in each external os. (**c**) Cervical septum seen at hysteroscopy. Cervical mucosa easily identified. (Photos permission of Samantha Pfeifer MD)

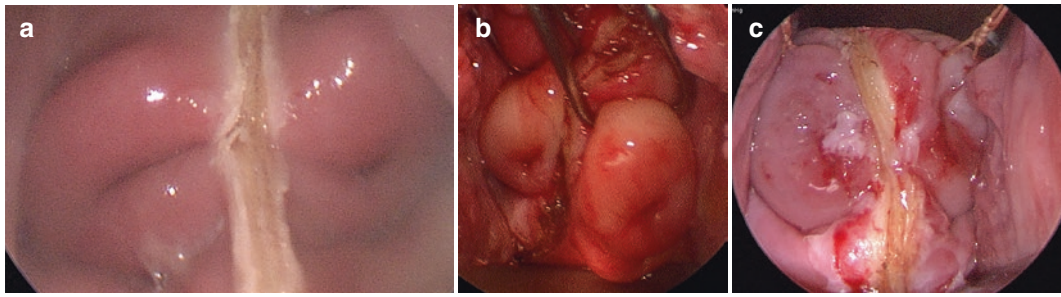

Fig. 4.4 (**a**) Two well-defined cervices see following resection of longitudinal vaginal septum. (**b**) Two separate cervices associated with complete septate uterus. Right cervix smaller and higher in vagina, left cervix larger and inferior. (**c**) Duplicated cervix showing placement of stitches on anterior lip of cervix for traction rather that Allis clamps. (Photos permission of Samantha Pfeifer MD)

cervical septum from a double cervix as surgical management may differ. A cervical septum appears as a single cervix or widened cervical body with a septum typically in the midline dividing the cervical canal into two parts (Fig. 4.3). In contrast, a double cervix has two distinct ectocervices which are separated by an intercervical cleft (Fig. 4.4) [4]. Both of these anomalies are often seen in combination with a longitudinal vaginal septum. A complete septum is also not always contiguous from fundus to cervix and may be observed to have been resorbed in the lower uterine segment creating a connection between the septum [5]. A complete septate uterus is often mistaken as a uterus didelphys by both clinicians and radiologists that are not familiar with the differences between these two anomalies.

When a uterine septum is identified, a thorough evaluation of the vagina, cervix, and fallopian tubes should be done to determine whether any additional anomalies are present. While other müllerian anomalies are associated with renal anomalies in 30% of cases, this association is not observed with septate uteri, and therefore a renal evaluation is not necessary in these patients [6, 7]. The structure of the septum has been demonstrated to be primarily muscle fibers and less fibrous tissue as assessed by MRI and biopsy specimens [8, 9].

The true prevalence of septate uteri in the general population is unknown because many patients with a uterine septum are asymptomatic and therefore never have this anomaly diagnosed. One study that evaluated uterine shape in nearly 700 patients at the time of tubal ligation followed

by a hysterosalpingogram reported a prevalence of müllerian anomalies of 3.2% in women who desire sterilization [10]. Septate uteri are one of the more commonly identified müllerian anomalies, accounting for 35–90% of diagnosed anomalies [10, 11]. The prevalence of septate uteri is increased in patients with a history of miscarriage (5%) and in patients with a history of both miscarriage and infertility (15%) [12]. Current data do not support an association between septate uteri and primary infertility; however, it is associated with first- and second-trimester miscarriage [11]. It should be recognized that the observed prevalence varies widely between studies. This is both due to the baseline prevalence in the study population (i.e., general population, infertile population, recurrent miscarriage population) as well as the fact that multiple classification systems to define a uterine septum exist and the prevalence depends on which definition is utilized in the study design.

Classification

The variability in shape and appearance of the septate uterus has led to difficulty in developing a universally accepted classification system. The American Society for Reproductive Medicine (ASRM) defines a uterine septum as a uterus with normal external contour or with an external fundal indentation of less than 1.0 cm and an internal fundal indentation that is greater than 1.0 cm in length measured from the interstitial line (a straight line drawn to connect the interstitial openings) to the tip and has an angle of indentation that is less than 90 degrees [13].

An arcuate uterus is defined as a fundal indentation that is less than or equal to 1.0 cm in length and has an angle of indentation that is greater than 90 degrees (Fig. 4.5) [13]. The arcuate uterus is thought to occur similarly due to an incomplete septum resorption during organogenesis. However, it is clinically important to distinguish an arcuate uterus because it is not associated with adverse reproductive outcomes and is thus considered a normal anatomic variant [7, 14]. Notably, the ASRM classification system was developed based on the current literature evaluating reproductive outcomes and the measurements were selected to differentiate between a septum that may cause adverse clinical outcomes and an indentation that is a normal variant.

The European Society of Human Reproduction and Embryology (ESHRE) and the European Society for Gynaecological Endoscopy (ESGE) jointly developed an alternative classification system that is more objective and leaves less room for clinical interpretation. ESHRE/ESGE defines a uterine septum as a uterus with normal external contour or that is indented less than 50% of the width of the uterine wall and with a fundal internal indentation with a length that measures greater than 50% of the width of the uterine wall, when measured from the interstitial line to the tip of the indentation (Fig. 4.6) [15]. The ESHRE/ESGE definition of septate uterus by 3D imaging was developed without any input of clinical outcomes associated with this definition. In addition, the ESHRE classification system does not include a separate definition for arcuate uteri and many uteri that would be classified as arcuate and a normal anatomic variant by ASRM criteria meet the definition of a uterine septum when using the ESHRE classification system [16].

The difference between the two classification systems was evaluated in a cohort of 44 patients with a uterine septum as defined by ESHRE criteria. In that cohort, 16 patients (36.4%) had an internal indentation less than 1 cm and would be classified as arcuate based on ASRM criteria [16]. Clinically, the importance in correctly differentiating a uterine septum from an arcuate uterus is that an arcuate uterus is considered a normal variant and does not require corrective surgery compared to the septate uterus that is associated with adverse reproductive outcomes. As there is no universally accepted standard definition of septate uterus, differences among the available definitions may lead to variability in diagnostic classifications with correspondingly increased or decreased incidence of surgery performed to correct these anomalies. Thus, there is concern that defining a septate uterus by ESHRE/ESGE criteria would lead to potential unnecessary surgery to correct an anomaly that is not associated with adverse reproductive outcomes.

