Chapter 2

Hysteroscopic Surgery for Submucosal Fibroids

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Additional information is available at the end of the chapter

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Abstract

This chapter presents a contemporary summary of the evidence of the clinical impact of submucosal fibroids and discusses the methods used to investigate and surgically manage this common gynaecological condition.

Keywords: fibroid, submucosal fibroid, leiomyoma, female infertility, abnormal uterine bleeding, surgery, hysteroscopy, resectoscope, hysteroscopic surgery, menorrhagia, recurrent miscarriage

1. Introduction

Submucosal leiomyomas or fibroids are estimated to be the cause of 5–10% of cases of abnormal uterine bleeding, pain, subfertility and infertility [1].

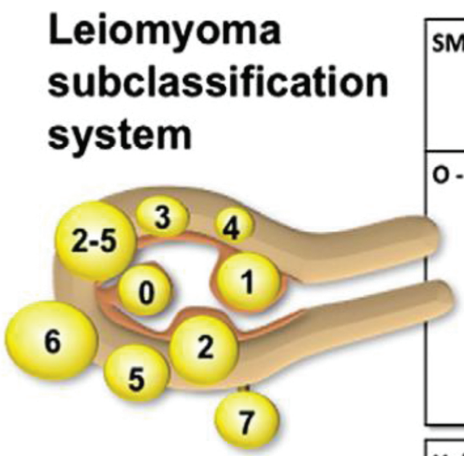
This chapter focuses on the diagnostic methods to determine the type of submucosal leiomyomas present, their impact on uterine bleeding and infertility, and the methods used to resect these leiomyomas.

2. Classification of fibroids

It is important to classify fibroids according to the degree of endometrial cavity distortion when considering therapeutic options such as a surgical approach. The degree of intramural extension has implications for operative difficulty and risk. The most widely used system classifies submucous leiomyomas into three subtypes according to the proportion of the lesion's diameter that is within the myometrium as determined by saline infusion sonography (SIS) or hysteroscopy. Type 0 leiomyomas are completely intracavitary, type 1 leiomyomas are less than 50% intramural and type 2 leiomyomas more than 50% intramural [2, 3].

This classification has been shown to be predictive of the likelihood of complete surgical resection, which is the most predictive indicator of surgical success. Uterine size and the number of leiomyomas also have been shown to be independent prognostic variables for recurrence [2, 4].

A newer and more detailed classification system has been devised and advocated by the International Federation of Gynecology and Obstetrics (FIGO). This system allows for categorization of the relationship of the leiomyoma outer boundary with the uterine serosa, a relationship that is important when evaluating women suitable for resectoscopic surgery. Thus, a type 2 leiomyoma that reaches the serosa is considered to be a type 2–5 lesion and therefore not a candidate for resectoscopic surgery (see **Figure 1**).



SM - Submucosal	0	Pedunculated intracavitary
	1	<50% intramural
	2	≥50% intramural
O - Other	3	Contacts endometrium; 100% intramural
	4	Intramural
	5	Subserosal ≥50% intramural
	6	Subserosal <50% intramural
	7	Subserosal pedunculated
	8	Other (specify e.g. cervical, parasitic)
Hybrid leiomyomas (impact both endometrium and serosa)	Two numbers are listed separated by a hyphen. By convention, the first refers to the relationship with the endometrium while the second refers to the relationship to the serosa. One example is below	
	2-5	Submucosal and subserosal, each with less than half the diameter in the endometrial and peritoneal cavities, respectively.

Figure 1. FIGO classification of submucous leiomyomas. Reproduced with permission granted by Elsevier.

2.1. Diagnostic methods for classifications of fibroids

The methods to confirm the presence of a submucous fibroid include ultrasonography (typically transvaginal ultrasonography, TVUS), saline infusion sonography (SIS), diagnostic hysteroscopy, hysterosalpingography and magnetic resonance imaging (MRI). The diagnosis of submucous fibroids is generally achieved with one or a combination of hysteroscopy and radiological techniques. The aims are to distinguish leiomyomas from adenomyosis, confirmation of submucous location, as well the number, size, location and extent of myometrial penetration of each identified submucous myoma. The relationship of the submucous myoma to the uterine serosa is of particular importance as transcervical resection is not appropriate when the leiomyoma is very close to or in contact with the serosal layer of the uterus, due to an increased risk of uterine perforation and visceral injury with significant associated morbidity.

A surgeon can get the best appreciation for the location and relationship of submucosal fibroids to the uterine serosa by reviewing the radiological images themselves prior to the planned operation. This well help them decide the best approach to resecting the fibroids. The quality of the images obtained therefore plays a significant role. These imaging modalities will be discussed in detail below [5].

2.1.1. Transvaginal ultrasonography (TVUS)

TVUS has a sensitivity of 0.8 and a specificity of 0.7 for diagnosing submucous fibroids, and is generally thought to have limited use for exclusion of submucous fibroids and polyps (negative likelihood ratio 0.29) [6]. However, a prospective study suggested that when TVUS has been used as a first-step investigation, diagnostic hysteroscopy can be avoided in 40% of cases. This would suggest that it is a viable non-invasive initial investigation [6]. Unfortunately, TVUS is very operator dependent, a factor that must be considered when evaluating its reliability.

2.1.2. Saline infusion sonography (SIS)

Hysterosonography or saline infusion sonography (SIS) is a non-invasive imaging technique performed at the time of transvaginal ultrasound. Saline is introduced into the uterine cavity at the time of ultrasound and distends the uterine cavity to give better visualization of the endometrium and any intrauterine tumours or polyps [7].

