Operative Hysteroscopy

Paul P. Smith and T. Justin Clark

Abstract

In this chapter, we aim to describe contemporary operative hysteroscopy. A further aim is to provide an outline for safe and effective practice when performing such procedures by summarizing the best available evidence supplemented by the authors' own experience. More specifically, this chapter will cover the available equipment, technologies, and techniques necessary to perform a variety of hysteroscopic procedures, namely, removal of fibroids and polyps, endometrial ablation, treatment of acquired and congenital uterine abnormalities, removal of placental remnants, and sterilization. We will also discuss the role of teaching, clinical governance, and audit in improving operative hysteroscopic services.

Keywords

Hysteroscopy • Vaginoscopy • Operative hysteroscopy • Outpatient hysteroscopy • Ambulatory hysteroscopy • Office hysteroscopy • Resectoscopy

Contents

P.P. Smith • T.J. Clark (✉)
Birmingham Women's NHS Foundation Trust, Edgbaston, UK
e-mail: paul.smith@doctors.net.uk; justin.clark@bwnft.nhs.uk

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1 Introduction

In 1869, the first successful diagnostic and operative hysteroscopy was performed when Pantaleoni used a cystoscope and candlelight to treat an endometrial polyp causing postmenopausal bleeding. Then in 1907, Charles David was the first to describe a lens system that allowed uterine cavity visualization. Yet, it was not until 1943 that Forestiere's cold light source and Hopkin's rod lens were combined to form the endoscopes that have become the basis for today's hysteroscopy.

With advances in technology and techniques, hysteroscopy has taken over from dilatation and curettage to become the gold-standard procedure for investigation and treatment of pathologies in the uterine cavity. It has the advantage of being able to visualize the uterine cavity directly and can sometimes allow simultaneous treatment to be performed. A large number of procedures can now be performed hysteroscopically. These include fibroid resection, polyp removal, sterilization, removal of chronically retained products of conception (RPOC), adhesiolysis, septoplasty, and endometrial ablation. Hysteroscopic surgery is minimally invasive, avoiding surgical incisions and the need for prolonged inpatient hospital stay. Furthermore, proficient operative hysteroscopy is both quick and safe. Increasingly procedures are being performed in a more convenient ambulatory or "office" setting avoiding the need for hospital admission or general anesthesia. Indeed, the concept of office-based "see-and-treat" hysteroscopy has been propagated over the last decade with simultaneous treatments being undertaken conditional upon the prior diagnostic hysteroscopy.

Although complication rates for operative hysteroscopy are low, some complications can be life threatening. It is therefore imperative that appropriate training programs are combined with an understanding of the equipment and techniques to make operative hysteroscopy a safe and efficient tool.

2 Equipment

Most operative hysteroscopes consist of an inflow channel for distension media, an outflow channel for distension media, an operating channel with a sheath to allow instrumentation, a light lead, and telescope with fiber-optic cables and a camera head (Fig. 1).

Some hysteroscopes use an angled optic that allows better visualization of the cavity. It is important to realize that when inserting the hysteroscope through the cervix, the endocervical canal is positioned at 6 o'clock if the optic is upward and 12 o'clock if the optic is downward (Fig. 2). For most hysteroscopes, the position of the light lead is the same as the location of the endocervical canal.

Light leads are fiber-optic cables that act as conduits for light between the generator and the telescope. Fiber-optic cables are prone to damage and are normally the cause of low light generated

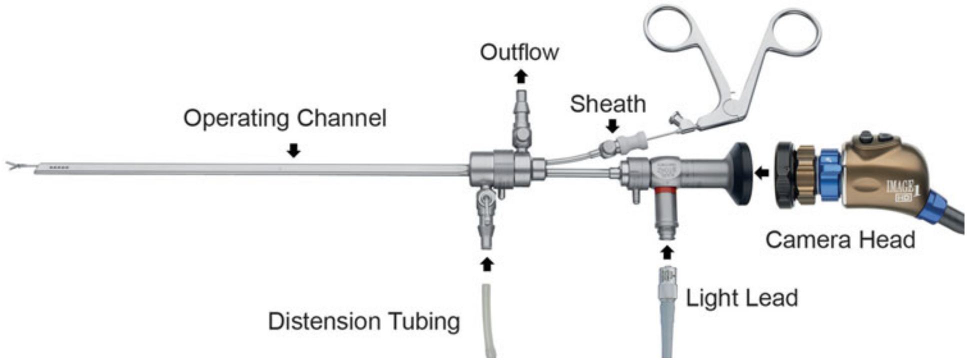
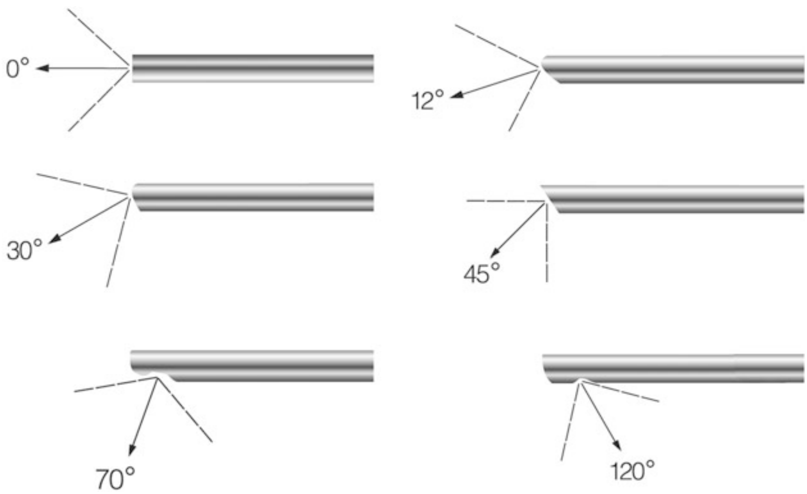


Fig. 1 Components of operative hysteroscope

Fig. 2 Endoscopic viewing angles (hysteroscopes have a 0°, 12°, 25°, or 30°)



by the telescope. Looking for dark spots at the end of the cable can assess this.