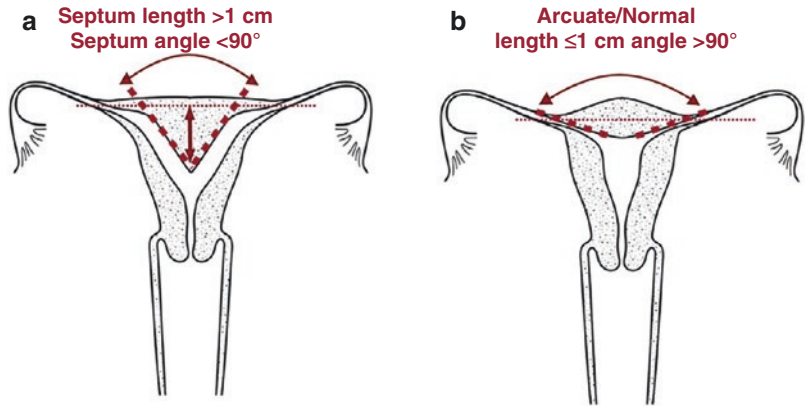

Fig. 4.5 ASRM Mullerian anomalies classification 2021 depicting the specific measurements of depth and angle of indentation to define partial septate and arcuate/normal uterus

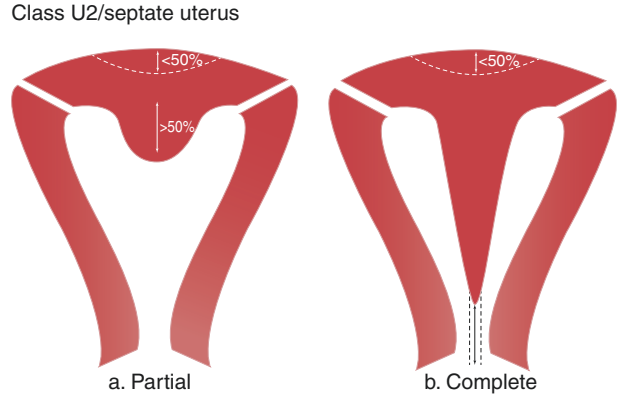

Fig. 4.6 ESHRE/ESGE definition of partial and complete septate uterus

Diagnosis

The most important point to understand when diagnosing a uterine septum is that both the internal and external uterine contour must be adequately visualized in order to distinguish a uterine septum from a bicornuate uterus. The internal indentation may appear the same in both types of müllerian anomalies; however, in a bicornuate uterus, the external fundus will also be indented greater than 1 cm per the ASRM definition [13]. If a uterine septum is incorrectly diagnosed in a patient with a bicornuate uterus, the risk of uterine perforation during "septum" incision is very high.

Accordingly, the imaging modality utilized to diagnose a uterine septum must be able to assess both the internal and external shape of the uterus. The gold standard has traditionally been direct visualization with combined hysteroscopy and laparoscopy. However, with the advent of improved imaging modalities, the diagnosis can almost always be made with less invasive radiologic imaging techniques. Evidence supports that the two best methods to use are either magnetic resonance imaging (MRI) or three-dimensional ultrasonography (3D) with or without saline infusion sonohysterography (SIS). Hysterosalpingography may also be a helpful adjunct to initially identify the presence of a müllerian anomaly; however, because this method is unable to assess the external contour of the uterus, it alone cannot distinguish between a uterine septum and a bicornuate uterus.

All studies that evaluate the sensitivity and specificity of imaging modalities to accurately diagnose uterine septum are limited by their small sample size and sometimes lack a gold

standard for comparison due to the invasive nature of surgical diagnosis. The sensitivity and specificity of MRI have been reported as high as 100% due to the ability to clearly delineate both the external and internal shape of the uterus [9]. Another study showed the diagnostic agreement between MRI and final clinical diagnosis (based on history, pelvic exam, complete imaging studies, surgery, and clinical follow-up) to be 70%; however, a clear measurement cutoff to distinguish a septum from an arcuate uterus was not utilized, and this represents a good example of the clinical ambiguity that can occur when evaluating the uterine shape without objective guidelines to distinguish between the different types of müllerian anomalies [17].

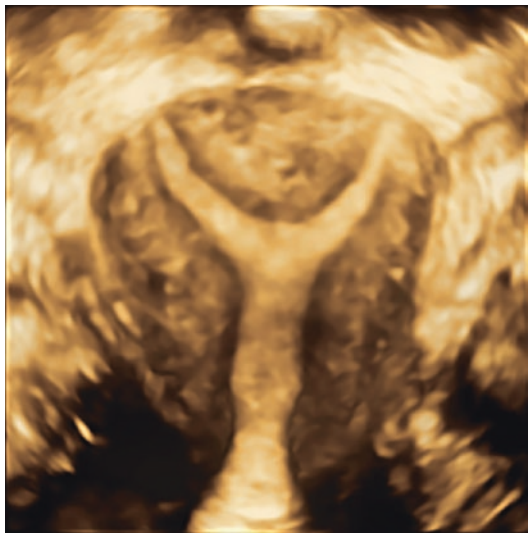

Fig. 4.7 3D-ultrasound coronal view of a uterus with partial septum

Transvaginal ultrasound is another excellent modality that can be used to accurately diagnose a uterine septum as it has comparable predictive value compared to MRI and it is readily available in many outpatient office settings. Both 3D transvaginal ultrasound (Fig. 4.7) and 2D-SIS (Fig. 4.8) have a diagnostic accuracy greater than 90%. When 3D transvaginal ultrasound is performed in combination with SIS, the sensitivity and specificity have been reported as high as 100% and can distinguish a septum from an arcuate uterus with high precision [18]. When considering radiologic imaging accuracy, it is important to remember that the test results are operator dependent and most studies that evaluate test accuracy are performed at high volume centers with gynecologic imaging experts. Therefore, the diagnostic accuracy of each imaging test is dependent on the evaluators experience with both the imaging modality and the diagnosis of uterine malformations.

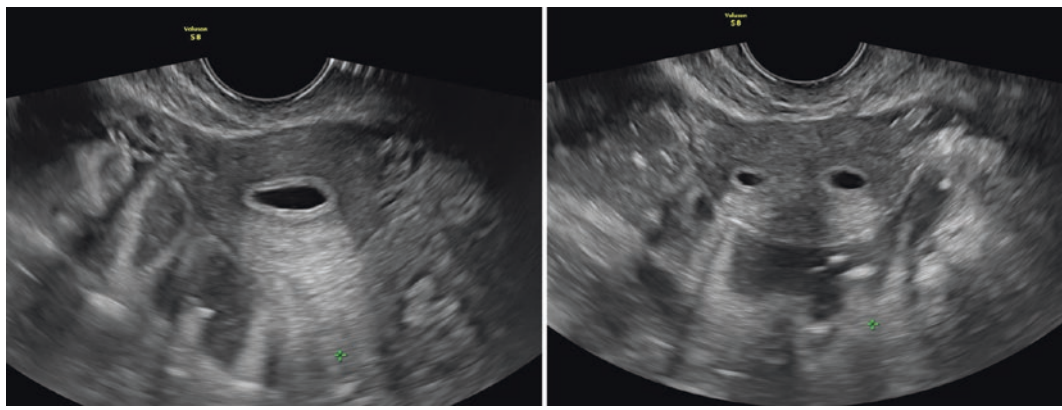

Fig. 4.8 2D-SIS axial view of a uterus with partial septum. (**a**) Lower uterine segment. (**b**) Superiorly located view (compared to Fig. 4.6a) with partial septum visualized

Impact on Fertility and Obstetric Outcomes

As mentioned previously, many women with a septate uterus will not have any difficulty achieving a pregnancy or experience any adverse obstetric events. Yet, there is a correlation between the occurrence of a uterine septum and history of miscarriage or preterm delivery. Most available literature evaluating this association is observational. Further, many studies are limited by a lack of a comparison group or by a paucity of delivery outcomes. In addition, many studies do not differentiate size, shape of septum or distinguish between partial and complete septum. The current management and counseling of patients with a uterine septum are mainly based on these descriptive and observational studies as well as expert opinion.