The procedure is best performed when the endometrium is thin and the patient is not pregnant, therefore the first ten days of a menstrual cycle. The cervix is identified by speculum examination and a fine catheter inserted into the cervical os with a saline containing syringe at the end of the catheter. A transvaginal ultrasound is then performed at the same time as the injection of the saline. The procedure takes no more than 10–15 minutes. The benefit of saline infusion sonography is that the intramural component of a submucous fibroid is then better visualized by the ultrasound (see **Figure 2**) [5]. There is high-quality evidence from a Cochrane systematic review that demonstrates SIS and hysteroscopy to be equivalent for the diagnosis of submucous leiomyomas, with both superior to TVUS [8]. The main drawbacks of this technique are the risk of infection (1%) and the discomfort associated with injection of sterile saline into the uterus.

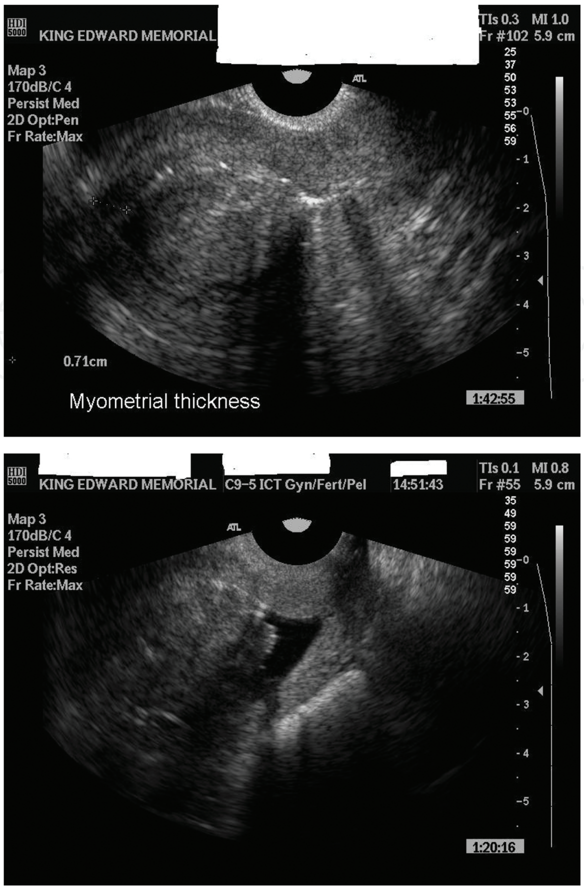


Figure 2. Ultrasound before and after instillation of saline as a contrast medium.

2.1.3. Diagnostic hysteroscopy

Hysteroscopy involves inserting a telescope (usually 2.7–4 mm) into the endometrial cavity. The procedure may be performed in an outpatient setting without anaesthetic, even in nulliparous women and is highly successful, although some women (approximately 25%) will require local anaesthesia and some women may prefer general anaesthesia. If the patient requires a local anaesthetic, it can be administered by a paracervical block using 5 mL of 1% lignocaine. This can be injected at the level where a tenaculum is applied to the cervix and also at the 3 o' clock and 9 o' clock positions deep enough to the level of the internal cervical os. Other options are topical local anaesthetic gel, spray or cream [9, 10].

As for any procedure on the uterus it is essential to exclude the possibility of pregnancy and active infection. The administration of a non-steroidal anti-inflammatory prior to the procedure has been demonstrated to reduce the patient's posthysteroscopy discomfort [11].

Two methods of uterine distension are used—carbon dioxide and normal saline instillation. A randomized controlled trial (RCT) of carbon dioxide versus normal saline instillation during hysteroscopy found that normal saline provided comparable visualization to carbon dioxide with reduced procedure time and patient discomfort [12]. The distending pressure normally used is 80–100 mmHg.

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Diagnostic hysteroscopy can be used to assess and document uterine abnormalities which should then be recorded by digital images. These can be used to plan an operative procedure and also facilitate the patient's understanding of their pathology (see **Figure 3**). The procedure should be performed quickly to avoid patient discomfort and manipulation of the cervix when rotating the hysteroscope should be avoided.

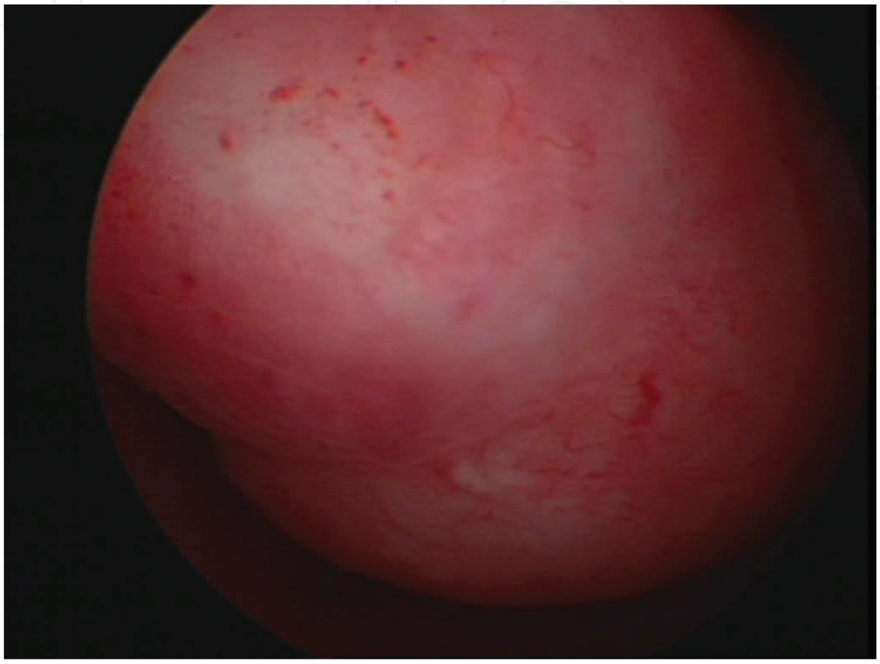

Figure 3. Hysteroscopic image of fibroid prior to resection.