A uterine septum may often go unnoticed until a patient undergoes a uterine evaluation. This diagnosis will often occur at the time of an infertility evaluation because all of these patients undergo a thorough uterine evaluation regardless of their obstetric history. This leads to an increased prevalence of septate uteri diagnosed in patients with infertility, but it is not clear if the septum is causal for infertility or if it is an incidental finding [19, 20]. Small studies aimed to evaluate this association have failed to identify a significant relationship [21–23]. A systematic review on the topic concluded that there is a significant gap in the literature of high-quality evidence; based on the current literature, it cannot be concluded that there is an association between infertility and septate uteri [7, 24].

However, when a patient presents with infertility and is diagnosed with a uterine septum, study results are mixed regarding whether septum incision will improve infertility treatment outcomes. The only randomized controlled trial to evaluate this question enrolled 80 women with a uterine septum and a history of either infertility, one or more miscarriages before 24 weeks, or a history of preterm delivery and randomized participants to septum incision or expectant management [25]. The outcomes of live birth, pregnancy loss, and preterm delivery were similar between groups. While this study provides the best prospective data on the use of septum incision in this population, it was only powered to detect an absolute improvement in live birth of 35% and is limited by the heterogenous population enrolled and the 9-year enrollment period.

In contrast, multiple retrospective studies have provided evidence that septum incision in infertile patients will improve infertility treatment outcomes [7]. Many otherwise good prognosis patients with infertility and a uterine septum are able to conceive spontaneously after septum incision [26]. In the largest study to evaluate the association between septum incision and embryo transfer outcomes, the authors observed that patients with a uterine septum have significantly lower odds of achieving pregnancy and live birth following embryo transfer compared to a matched control group, but that patients that are treated with uterine septum incision have similar odds of achieving pregnancy and live birth following embryo transfer compared to a matched control group (20).

In patients with a septum that achieve a pregnancy, many will go on to have an uncomplicated term gestation delivery. In a retrospective study of a heterogenous group of women who selected uterine septum incision compared to women who selected expectant management, uterine septum incision did not affect miscarriage, preterm delivery, or live birth outcomes [27]. Still, observational and descriptive studies that have assessed the impact of septate uteri on adverse pregnancy outcomes report an association with miscarriage and preterm delivery. Retrospective studies have reported that in women with a septate uterus, first-trimester miscarriage was observed in 36–42% compared to a 9–12% occurrence in patients with a normal uterine cavity [22, 28, 29]. A meta-analysis that evaluated obstetric outcomes similarly reported a higher risk of first trimester miscarriage in patients with a septate

uterus (RR 2.65, 95% CI 1.39–5.06). This analysis also reported that pregnant patients with a septate uterus have an increased risk for preterm delivery (RR 2.11, 95% CI 1.51–2.94), malpresentation (RR 4.35, 95% CI 2.52–7.50), intrauterine growth restriction (RR 2.54, 95% CI 1.04–6.23), and perinatal mortality (RR 2.43, 95% CI 1.10–5.36) [24].

Based on these data, pregnant patients with a uterine septum should be counseled on the risks of adverse obstetric outcomes, but that the absolute risk of these outcomes remains low. When a uterine septum incision is performed in patients with a history of infertility, miscarriage, or recurrent pregnancy loss, two meta-analyses report that miscarriage risk and live birth outcomes are improved [24, 30]. Again, it is important to understand that the published data on this topic is retrospective and some studies lack a comparison group and is therefore at risk of selection bias.

The size and shape should not be taken into consideration when determining whether to incise a uterine septum. Given the wide variability in septum presentation in both length and thickness, most studies do not stratify patients by septum size. Studies that do stratify patients by either septum length, thickness, or both to assess the effect of septum size on obstetric outcomes have not observed an association between adverse reproductive outcomes (including miscarriage, preterm delivery, and live birth outcomes) and septum length or thickness [31–33].

Therefore, patients should be counseled to undergo uterine septum incision if they have a history of miscarriage, preterm delivery, and/or recurrent pregnancy loss. The effect of a uterine septum on implantation is still unclear because the data evaluating this association are limited. However, in patients that present with a history of infertility and a diagnosis of a uterine septum, incision should be offered to improve treatment outcomes. Finally, in a patient that desires fertility with an incidentally diagnosed uterine septum but no history of infertility or adverse obstetric outcome, septum incision can be considered after a discussion regarding the risks, benefits, and alternatives discussed above. In a patient that does not desire fertility with an incidentally diagnosed uterine septum, there is no role for septum incision.

Operative Technique

Uterine septum incision is most commonly performed via the hysteroscopic route. Before the advent of hysteroscopy, septum resection was done via laparotomy using either the Jones metroplasty or modified Tompkins metroplasty techniques (Fig. 4.9). The Jones metroplasty is essentially a wedge resection of the septum and overlying myometrium and uterine serosa followed by closure of the remaining myometrium. The Tompkins metroplasty differs in that no myometrium is removed. Instead, an incision is made through the fundal myometrium, anterior to posterior, and continues through the middle of the septum in order to divide it in half. A second incision is made perpendicular to the first incision, but through the septum only in order to incise it on each side. The myometrial and serosal layers are then closed. These invasive techniques now mostly serve as historical perspective.

In current practice, operative hysteroscopy is a less invasive option that produces effective results and is the standard of care for treatment of uterine septum. While the procedure is commonly referred to as septum resection, the procedure most often utilized is actually septum incision or transection. This procedure can be safely performed in either the office setting or in an operating room under anesthesia. There are a few hysteroscopic instruments that are commonly used for septum incision including hysteroscopic scissors, monopolar or bipolar electrocautery, or laser. Each technique has theoretical advantages, but no large well-designed studies have been performed to compare techniques [7]. All methods are considered to generally produce comparable clinical results, and the choice is determined by surgeon preference. The primary questions to consider to ultimately determine the best technique to use include the following:

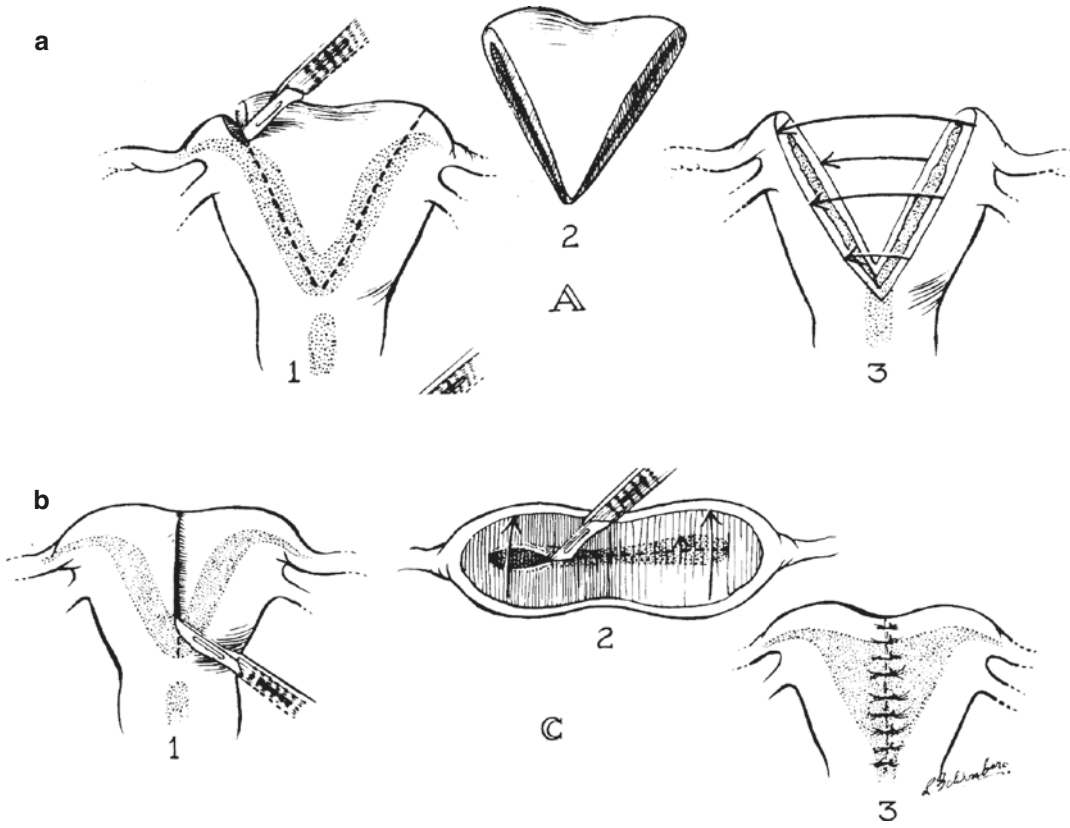

Fig. 4.9 Depiction of abdominal metroplasty techniques. (**a**) Jones metroplasty. (**b**) Tompkins metroplasty. (Figure from Rock and Jones [33]. Permission to use this figure was granted by Elsevier)

1. Will the procedure be performed in the office or operating room?
2. Does cervical dilation need to be avoided?
3. Should energy sources be avoided?
4. How does cost vary between instruments?
5. How complex is the instrument to set-up or to operate?
6. What distension media options are available?

Hysteroscopic cold scissors require the least amount of equipment and therefore are a cost-effective option and are ideal for use in the office setting. Hysteroscopes with an outer diameter as small as 5 millimeters have been made to accommodate the scissors, and cervical dilation is often not necessary when using a hysteroscope of this size. Additionally, some clinicians prefer to use scissors in order to avoid the use of energy sources in the endometrial cavity that may increase the risk of postoperative intrauterine adhesions or endometrial injury. Some difficulties encountered include poor visibility if the scissors pass through the inflow channel as this reduces flow of distending fluid and clearing of blood. The true risk reduction to endometrial damage with the use of cold scissors for septum incision has not been well studied and remains more of a theoretical concern.

Many hysteroscopic electrocautery devices have been developed that can also be used for septum incision. These options include hooks, loops, and various pointed tip electrodes. Some of these options are designed to be used with larger diameter hysteroscopes (22 or 26 French)

and cervical dilation may be required. When using electrocautery, surgeons must always be aware of the thermal spread from the contact surface of the instrument, which varies depending on the instrument type, power setting, and the application time. In general, bipolar devices result in less thermal spread compared to monopolar devices, with thermal spread up to 2–6 mm recorded for bipolar instruments and thermal spread of greater than 10 mm recorded for monopolar instruments [34, 35]. This risk is important to be aware of when operating within the endometrial cavity as myometrial damage may occur, but also if uterine perforation occurs due to the injury that can then occur to intra-abdominal organs.

If uterine perforation occurs, the surgeon must decide whether to end the procedure and expectantly manage the patient or whether abdominal exploration to evaluate for injury should be performed. This decision should be made based on the risk of intra-abdominal injury at the time of perforation taking into consideration the risk of potential bladder, bowel, or vascular injury depending on the location of injury and causal instrument. Generally, if perforation occurs with a blunt instrument and no electrocautery, expectant management can be considered if there are no other signs of vascular or visceral organ injury. If perforation occurs with the use of electrocautery or if the surgeon is concerned for possible intra-abdominal injury based on the type and location of perforation, abdominal exploration should be performed. The hysteroscopic surgeon should be aware and capable of performing management of uterine perforation.

The hysteroscopic use of laser (argon, KTP [potassium titanyl phosphate], and Neodymium-YAG) has also been described as a successful method for uterine septum incision [36, 37]. While effective, the use of laser is generally more expensive, more dangerous for the operating room staff, and leads to longer operating times when compared to incision with scissors [38]. Thus, this method is less commonly utilized than the other techniques previously described.

The choice of distension media to us depends on the time of operative instrument chosen for incision [39]. Both electrolyte-free and electrolyte-rich media can be used. Electrolyte-free media such as 3% sorbitol, 1.5% glycine, and 5% mannitol are commonly used with monopolar devices. The greatest risks that can occur when using these solutions is electrolyte imbalance such as hyponatremia, which has been observed when high amounts of solution are absorbed into the systemic circulation. Maximum absorption of electrolyte-free media is 1000 ml [39, 40]. When using electrolyte-free solutions, the surgeon must always be aware of the operating fluid deficit and institutional procedures and guidelines used to mitigate the risks of fluid overload and electrolyte imbalance. High amounts of distension media absorption are more likely to occur with prolonged procedures. However, uterine septum incision procedures are generally completed in under 30 minutes and therefore high fluid deficits are rarely observed with this procedure.

When using bipolar instruments, an electrolyte-rich media, such as normal saline, must be used for distention. This media is advantageous because it is isotonic and contains physiologic electrolytes, thus, mitigating the risk of electrolyte imbalances like hyponatremia making it the preferred choice by many surgeons, especially for cases with an expected longer operating time. The maximum fluid deficit with normal saline is far greater than with glycine and approaches 2000–2500 [39, 40]. However, high fluid deficits with normal saline can still cause fluid overload and the surgeon must always pay close attention to fluid management during any hysteroscopic procedure.