2.1.4. Magnetic resonance imaging (MRI)

Magnetic resonance imaging (MRI) is a costly imaging technique which is not available in all units. However, the use of T2-weighted images allows accurate localisation of the demarcation between the endometrium and myometrium. MRI is the most accurate modality in assessing the adnexae and the uterus because it provides information on the size, location, number and perfusion of leiomyomas as well as the presence of other uterine pathology including adenomyosis or endometriosis [13].

A double-blinded study demonstrated that although TVUS and MRI are roughly equivalent in diagnosing the presence of leiomyomas, the determination of other features such as location and proportion of the tumour in the endometrial cavity, is best accomplished with MRI. It was shown to be the most reliable method of evaluation when compared with vaginal ultrasound, hysterosonography and hysteroscopy, with 100% sensitivity and 91% specificity (gold standard was pathological examination) [14].

MRI was superior to the TVUS and SIS in evaluating the relationship of submucous leiomyomas to the myometrium [15]. MRI is becoming more available for the assessment of submucosal fibroids; however, the costs involved and its availability limit its use.

3. Indications for surgery

If a submucosal fibroid is confirmed with selected diagnostic modalities, the decision to operate should be individualized based on the patient and their symptoms. It is believed that one in three women with fibroids experience abnormal uterine bleeding (AUB) and that the presence of a submucosal fibroid increases the chance of this. The two most common indications for surgery are described below [16, 17].

3.1. Menorrhagia

There is little evidence implicating the role of FIGO staged submucous leiomyomas as the cause of haemorrhage requiring urgent intervention [18]. However, there is evidence to suggest that submucous leiomyomas can cause chronic abnormal uterine bleeding and heavy menstrual bleeding (HMB).

A systematic review of 11 studies demonstrated the prevalence of submucous myomas in women with AUB was 23.4%. Submucous myomas were found in 23.4% of premenopausal women (six studies) and 4.5% of postmenopausal women with AUB (one study). Although these studies fell short of proving that submucous myomas cause AUB they suggest that there may be a relationship. The incidence of submucous fibroids in 323 consecutive asymptomatic women undergoing sterilization was reported at 1.8%, whereas in a series of women with abnormal uterine bleeding, submucous fibroids were reported more frequently (6–34%) [19].

Broadbent and Magos [20], measured menstrual blood loss before and after hysteroscopic surgery of submucosal fibroids and showed that surgery improved both dysmenorrhea and heavy bleeding. They demonstrated that after surgery there was a significant reduction in the duration, blood loss and pain score associated with menstruation.

There are various theories for the pathophysiology of how submucous fibroids contribute to abnormal uterine bleeding and menorrhagia. It is thought that the mechanisms involved in haemostasis and prostaglandin production in the endometrium can be disturbed by the presence of fibroids. Another hypothesis is that it can be due to increased endometrial surface area of the endometrium. Both submucous and intramural fibroids have the potential to cause this [21].

3.2. Infertility

Women undergoing IVF treatment in the presence of a submucosal fibroid have lower clinical pregnancy rates than those without fibroids (10% vs. 30%) as seen in a retrospective comparative study of over 400 assisted reproductive treatment cycles. This may suggest an association between submucosal fibroids and subfertility. One major drawback was that in this study there were only nine patients in the submucosal fibroid group. Similar results were recorded in a study by Farhi et al. [22, 23]. There have been no appropriately designed studies to demonstrate a direct causal relationship between the presence of fibroids and infertility.

Many hypotheses have been generated to explain how fibroids might cause infertility. Perfusion studies have shown that blood flow to uterine fibroids is less than that to the adjacent myometrium. Blood flow to the uterine arteries is also different in a fibroid uterus than a non-fibroid uterus [24]. This and the fact that there may be endometrial inflammation and an altered local hormonal environment may affect embryo implantation. Myomas also seem to alter uterine contractility possibly interfering with sperm and ovum interaction or embryo migration [25]. This may especially be true in a uterus with multiple large fibroids with cavity distortion.

Six systematic reviews or meta-analyses published between 2001 and 2010 assessed whether fibroids have an impact on fertility. On the whole, it appears that women with fibroids have decreased fertility. The presence of fibroids, regardless of location, significantly decreases both implantation and clinical pregnancy rates (RR 0.821; 95% CI 0.722–0.932, $P = 0.002$ and RR 0.849; 95% CI 0.734–0.982, $P < 0.03$, respectively). The impact of fibroid number and size on fertility has not been clearly elucidated. Reproductive success does, however, seem to be related to fibroid location [26, 27].

All systematic reviews and meta-analyses agree that subserosal fibroids do not have an impact on fertility. Submucosal fibroids (fibroids with endometrial impingement), however, have been shown uniformly to have a negative impact on rates of implantation, clinical pregnancy rate, miscarriage and live birth/ongoing pregnancy, although available studies are few and small [24, 27].

In conclusion, submucosal fibroids are associated with reduced fertility and an increased miscarriage rate. Hysteroscopic myomectomy for submucosal fibroids is likely to improve fertility outcomes; however, the quality of available studies is poor and further research is required. The relative effect of multiple or different sized fibroids on fertility outcomes are also uncertain [28].

4. Surgical management of submucosal fibroids

Surgical resection remains the mainstay for women with symptomatic submucosal fibroids. Medical therapy with gonadotrophin-releasing hormone analogues (GnRHa) appears useful in the short term but side effects limit their long-term use [5]. Medical management of fibroids delays efforts to conceive and is not recommended for the management of infertility associated with fibroids. However, short-term GnRH analog use in infertile women with fibroids can be useful for preoperative correction of anaemia or short-term reduction in fibroid volume [28].

Newer, novel therapies including aromatase inhibitors, mifepristone, selective estrogen receptor modulators and selective progesterone receptor modulators have shown promise in symptom improvement and fibroid regression without the hypoestrogenic symptoms associated with GnRH analogues however they are currently only used in the setting of approved clinical trials on the management of fibroids in women with infertility.

The same applies to other alternatives to surgery such as uterine artery embolization (UAE), magnetic resonance-guided focused ultrasound surgery (MRgFUS), myolysis and radiofrequency ablation (RFA) all of which are still being investigated in terms of their long-term impact on fertility [24, 28].

4.1. Transcervical resectoscopic myomectomy (TCRM)

Transcervical resectoscopic myomectomy (TCRM) was performed in 1976 with a modified urologic resectoscope [29]. Traditionally, this has been the most common method of hysteroscopic resection of fibroids, but various new modalities such as vapourisation, morcellation and dissection are now being used in the surgical management of fibroids [3].

Hysteroscopic myomectomy is the least invasive surgical approach for fibroid removal. It is most effective for patients with submucosal fibroids completely within the uterine cavity (type 0) or with at least 50% of the fibroid volume within the uterine cavity (type 1). Fibroids with less than 50% of the fibroid volume in the cavity (type 2) are much more difficult to resect completely and are more often associated with the need for repeated procedures.

Submucous fibroids less than or equal to 5 cm diameter can be removed hysteroscopically however anything larger in diameter should be removed abdominally whether by laparoscopy or laparotomy (midline or pfannensteil) depending on surgeon's skill and preference. Type 2 fibroids tend to require a multi-staged procedure when compared to type 0 and 1 [4, 24].

4.1.1. Patient selection

Achievement of a high likelihood of surgical success requires good patient selection and relevant factors such as the number of submucous myomas, their location, size and type, and their relationship to the uterine serosa should be considered. When evaluating the suitability of patients for TCRM, it is important to consider the myoma type, the potential for incomplete excision and the patient's tolerance for more than one procedure if required. The indication for fibroid resection is also very important.

With resection of fibroids for abnormal bleeding, it is found that type 2 myomas could be eventually resected but required a larger number of repeat procedures than the more superficial types 0 and 1 myomas, which almost invariably are completed with a single operation [30, 31].

A recently published randomized controlled trial compared treatment of submucous myomas in 215 women with primary infertility. Fertility rates increased after TCRM for type 0 and type 1 myomas, but no significant difference was noted between the groups for type 2 myomas. However, a number of questions related to the effects of resection of myomas on fertility remain unanswered and highlight the need for careful patient selection in this population [32].

The same applies with regard to multiple pregnancy loss. Data from Pritts et al. suggest that in selected patients submucous myomectomy may reduce the rate of spontaneous abortion; however, more data are required to confirm this [27].

4.1.2. Pre-operative preparation

4.1.2.1. Suppressive medical therapy before TCRM

Commencing the patient on a gonadotrophin hormone-releasing (GnRH) analogue or selective progesterone receptor modulator (mifepristone or ulipristal acetate) [33] prior to the surgery allows the surgeon to operate when the endometrium is thin which can reduce operative time by allowing better visualization during the procedure. Theoretically, this also reduces intraoperative bleeding and fluid absorption. However, its main proven benefit is that it can reduce menstrual blood loss and correction of anaemia prior to surgery. This also aids with restoration of haemoglobin and iron stores for the woman. Whereas high-quality data exist demonstrating the efficacy of GnRH agonists in facilitating the treatment of anaemia before the procedure the data regarding the impact on other outcomes is more mixed, although the use of selective progesterone receptor blockers may show promise [34–36].

4.1.2.2. Cervical preparation before TCRM

Various methods are available for preoperative ripening of the cervix prior to hysteroscopic resection. The benefit of cervical ripening is to reduce the risk of cervical tears and uterine perforation that is associated with forceful dilatation. These risks are increased in postmenopausal women, for those without previous vaginal delivery and for women with previous surgery for cervical surgery or neoplasia. Options for ripening include laminaria tents, preoperative prostaglandins such as misoprostol and intraoperative intracervical injection of dilute vasopressin [3].

Probably the best available evidence is for use of prostaglandins. High-quality evidence from randomized controlled trials suggests that misoprostol, a synthetic prostaglandin E_1 analogue (200–400 mcg) taken orally or vaginally, 12–24 hours before surgery, facilitates cervical dilation and minimizes traumatic complications in premenopausal women [37]. The cervix is then usually dilated to accept a size 10 Hegar dilator.

4.1.2.3. Prophylactic antibiotics and intra-operative preparation

The risk of infection from hysteroscopic procedures is low, in the order of 0.5–1% with a risk of endometritis following resectoscopic myomectomy of 0.51% [38]. Most operators would however routinely administer prophylactic antibiotics to limit postoperative febrile morbidity, although there is no prospective data to support this practice.