Procedural Steps

Partial Septate Uterus

Regardless of the hysteroscopic instrument chosen for septum incision, the principles of the procedure remain the same. Once the hysteroscope is in the uterine cavity, the surgeon should perform a careful survey of the cavity and identify the location of both tubal ostia. It

is easy to become disoriented within the endometrial cavity during hysteroscopic septum incision if the surgeon is not constantly monitoring these landmarks. Two techniques can be utilized: shortening and thinning (Fig. 4.10 and Video 4.1). Shortening involves incising the septum starting at the leading edge and continuing toward the fundal region. The septum is incised horizontally typically starting at one side moving across to the other side, parallel to the anterior and posterior uterine walls and in the same plane defined by the tubal ostia. If the incision begins to deviate toward the anterior and posterior walls, this trajectory could eventually lead to uterine perforation if not recognized and corrected. Thinning technique involves incising the septum along the lateral edges of the septum on both sides to reduce the width of the septum. The shortening technique can then be facilitated as the septum will be smaller. Another benefit of this technique is it helps to keep the surgeon in the intended plane throughout the procedure as these incisions are placed in the correct plane midline between anterior and posterior uterine walls and in the plane of the tubal ostia. In practice, it is often helpful to use a combination of these two techniques depending on the size and shape of the septum to be incised.

If scissors are utilized, small incisions are made at the leading edge allowing the septal fibers to separate (Video 4.2). Blood vessels if visualized may be avoided to minimize bleeding. If using electrocautery, a combination of a brief incision with energy followed by gentle blunt dissection without energy can be used to safely incise the septum with the least amount of applied thermal energy. As the incision progresses, the surgeon must constantly be aware of the incisional plane and the uterine orientation by monitoring the location of the tubal ostia in relation to the incision (Fig. 4.11). It is usually not possible to keep the ostia continuously visible during the procedure due to the proximity that must be maintained between the operating instrument and the surface of the septum. Thus, the surgeon must frequently move the camera from the incision to the ostium to ensure the orientation of the uterus has not been lost. If this occurs, there is a high risk of perforation as the surgeon will no longer be incising the correct plane.

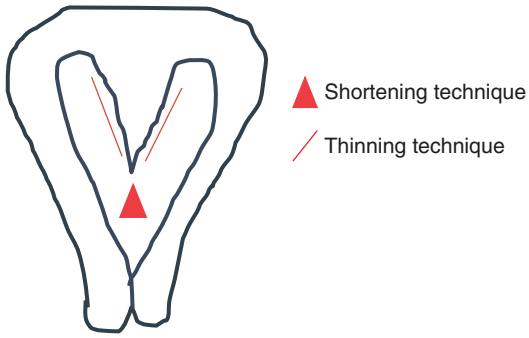

Fig. 4.10 Depiction of incision techniques: shortening and thinning

Complete Septate Uterus

With a complete septate uterus, there is debate regarding whether the cervical septum should be incised as part of the uterine septum incision or left intact. The concern with cervical septum incision is that it could compromise the remaining cervical tissue leading to cervical insufficiency in pregnancy. However, there are no high-quality studies that evaluate pregnancy outcomes after cervical septum incision and results

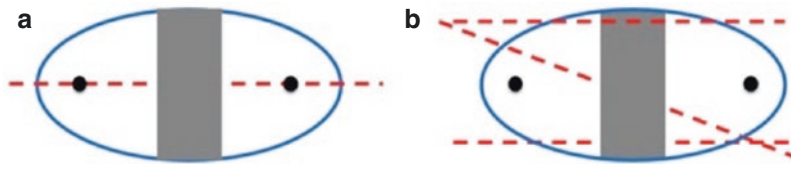

Fig. 4.11 (**a**) Correct plane of incision (red dashed line) – same plane as ostia (black dots). (**b**) Incorrect planes – can lead to damage to myometrium and possible perforation

are conflicting. Nor do these studies clearly define a cervical septum or differentiate it from a duplicated cervix. A cervical septum appears as a single thickened outer rim with a band that may be thin or thick dividing the cervix (Fig. 4.3). This band is typically continuous with the uterine septum and longitudinal vaginal septum when present. With a duplicated cervix, there are two distinct cervical entities, and the cervical ostia are separated by a large distance or may even be in different planes (Fig. 4.4).

Incising the cervical septum along with the uterine septum for a complete septate uterus has been advocated as this procedure has been shown to be significantly shorter, associated with less fluid absorption, less bleeding, and easier when compared to preservation of the cervical septum [41, 42]. Techniques described include cutting the cervical septum with Metzenbaum scissors [41], or cutting the cervical septum with scissors after first dilating each cervical canal to 10 mm [43, 44]. In lieu of scissors, a 5-mm hand-held tissue sealing device can be used to transect the cervical septum with minimal bleeding. Others have reported using the hysteroscopic resectoscope [42]. In these studies, the uterine septum was incised with hysteroscope and either scissors or bipolar or monopolar cautery independent of the technique to remove the cervical septum. All these techniques have been shown to be performed immediately following resection of longitudinal vaginal septum. The cervical septum was observed to recur following incision in 3 of 10 patients in one observational study [44]. Cervical incompetence following incision of cervical septum is a concern with incidence of cerclage in studies ranging from 9% to 24% [42, 43]. However, in a randomized controlled trial of 28 patients comparing cervical septum incision versus preservation, rates of cerclage placement were not significantly different nor were preterm delivery rates between the two groups [41].

For a complete septate uterus with duplicated cervix, there are a couple of effective techniques to incise the uterine septum without compromising the cervical septum. The main strategy is to make an opening in the septum just above the level of the internal cervical os, to create a leading edge of the uterine septum that can be incised hysteroscopically. The challenge is to identify a thin portion of uterine septum in the correct location and the correct plane to create this opening. One approach is to make a blind entry across at the presumed correct location, but this risks deviating the incision toward the anterior or posterior wall especially if the uterus is rotated thereby increasing the risk of perforation. A safer option is to identify where to incise the septum by placing an instrument in the contralateral side to tent the septum where the incision should be made (Fig. 4.12). Instruments that have been used include a foley balloon, a uterine sound, or a thin curved clamp in the endocervical/uterine canal with the hysteroscope in the adjacent canal. The septum may then be incised over the area demarcated by these instruments using scissors, or any hysteroscopic tools used for uterine septum incision. When using a balloon, once it is beyond the cervix, it can be slowly inflated and the incision can be made through the septum above the cervix, using the balloon to delineate the location for the incision and the prevent the instrument from perforating through the contralateral uterine wall. Although the foley is effective, it can distort the anatomy and make it difficult to pass the hysteroscope. A thin long curved clamp can overcome these issues (Fig. 4.12a and Video 4.3). Once inserted through the contralateral side of the cervix and beyond the cervix, the surgeon can angle the tip of the clamp into the septum and then open the clamp to delineate a clear area where the incision can safely be made to incise the cervix in the lower uterine segment without perforating through the contralateral wall.

Once the septum has been crossed, the hysteroscopic distending media will egress through the adjacent cervical canal and uterine distension may be difficult. When this occurs, occlusion of the second cervical opening can be helpful. This can be done by placing a figure-of-eight stitch around the cervical opening, using an Allis clamp to occlude the external cervical os, or by placing a foley balloon through the cervix, slightly inflating the balloon, and then pulling back on the foley catheter until the second cervical opening is occluded. Interestingly, incidence of cesarean

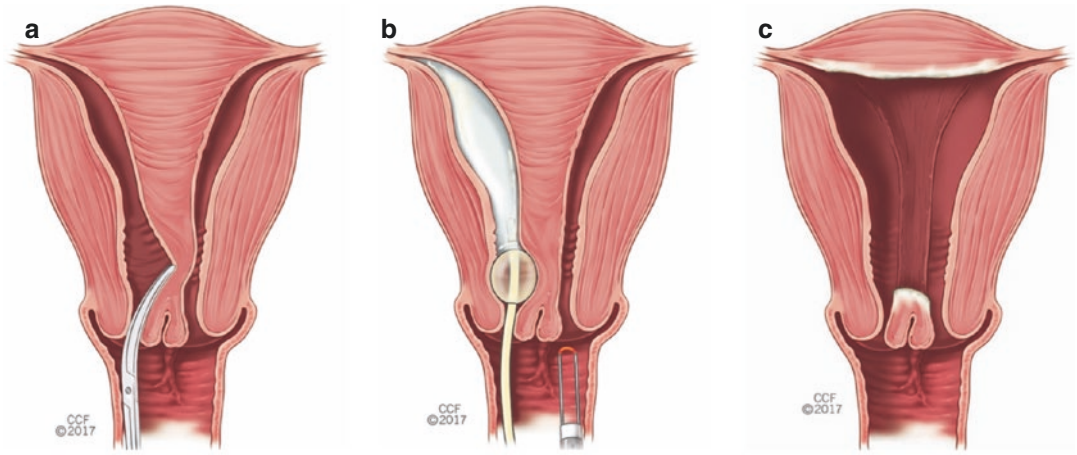

Fig. 4.12 Technique for complete uterine septum incision while preserving cervical septum. (**a**) Using a fine long curved clamp to identify where to cross lower uterine septum. (**b**) Use of foley balloon catheter to mark where to cross lower uterine septum. (**c**) Complete septate uterus following incision of uterine septum while preserving cervical septum. (Figure from Jeff Goldberg MD, Cleveland Clinic Foundation)

section following preservation of the cervical septum was higher, 7% versus 2% ($P < 0.05$) in one randomized study [41]. However, vaginal delivery is not impeded with an intact cervical septum or complete duplicated cervix post hysteroscopic septum as the fetal head displaces the cervix or cervical septum to one side as it descends [44].

Septate uteri can also be associated with the presence of a longitudinal vaginal septum. In one retrospective study of patients with longitudinal vaginal septum, a septate uterus was present nearly 2/3 of cases [45]. The decision to resect a longitudinal vaginal septum and the available techniques are beyond the scope of this chapter, but it is possible to resect the vaginal septum at the time of cervical septum surgery. When these procedures are done together, it is usually best to first resect the vaginal septum to allow for easier vaginal wall retraction and visualization during the cervical septum incision.

Once the uterine septum is incised, the procedure is complete. However, deciding when enough of the septum has been incised is a crucial step. If the septum is incised too far resulting in thinning of the fundal myometrial wall, there is a risk for uterine rupture to occur in future pregnancies. Eighteen cases of uterine rupture in subsequent pregnancy have been reported following septum incision seen in association with excessive septum excision/incision, penetration of myometrium, uterine wall perforation, or excessive use of cautery or laser energy [30]. This risk can seemingly be mitigated by a careful surgical approach and appropriate knowledge for when to stop the incision. Ending the procedure once the septum has been incised down to one centimeter away from the interstitial line is a safe distance as this ensures that the myometrial wall remains intact and is a length of indentation that does not affect pregnancy outcomes [14].

Clues that the incision is nearing the interstitial line can be gathered from visual signs, direct measurement, and external monitoring with laparoscopy or ultrasound imaging. Visually, the myometrial wall is often much more vascular than the septum. When bleeding begins to occur at the level of the incision, this is a sign that myometrium is near and the remaining length of the septum should be reassessed. It is important to remember that the septum can contain muscle and vessels which may also cause bleeding during incision and this approach may lead to a large residual septum. Length of the residual septum may also be assessed by placing the extended operating instrument and directly measuring the

depth. When utilizing this technique, one should know the size of visual markers such as the length of scissors or insulation on the operating instrument. Simultaneous transabdominal or transrectal ultrasonography has been shown to be effective to assess when septum incision is complete and has the advantage of being able to measure the remaining thickness of the uterine wall. Direct external visualization of the uterus with laparoscopy can be used; however, transabdominal ultrasound monitoring is less invasive and has similar efficacy and safety when used to monitor the procedure [46].

Assessing for Adequacy of Septum Incision and Adhesion Formation

After uterine septum incision is complete, it can take weeks for endometrial growth to cover the anterior and posterior walls of the uterine cavity where the septum was previously located. In the interim, these opposing edges remain at risk for adhesion formation and distortion of the uterine cavity. Adhesion formation after septum incision has been reported to occur in 5.3–24.1% of cases [47–49]. Hormonal and barrier methods have been proposed to decrease the risk of postoperative adhesion formation; however, studies evaluating the use of these methods are small. Barrier methods create a physical separation between the uterine walls to prevent adhesion formation during the period of endometrial growth, and hormonal methods may help to facilitate and expedite recovering of the incised uterine will with normal endometrium.

One study of 100 women treated with uterine septum incision was randomized to four groups: no adhesion prevention, estradiol plus norgestrel daily for 2 months, copper IUD, and a combination of estradiol plus norgestrel plus copper IUD. Patients underwent cavity evaluation 2 months postoperatively and adhesions were present in 5.3% of control group, 0% of the hormone treatment group, 12% of the copper IUD group, and 10.5% of the hormone plus copper IUD group with no statistical significance in any treatment group compared to the control group [47]. Even though this study is one of the largest to prospectively evaluate adhesion prevention techniques after uterine septum incision, it is limited by the small patient cohort and a failure to perform an intention to treat analysis. Five patients in the hormone treatment group self-discontinued the medication, and four patients in the copper IUD group had the IUD removed.

Despite a lack of conclusive data, many surgeons recommend the use of adhesion prevention after septum incision given the high rate of postoperative adhesion formation. When barrier methods are used, a barrier with a large enough surface area to prevent the uterine walls from touching should be used. Therefore, a foley balloon or a balloon specially shaped to fit into the uterine cavity are likely to be more effective than a T-shaped IUD device. When hormone therapy is used by itself or in combination to a barrier method, a physiologic dosing schedule should be chosen by administering estradiol at physiologic doses for 21–28 days with the addition of a progestin around days 10–14.

Another method used to manage postoperative adhesions is a second-look office hysteroscopy with incision of any adhesions at that time. In one study that used this method, adhesions were observed in 25.6% of patients at 1 month postoperatively [48]. The majority of adhesions were filmy and were able to be incised with the tip of the hysteroscope or scissors. At repeat hysteroscopy performed at 3 months postoperatively, adhesions were observed in only 1.7% of patients.