4.1.2.4. Anaesthesia

Resection of a submucosal fibroid is usually performed after the administration of general anaesthetic, although it may be performed with spinal anaesthesia or with local anaesthetic; paracervical block and intrauterine injection of local anaesthetic in association with intravenous sedation [39].

Increasingly over the last decade, more operative hysteroscopic procedures have been performed in an office-based setting. Mcilwaine et al. showed in a study of 42 patients that the

Myosure lite device (uses electromechanical energy) can be successfully used to resect small fibroids in the outpatient setting with a high level of patient satisfaction with the use of local anaesthetic in a paracervical block [40].

4.2. Surgical technique

Patients are generally placed in lithotomy position: Trendelenburg positioning should be avoided. After an examination under anaesthesia, a bivalve speculum is placed in the vagina and the cervix identified. After placing a single tooth tenaculum on the anterior lip of the cervix (if the patient is conscious local anaesthetic spray can be applied prior to this), the cervix is dilated with Hegar dilators to size 10 sufficient to accommodate the 9 mm outer sheath of a standard resectoscope. The longer dilators with a gradually tapered tip are safer and minimize the risk of perforation [41].

The correct and safe use of instruments available will enable the surgeon to most effectively carry out hysteroscopic fibroid resection. In the past, smaller fibroids have been removed with conventional instruments such as grasping polyp forceps or scissors; however, there is now a growing trend towards performing the procedure with devices under direct vision [3]. They have the added benefit of early recognition of the complication of uterine perforation and reducing its associated morbidity.

4.2.1. Hysteroscopic systems

For optimum safety and effectiveness, the surgeon should have a detailed understanding of the design and assembly, and where necessary, troubleshooting strategies for the system in use.

The most commonly employed system for removal of submucous myomas is the urologic resectoscope, slightly modified for gynaecological use. With this instrument, the fibroid can be resected under direct vision. The resectoscope consists of a 26 French gauge outer sheath diameter and 0° or 30° fore-oblique telescope with a 4 mm outer diameter. All modern resectoscopes are of a continuous flow design, allowing constant turnover of distending media that facilitates visualization of the fibroid by rinsing out blood and debris. There is a large calibre inflow (cystoscopy tubing) and outflow tubing that are connected to a fluid management system. The inflow is pressurized with a peristaltic pump with a maximum pressure setting of 150 mmHg and a maximum flow setting of 450 mL/minute, similar to standard resectoscopy [42]. Pressures selected are based on the mean arterial pressure of the patient as a first-line barrier to fluid intravasation, typically 80 mmHg.

Standard technique to remove polyps and submucous myomas is resectoscopy with monopolar high-frequency electrical current. By means of a 5mm wire loop electrode, mounted on a working element with handpiece and integrated in an endoscope, tissue can be cut. Monopolar current necessitates the use of nonconducting, nonphysiologic, electrolyte-free irrigation and distention liquids such as sorbitol 5% or glycine 1.5% [3, 41, 42].

The outflow tubing should be connected to both the under the buttocks collection bag as well the outflow adaptor of the hysteroscope itself. This maintains a negative pressure in the outflow

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tract and allows for continuous suction of debris-laden fluid from the endometrial cavity and an accurate count of fluid lost. The negative pressure may be increased if the view is too cloudy or decreased if there is inadequate uterine distension prior to increasing the distension pressure [5, 41].

More commonly bipolar resectoscopes are being used as they require the use of isotonic conductive media, such as normal saline or lactate Ringers solution. This is because in a bipolar loop the active and return electrodes are in close proximity to one another a lower impedance media can be used. The risk of volume overload and electrolyte disturbance is significantly reduced with isotonic solutions.

Small-diameter bipolar electrodes or laser fibers can be passed through the instrument channel of most standard hysteroscope sheaths 5 mm or greater in diameter. In some instances, dissection of smaller submucous myomas can be accomplished with such energy sources.

The hysteroscopic morcellator is gaining more popularity in recent years. It was developed based on an orthopaedic shaver. It is a hollow device with a sideways opening that allows the blade to morcellate the leimyoma. It also has the ability to suction morcellated fragments of the fibroid simultaneously. This can also be used with saline distension media and does not require electrical current [42] (see **Figure 4**).

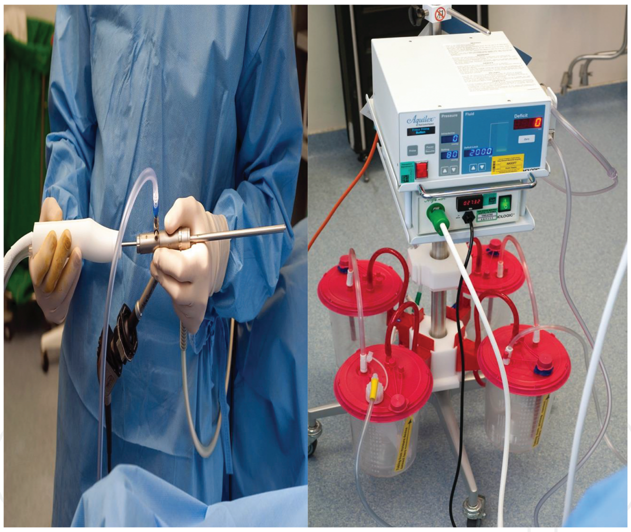

Figure 4. Surgeon holding *Myosure(Hologic)* hysteroscopic device (right). Inflow and outflow tubing for fluid management system (*Aquilex Hologic*) (left).