Due to the risk of adhesion formation or incomplete septum incision, all septum incision procedures should be followed up with a cavity evaluation to ensure that the septum has been adequately incised and that no intrauterine adhesions are present. Office hysteroscopy, as described above, is an effective option because it can be both diagnostic and therapeutic. Other options include imaging techniques that are able to evaluate the cavity for both adhesions and residual septum with a high sensitivity and specificity – either hysterosalpingography or a 3D-SIS. If a residual septum or intrauterine adhesions are identified, a second procedure to restore the cavity should be performed.

Attempting Pregnancy Following Septum Incision

Once a uterine septum has been incised, patients should wait to conceive until a follow-up evaluation confirms a normal uterine cavity and the endometrium has sufficiently covered the entirety of the uterine cavity. Data from second-look hysteroscopies have described the length of time that it takes for endometrium to cover the area of septum incision. One study of 19 patients was designed to specifically evaluate the endometrial repair that occurs after septum incision. Hysteroscopy was performed 1, 2, 4, and 8 weeks following septum incision with hysteroscopic scissors [38]. At 1 week postoperatively, the incised area was still very clearly visualized on hysteroscopy with an absence of epithelial cells on histological examination. At 2 weeks postoperatively, the incised area was still depressed with areas still lacking endometrial covering with simple epithelium without stromal tissue observed on histology. Four weeks postoperatively, the incised areas remained depressed in comparison to the adjacent endometrium, but these were completely covered by a thin epithelium. Proliferative endometrium with epithelium and stroma was observed on histology. At 8 weeks postoperatively, the endometrial cavity and histology appeared normal, with only a slight depression at the incised area identified in three patients. Other studies that include second-look hysteroscopies have similarly reported that the endometrial lining appears normal in most patients after 2–3 months [49, 50]. Therefore, it is reasonable to wait for 2 months after uterine septum incision prior to attempting pregnancy, either naturally or with infertility treatment [7].

Conclusion

Septate uterus may be asymptomatic or lead to poor reproductive outcomes. Septum may be partial or complete. Diagnosis may be confirmed by 3D ultrasound, SIS, MRI, or HSG or hysteroscopy in conjunction with ultrasound confirmation of external uterine contour. Septum incision is indicated following poor reproductive outcome or for those individuals with infertility. Septum incision may also be performed for asymptomatic individuals to decrease potential for poor reproductive outcome following counseling of the risks and benefits. Many techniques have been described and none have been proven superior. Care should be taken to avoid damage to the fundal myometrium by either excessive septum incision or cautery. Reproductive outcomes following septum incision have been shown to improve.

References

1. Taylor H, Pal L, Emre S. Speroff's clinical gynecologic endocrinology and infertility. 9th ed. Lippincott Williams & Wilkins; 2019.
2. Hoffman B, Schorge J, Bradshaw K, Halvorson L, Schaffer J, Corton MM. Williams Gynecology. 2nd ed. McGraw-Hill; 2012.
3. Rikken JFW, Leeuwis-Fedorovich NE, Letteboer S, Emanuel MH, Limpens J, Veen F van der, et al. The pathophysiology of the septate uterus: a systematic review. BJOG Int J Obstet Gynaecol. 2019;126(10):1192–9.
4. Ludwin A, Ludwin I, Pityński K, Banas T, Jach R. Differentiating between a double cervix or cervical duplication and a complete septate uterus with longitudinal vaginal septum. Taiwan J Obstet Gynecol. 2013;52(2):308–10.
5. Acién P, Acién M, Sánchez-Ferrer ML. Müllerian anomalies "without a classification": from the didelphys-unicollis uterus to the bicervical uterus with or without septate vagina. Fertil Steril. 2009;91(6):2369–75.
6. Oppelt P, von Have M, Paulsen M, Strissel PL, Strick R, Brucker S, et al. Female genital malformations and their associated abnormalities. Fertil Steril. 2007;87(2):335–42.
7. Uterine septum: a guideline. Fertil Steril. 2016;106(3):530–40.
8. Dabirashrafi H, Bahadori M, Mohammad K, Alavi M, Moghadami-Tabrizi N, Zandinejad K, et al. Septate uterus: new idea on the histologic features of the septum in this abnormal uterus. Am J Obstet Gynecol. 1995;172(1, Part 1):105–7.
9. Pellerito JS, McCarthy SM, Doyle MB, Glickman MG, DeCherney AH. Diagnosis of uterine anomalies: relative accuracy of MR imaging, endovaginal sonography, and hysterosalpingography. Radiology. 1992;183(3):795–800.
10. Simón C, Martinez L, Pardo F, Tortajada M, Pellicer A. Müllerian defects in women with normal reproductive outcome. Fertil Steril. 1991;56(6):1192–3.