4.2.2. Myomectomy procedure

There are three basic methods for removing leiomyomas under hysteroscopic direction; morcellation, cutting with an electrosurgical loop and vaporization. The most commonly employed approaches use the resectoscope, a radiofrequency electrosurgical generator, and either a loop or a bulk-vapourising electrode.

When performing radiofrequency-based hysteroscopic myomectomy on women who wish to preserve fertility, care should be taken to minimize thermal damage to the tissue adjacent to the incision and that the loop does not touch adjacent healthy endometrium.

The traditional resectoscopic removal involves a slicing action of the fibroid. It can be performed with monopolar or bipolar cutting or coagulating current at a setting of 100 W. The electrosurgical loop is advanced beyond the fibroid and a repeated action of passing the cutting loop over the tissue in a backward direction, away from the fundus of the uterus is performed. In a pedunculated fibroid, the stalk can be transected and then removed by polyp forceps. Performing the procedure in a systematic way, starting at the top of the fibroid and working ones' way down to its base is the ideal approach. It is important to avoid damage to normal endometrial tissue with the loop as much as possible. Repetitively removing the resectoscope from the uterus to remove tissue fragments is time consuming, causes cervical trauma and can lead to a loss of uterine distention with compensatory increased use of distention media. To avoid this resected tissue, fragments can be pushed towards the uterine fundus and removed at the end of the operation. The closer the association of the fibroid with the serosa of the uterus, the more challenging the resection is due to the significant intramural component. Methods to facilitate extrusion of the intramural component include using the natural contractility of the uterus [43], intraoperative prostaglandins to stimulate uterine smooth muscle contraction [38], intravenous ergometrine [44] and repeated release of the uterine distending pressure, to allow for natural uterine extrusion.

For deep type 1 and type 2 fibroids that approach the uterine serosa (millimetres), it may be safer to perform a laparoscopy at the same time as the resection. This does not always prevent perforation but ensures early recognition of this complication and associated damage to other viscera. There is also the thought that the gas used to distend the abdominal cavity at laparoscopy can create a safety buffer in the unfortunate event of a perforation [45]. Type 0 and most type 1 fibroids are much more easily removed.

When a submucosal fibroid has a significant intramural component (type 2), a multi-staged procedure will result in a more complete resection and is generally also thought to be safer as it avoids the complication of perforation which can occur during resection of the base of the fibroid.

Electrosurgical vapourisation of fibroids involves using an electrode of cylindrical or spherical shape which uses current to vapourise the tissue. This does not produce any tissue fragments which can be a disadvantage if a specimen is required for histopathological assessment [46]. There is some lower quality evidence which suggests that reduced systemic absorption of distention media may occur with hysteroscopic myomectomy using this approach [47]. This could be because tissue fragments are not produced and the procedure can be performed faster without the need for removing tissue fragments. As with any current, the duration of contact, resistance of the tissue and the power (wattage) determine the degree of current delivered through the dispersive electrode. The surgeon is responsible for being aware of the power settings, as if they are too high there is a risk of skin burns to the patient through the skin plate (see **Figure 5**).

Another technique with increasing popularity is hysteroscopic morcellation. Using a modified prototype based on an orthopaedic arthroscopic tissue shaver, Dr. Mark Hans Emanuel was able to create a first-generation device that used mechanical energy rather than electrical energy to resect uterine tissue.

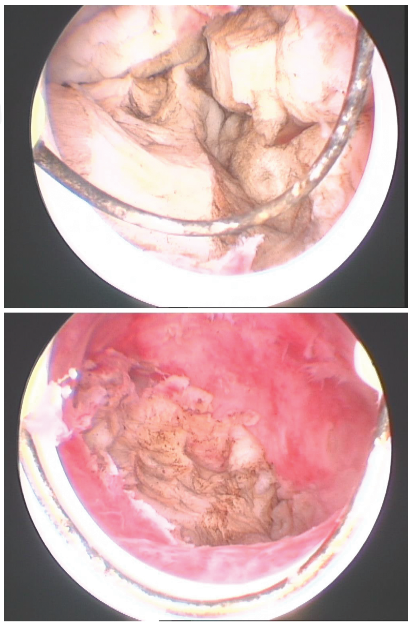

Figure 5. Hysteroscopic resection of a type 0 Fibroid (top) and at the end of a completed resection (bottom).

Hysteroscopic morcellation aims to remove uterine leiomyomas during a single insertion of a hysteroscope into the uterus. This contrasts with traditional hysteroscopic resection of leiomyomas, in which the instrument is reinserted into the uterus multiple times. Hysteroscopic morcellation is intended to reduce the risk of traumatic injury to the uterus and the risk of inadvertent fluid overload associated with traditional procedures (because the procedure may be completed more rapidly). An intended advantage of the procedure over thermal ablation techniques is avoiding the risk of thermal injury.

A hysteroscope is inserted into the uterus through the cervix, and saline is pumped through a small channel in the hysteroscope to distend the uterus. A specially designed morcellator is introduced via the hysteroscope and used to cut and simultaneously aspirate the leiomyoma tissue. The aspirated tissue can be collected for histological analysis. For polyps and type 0 and type 1 submucous myomas, hysteroscopic morcellation has been demonstrated to be both faster and easier to learn than traditional resectoscopy. The earliest published trial with a hysteroscopic morcellation device by Emanuel and colleagues showed a significant reduction in operating room time when removing polyps and type 0 and type 1 submucous myomas. In that study, polyps were removed with a 72% reduction in operating room time with a morcellator as compared with a resectoscope type 0 and type 1 myomas were removed in 61% less time, respectively [42]. Hence, hysteroscopic morcellation is most useful for small or pedunculated leiomyomas [48].

5. Complications

Hysteroscopic resection of submucosal fibroids is very safe in experienced hands. However, potential surgical complications include fluid overload, intraoperative and postoperative bleeding, uterine perforation, gas embolism, and infection with associated uterine synechiae.

5.1. Excessive fluid absorption

Excess absorption of non-crystalloid distension media can cause serious fluid and electrolyte imbalance, pulmonary and cerebral oedema, cardiac failure, and death [49]. Although complications associated with excess fluid absorption are relatively uncommonly encountered, premenopausal women undergoing resectoscopic surgery in the uterus may be at greater risk because of the inhibitory impact of female gonadal steroids (most likely estrogen) on the sodium/potassium ATP'ase pump [50]. Studies have demonstrated that 100 mL intravasation correlates with a sodium decrease of approximately 1 mmol/L. One study demonstrated that cerebral oedema could be identified during computed tomography scanning from an intravasation of only 500 mL. Therefore, a meticulous measure of the inflow and outflow of fluid used is extremely important [51].

Fluid absorption is increased when intrauterine pressure exceeds mean arterial pressure. Consequently, the intrauterine pressure should be maintained at the lowest pressure that allows good visualization for performance of the hysteroscopic myomectomy.

Nonconducting (electrolyte free) distention mediums such as glycine 1.5% or mannitol 5% are used with the monopolar electrosurgical system. With excess absorption of these fluids, there is a risk of hyponatraemia; however, the more serious complication is of cerebral oedema due to a hypo-osmolar effect on plasma concentration. This rare side effect can be fatal.

Electrolyte containing isotonic distention media (normal saline) can be used when mechanical or bipolar resections are employed. Its use reduces the risk of hyponatraemia and changes in serum osmolality when compared with nonconducting media. It can still cause fluid overload with consequent pulmonary oedema and therefore meticulous fluid balance should still be maintained.

5.2. Trauma

Other major complications consist of haemorrhage and uterine perforation. Perforation of the uterus can occur with dilators, mechanical grasping tools or the resectoscopic system. If perforation occurs with mechanical instruments, and no bowel injury is suspected, the patient can be managed expectantly with close observation for a 24-hour period. Laparoscopy must be performed if bowel injury is suspected, where there appears to be a large perforation, or in the presence of heavy bleeding. If perforation occurs with an activated electrode, one has to assume that there has been a bowel injury until proven otherwise, and laparoscopy or laparotomy is recommended.

Uterine perforation can be a complication with serious associated morbidity. Reassuringly, the risk of this is generally low. In a study of 2100 operative hysteroscopies performed by experienced surgeons, 782 involved fibroid resection and uterine perforation occurred in 1.2% of those procedures and 1.6% of all hysteroscopies [52]. The prospective Mistletoe study which analysed techniques of endometrial ablation demonstrated a slightly higher uterine perforation rate of up to 2.5% when using the electrosurgical resection loop [53]. Up to a third of uterine perforations are thought to occur during cervical dilatation before the resection is actually commenced. This could be avoided by use of cervical priming agents as discussed prior to allow easier dilatation. Unrecognized injury is a serious incident as it is possible that a bowel burn may have occurred, if perforation occurred when using an activated electrode, potentially leading to peritonitis and a high index of suspicion must always be exercised.

The above group also looked at rates of haemorrhage. Haemorrhage was defined as abnormal bleeding at the end of the procedure. In the 782 fibroid resections, the risk of operative haemorrhage was 0.4% [46].

5.3. Bleeding

Heavy bleeding from the endometrial cavity is uncommon after hysteroscopic surgery in general. If there is continuous bleeding after resection, a Foley catheter can be inserted into the uterine cavity and distended with up to 40 mL of saline until the bleeding settles from a tamponade effect. The balloon can be removed if the bleeding has settled in a few hours.

Other pharmacological agents that have been investigated to reduce blood loss at myomectomy include tranexamic acid, prostaglandin E2 analogues (misoprostol and dinoprostone) and ascorbic acid. Randomized controlled trails of these agents compared to placebo showed statistically significant reduction in blood loss; however, sample sizes in these studies were small and had low to moderate quality evidence [54].

A more invasive option for controlling bleeding is uterine artery embolization with interventional radiologic techniques if bleeding persists despite above measures.

5.4. Thermal burns

One must be very careful to avoid unintentional activation of the monopolar or bipolar pedals. If this occurs while the active electrode is resting on the patient it can cause serious burns to the abdomen, perineum, vagina or vulva [3].

More sinister burns occur when the uterus is perforated by an active electrode causing injury to surrounding structures, most commonly the bowel or blood vessels. This type of injury can be prevented by making sure not to activate the electrode while it is being advanced into the endometrial cavity. It should only be activated when being withdrawn. As discussed before, if a uterine perforation is suspected due to an active electrode, the surgeon must perform an exploratory laparoscopy or laparotomy depending on the extent of perforation.

5.5. Adhesions

Intrauterine adhesions can occur after hysteroscopic myomectomy to the point that they adversely impact fertility. The incidence of intrauterine adhesions after hysteroscopic myomectomy was shown in one study to be 7.5% [55]. Postoperative adjuvant therapy, including estrogen therapy for four to eight weeks or insertion of an intrauterine device, paediatric Foley catheter or other balloon for one week postoperatively, have all been used to prevent further adhesion development. However, there is scant evidence to support the use of these postoperative therapies [56, 57].