11. Grimbizis GF, Camus M, Tarlatzis BC, Bontis JN, Devroey P. Clinical implications of uterine malformations and hysteroscopic treatment results. Hum Reprod Update. 2001;7(2):161–74.
12. Chan YY, Jayaprakasan K, Zamora J, Thornton JG, Raine-Fenning N, Coomarasamy A. The prevalence of congenital uterine anomalies in unselected and high-risk populations: a systematic review. Hum Reprod Update. 2011;17(6):761–71.
13. Pfeifer SM, Attaran M, Goldstein J, Lindheim S, Petrozza J, Rackow B, Zuckerman A, Siegelman E, Troiano R, Winters T, Ramaiah SD. ASRM Mullerian anomalies classification 2021. Fertil Steril. 2021;116:1238–52.
14. The American Fertility Society classifications of adnexal adhesions. distal tubal occlusion, tubal occlusion secondary to tubal ligation, tubal pregnancies, Müllerian anomalies and intrauterine adhesions. Fertil Steril. 1988;49(6):944–55.
15. Grimbizis GF, Gordts S, Di Spiezio SA, Brucker S, De Angelis C, Gergolet M, et al. The ESHRE/ESGE consensus on the classification of female genital tract congenital anomalies. Hum Reprod Oxf Engl. 2013;28(8):2032–44.
16. Ludwin A, Ludwin I. Comparison of the ESHRE–ESGE and ASRM classifications of Müllerian duct anomalies in everyday practice. Hum Reprod. 2015;30(3):569–80.
17. Mueller GC, Hussain HK, Smith YR, Quint EH, Carlos RC, Johnson TD, et al. Müllerian duct anomalies: comparison of MRI diagnosis and clinical diagnosis. Am J Roentgenol. 2007;189(6):1294–302.
18. Ludwin A, Pityński K, Ludwin I, Banas T, Knafel A. Two- and three-dimensional ultrasonography and Sonohysterography versus hysteroscopy with laparoscopy in the differential diagnosis of septate, Bicornuate, and arcuate uteri. J Minim Invasive Gynecol. 2013;20(1):90–9.
19. Raga F, Bauset C, Remohi J, Bonilla-Musoles F, Simón C, Pellicer A. Reproductive impact of congenital Müllerian anomalies. Hum Reprod. 1997;12(10):2277–81.
20. Tomaževič T, Ban-Frangež H, Virant-Klun I, Verdenik I, Požlep B, Vrtačnik-Bokal E. Septate, subseptate and arcuate uterus decrease pregnancy and live birth rates in IVF/ICSI. Reprod Biomed Online. 2010;21(5):700–5.
21. Maneschi F, Zupi E, Marconi D, Valli E, Romanini C, Mancuso S. Hysteroscopically detected asymptomatic müllerian anomalies. Prevalence and reproductive implications. J Reprod Med. 1995;40(10):684–8.
22. Shuiqing M, Xuming B, Jinghe L. Pregnancy and its outcome in women with malformed uterus. Chin Med Sci J Chung-Kuo Hsueh Ko Hsueh Tsa Chih. 2002;17(4):242–5.
23. Demir B, Dilbaz B, Karadag B, Duraker R, Akkurt O, Kocak M, et al. Coexistence of endometriosis and uterine septum in patients with abortion or infertility. J Obstet Gynaecol Res. 2011;37(11):1596–600.
24. Venetis CA, Papadopoulos SP, Campo R, Gordts S, Tarlatzis BC, Grimbizis GF. Clinical implications of congenital uterine anomalies: a meta-analysis of comparative studies. Reprod Biomed Online. 2014;29(6):665–83.
25. Rikken JFW, Kowalik CR, Emanuel MH, Bongers MY, Spinder T, Jansen FW, et al. Septum resection versus expectant management in women with a septate uterus: an international multicentre open-label randomized controlled trial. Hum Reprod [Internet] 2021 [cited 2021 Apr 7];(deab037). Available from: https://doi.org/10.1093/humrep/deab037.
26. Shokeir T, Abdelshaheed M, El-Shafie M, Sherif L, Badawy A. Determinants of fertility and reproductive success after hysteroscopic septoplasty for women with unexplained primary infertility: a prospective analysis of 88 cases. Eur J Obstet Gynecol Reprod Biol. 2011;155(1):54–7.
27. Rikken J, Verhostert K, Emanuel M, Bongers M, Spinder T, Kuchenbecker W, et al. Septum resection in women with a septate uterus: a cohort study. Hum Reprod. 2020;35(7):1578–88.
28. Woelfer B, Salim R, Banerjee S, Elson J, Regan L, Jurkovic D. Reproductive outcomes in women with congenital uterine anomalies detected by three-dimensional ultrasound screening. Obstet Gynecol. 2001;98(6):1099–103.
29. Kupešić S, Kurjak A, Skenderovic S, Bjelos D. Screening for uterine abnormalities by three-dimensional ultrasound improves perinatal outcome. J Perinat Med. 2002;30(1):9–17.
30. Valle RF, Ekpo GE. Hysteroscopic Metroplasty for the septate uterus: review and meta-analysis. J Minim Invasive Gynecol. 2013;20(1):22–42.
31. Zlopaša G, Škrablin S, Kalafatić D, Banović V, Lešin J. Uterine anomalies and pregnancy outcome following resectoscope metroplasty. Int J Gynecol Obstet. 2007;98(2):129–33.
32. Kupesic S, Kurjak A. Septate uterus: detection and prediction of obstetrical complications by different forms of ultrasonography. J Ultrasound Med. 1998;17(10):631–6.
33. Tomaževič T, Ban-Frangež H, Ribič-Pucelj M, Premru-Sršen T, Verdenik I. Small uterine septum is an important risk variable for preterm birth. Eur J Obstet Gynecol Reprod Biol. 2007;135(2):154–7.
34. Moore O, Haimovich S. Energy sources in hysteroscopy [Internet]. In: Tandulwadkar S, Pal B, editors. Hysteroscopy simplified by masters. Singapore: Springer; 2021 [cited 2021 Apr 7]. p. 11–20.Available from: https://doi.org/10.1007/978-981-15-2505-6_3.
35. Sutton PA, Awad S, Perkins AC, Lobo DN. Comparison of lateral thermal spread using monopolar and bipolar diathermy, the Harmonic Scalpel™ and the Ligasure™. Br J Surg. 2010;97(3):428–33.
36. Daniell JF, Osher S, Miller W. Hysteroscopic resection of uterine Septi with visible light laser energy. J Gynecol Surg. 1987;3(4):217–20.

37. Choe JK, Baggish MS. Hysteroscopic treatment of septate uterus with Neodymium-YAG laser. Fertil Steril. 1992;57(1):81–4.
38. Candiani GB, Vercellini P, Fedele L, Carinelli SG, Merlo D, Arcaini L. Repair of the uterine cavity after hysteroscopic septal incision. Fertil Steril. 1990;54(6):991–4.
39. AAGL Practice Report. Practice guidelines for the management of hysteroscopic distending media. J Minim Invasive Gynecol. 2013;20(2):137–48.
40. The use of hysteroscopy for the diagnosis and treatment of intrauterine pathology: ACOG Committee Opinion, Number 800. Obstet Gynecol 2020;135(3):e138.
41. Parsanezhad ME, Alborzi S, Zarei A, Dehbashi S, Shirazi LG, Rajaeefard A, et al. Hysteroscopic metroplasty of the complete uterine septum, duplicate cervix, and vaginal septum. Fertil Steril. 2006;85(5):1473–7.
42. Darwish AM, ElSaman AM. Extended resectoscopic versus sequential cold knife–resectoscopic excision of the unclassified complete uterocervicovaginal septum: a randomized trial. Fertil Steril. 2009;92(2):722–6.
43. Grynberg M, Gervaise A, Faivre E, Deffieux X, Frydman R, Fernandez H. Treatment of twenty-two patients with complete uterine and vaginal septum. J Minim Invasive Gynecol. 2012;19(1):34–9.
44. Vercellini P, De Giorgi O, Cortesi I, Aimi G, Mazza P, Crosignani PG. Metroplasty for the complete septate uterus: does cervical sparing matter? J Am Assoc Gynecol Laparosc. 1996;3(4):509–14.
45. Haddad B, Louis-Sylvestre C, Poitout P, Paniel B-J. Longitudinal vaginal septum: a retrospective study of 202 cases. Eur J Obstet Gynecol Reprod Biol. 1997;74(2):197–9.
46. Coccia ME, Becattini C, Bracco GL, Bargelli G, Scarselli G. Intraoperative ultrasound guidance for operative hysteroscopy. A prospective study. J Reprod Med. 2000;45(5):413–8.
47. Tonguc EA, Var T, Yilmaz N, Batioglu S. Intrauterine device or estrogen treatment after hysteroscopic uterine septum resection. Int J Gynecol Obstet. 2010;109(3):226–9.
48. Yu X, Yuhan L, Dongmei S, Enlan X, Tinchiu L. The incidence of post-operative adhesion following transection of uterine septum: a cohort study comparing three different adjuvant therapies. Eur J Obstet Gynecol Reprod Biol. 2016;201:61–4.
49. Yang J-H, Chen M-J, Chen C-D, Chen S-U, Ho H-N, Yang Y-S. Optimal waiting period for subsequent fertility treatment after various hysteroscopic surgeries. Fertil Steril. 2013;99(7):2092–2096.e3.
50. Wang S, Shi X, Hua X, Gu X, Yang D. Hysteroscopic transcervical resection of uterine septum. JSLS. 2013;17(4):517–20.