If, on preoperative assessment, it can be anticipated that a large proportion of the cavity will be stripped of endometrium after resection, an abdominal approach (laparotomy, laparoscopy or "robotic") to myomectomy should be considered to reduce the formation of adhesions. In a retrospective study, when second look hysteroscopy was performed after one to three months on 153 women who underwent TCRM, 2 of 132 (1.5%) with single myomectomy had intrauterine adhesions [58].

6. Effectiveness of hysteroscopic resection of submucosal fibroids

6.1. Management of subfertility

There is a lack of prospective randomized controlled trials assessing the true impact of surgical management of submucosal fibroids on fertility. This would be challenging to perform for obvious reasons. Many studies do not document that a comprehensive assessment of various causes of infertility was performed on the patient prior to surgery to isolate only those patients where the fibroid was the causative factor of subfertility. Other confounding factors are that conception rates are not recorded before and after surgery.

A recently published RCT compared TCRM with no treatment in 215 women with primary infertility with demonstrated submucous fibroids on ultrasound. The two randomized groups were women who underwent either TCRM or diagnostic hysteroscopy with biopsy only. At follow up, 63% of the treatment group conceived but only 28% of the biopsy group had (RR 2.1 CI 1.5–2.9). The investigators concluded that fertility rates increased after hysteroscopic myomectomy in women with type 0 and type 1 myomas ($p < 0.05$) but the same was not seen in women with type 2 myomas [59].

Similarly, Bozdag et al. demonstrated an improvement in spontaneous conception rates after the surgical removal of submucosal fibroids, but pregnancy rates following the removal of intramural or subserosal fibroids were no more improved than in the expectant management group of women with intramural or subserosal fibroids in situ [60]. A recent meta-analysis also demonstrated similar findings, with an improvement in pregnancy rates in infertile patients undergoing surgical removal of submucosal fibroids, but not in those undergoing surgical removal of intramural fibroids [27].

In summary, the evidence suggests that in women with otherwise unexplained infertility, submucosal fibroids should be removed in order to improve conception and pregnancy rates but removal of subserosal fibroids is not recommended, and this approach is endorsed by national bodies [61]. There is fair evidence to recommend against myomectomy in women with intramural fibroids (hysteroscopically confirmed intact endometrium) and otherwise unexplained infertility, regardless of the size of the fibroids.

6.2. Management of menorrhagia

Derman et al. in 1991 performed the first large-scale trial of the long-term success of hysteroscopic electrosurgical resection of fibroids [62]. Over a 9-year follow-up period, 84% of patients avoided a further procedure and 7% of patients needed a second hysteroscopic resection. Further studies by Emanuel et al. and Hart et al. showed that 91% of patients avoided further surgery at two years follow-up and 73% at eight years follow-up. It was also shown that risk factors for requiring surgery included a larger uterus and multiple fibroids [51].

Five series involving over 1400 women have shown that hysteroscopic myomectomy is an effective management option for dysfunctional uterine bleeding. Failure rates ranged from 14.5% to 30% for up to 4 years' follow-up [63]. This would suggest surgery should be considered as first-line treatment for the management of symptomatic fibroids, including submucous fibroids. Submucous myomas (types 0, 1 and 2) up to 5 cm in diameter can be removed hysteroscopically. Type 2 myomas are more likely to require a two-staged procedure than types 0 and 1 because of the risk of excessive fluid absorption and uterine perforation. The risk of uterine perforation is particularly high when there is less than 5 mm distance between the uterine serosa and the fibroid [2].

After TCRM alone, long-term cohort studies have indicated that patient satisfaction is in the range of 70–80%, with 14–16% of women requiring additional surgery [64].

When women with heavy menstrual bleeding who are not interested in future fertility and have selected type 2 and type 1 submucous myomas, generally 3 cm or less in diameter, endometrial ablation appears to confer a high degree of success in the short term [3]. In a single-armed, one-year study of the Novasure radiofrequency ablation system (Hologic Inc., Bedford, MA) in patients with type 1 or 2 myomas, 95% of the 65 patients were successfully treated [65]. At the present time, there is inadequate evidence to suggest that one device or technique, such as resectoscopic ablation, is clearly more efficacious than another.

Therefore, if the main symptom is heavy menstrual bleeding only and fertility is not required, consideration should be given at the time of transcervical resection of myoma to also perform endometrial ablation. This has been demonstrated in a cohort study, which showed a higher success rate in controlling bleeding when ablation was added to myomectomy [66].

7. Repeat resection of fibroids

As can be seen from the success of surgery, for most patients the chance of avoiding further surgery is about 80% with long-term follow-up [67], but the success is lower in patients with type 2 fibroids [2, 67].

The recurrence rate of fibroids is 15% and 10% of women who have a myomectomy will eventually need a hysterectomy within 10 years. Factors more likely to be associated with recurrence of fibroids are the woman's age, number of fibroids, larger uterine size and childbirth after myomectomy [68].

The success rate of a repeat resection has been described by Istre and Langebrekke [17]. Twenty-eight per cent of their 118 patients who needed repeat surgery (ablation or myomectomy) eventually proceeded to a hysterectomy. The main indication was pain due to a haematometra. One of the major causes of primary surgery failure was found to be deep adenomyosis and associated pain. It was suggested that MRI could be used as a diagnostic tool in those presenting with failed initial surgery, to select patients with adenomyosis, who are less likely to benefit from repeat surgery unless it is a hysterectomy. Of course, this option would not be of use to patients wishing to preserve fertility [69].

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