3 Patient Preparation

An important part of patient preparation is adequate counseling about the rationale for the procedure and what it involves. The patient experience is important to describe especially for those women undergoing office-based procedures without general anesthesia. Potential complications and the expected clinical outcomes need to be discussed in a frank manner. Patient information leaflets are an essential component in preoperative counseling because they support verbal information given to further ensure that patients are adequately informed and prepared for their hysteroscopic procedure.

4 Technique

Although not always practical, hysteroscopy should be performed in the first half of the menstrual cycle when the endometrium is at its thinnest. Pregnancy should be ruled out before all cases begin. When positioning patient for hysteroscopic procedures, the patient should be in the lithotomy position with the buttocks slightly over the edge of the operating table.

4.1 Prevention of Cervical Trauma and Perforation

There is evidence to suggest the hysteroscopic procedures under direct vision are more accurate than dilatation and curettage (Loffer et al. 2000; Valle 1981). Not only should procedures under direct vision be done in preference to blind procedures for the purpose of accuracy but also for safety reasons. As further advances are made resulting in miniaturization of equipment, the need for blind dilatation, which risks uterine trauma, will also be reduced.

Cervical trauma and patient discomfort can be reduced by using the thinnest hysteroscopic equipment available and the "no touch" or vaginoscopic technique. The vaginoscopic technique is achieved by guiding the hysteroscope into the uterus under direct vision without using any potentially painful instrumentation. The easiest way to do this is to enter the vagina allowing the distension media to fill the cavity and follow the posterior wall of the vagina down into the posterior fornix. The hysteroscope is then maneuvered into the cervix above and pushed through the cervical canal into the uterus. The vaginoscopic technique can only be used for hysteroscopes less than six millimeters in diameter.

The administration of oral or vaginal prostaglandins such as misoprostol prior to operative procedures has been researched and has shown that spontaneous cervical dilatation is increased but with no decrease in complications (Cooper et al. 2011a). There are inconsistent results of the benefits of osmotic dilatators such as laminaria prior to operative procedures.

5 Distension Media

The technique of hysteroscopy requires a distension medium to be instilled into the uterine cavity to allow visualization of the uterine cavity enabling both the diagnosis and surgical treatment of intrauterine pathology. A variety of distension media can be used including liquids such as glycine, dextran, sorbitol, water and normal saline, and gases such as carbon dioxide. Comparisons of normal saline to carbon dioxide as distension media have shown no difference in pain or visualization, although procedures done with normal saline were found to be significantly faster (Cooper et al. 2011b). However, carbon dioxide is infrequently used nowadays because special insufflation equipment is needed and its use is restricted to simple diagnosis. The plethora of new therapeutic hysteroscopic systems requires fluid distension media to continuously irrigate the uterine cavity removing blood and tissue debris thereby providing a clear operative picture.

The use of isotonic fluid normal or "physiological" saline is the preferred fluid media for operative hysteroscopic procedures because inadvertent fluid overload does not lead to severe osmotic imbalance (hypervolemic hyponatremia) (Berg et al. 2009). Mechanical technologies such as tissue removal systems can be used in normal saline. When it comes to operative procedures using electrical energy, the type of distension media is dictated by whether monopolar or bipolar electrical circuits are being used. Bipolar electrodes require conductive, electrolytic solutions such as normal saline (285 mOsm/L) or Ringer's lactate (279 mOsm/L), while procedures using monopolar electrodes need nonconductive, hypo-osmolar, nonionic solutions such as glycine 1.5% (200 mOsm/L) or sorbitol 3% (165 mOsm/L).

The new generation of bipolar electrodes is generally safer than monopolar electrodes because they do not affect serum osmolality or sodium levels. However, all solutions can cause complications from intravascular absorption of large volumes of fluid into the circulatory system. Excessive fluid absorption is most likely with prolonged hysteroscopic procedures using larger diameter endoscopes with continuous irrigation of fluid or where blood vessels within the myometrium are opened. Thus, particular care is required with resection of the endometrium (transcervical resection of the endometrium – TCRE) and hysteroscopic myomectomy (transcervical resection of fibroids – TCRF). Serious complications arising from expansion of the extracellular fluid volume with the potential to generate fluid overload, pulmonary edema, include acute pulmonary edema, cerebral edema, and cardiac failure. Therefore, it is important to accurately measure the input and output of fluid during operative hysteroscopy so that significant fluid deficits can be recognized and managed promptly. While delivery of the distension medium can be safely and effectively achieved using simple gravity or pressure bags, automated pressure delivery systems facilitate the creation of a constant intrauterine pressure and accurate fluid deficit surveillance. The American Association of Gynecologic Laparoscopy (AAGL) guidelines recommend that when fluid deficits with a nonelectrolyte solution reach 1500 or 2500 mL with normal saline, the procedure should be brought to a halt (Loffer et al. 2000).

6 Hysteroscopic Treatment of Fibroids

6.1 Submucous Fibroids

Fibroids or leiomyomas are benign overgrowths of the smooth muscle layer of the uterus. They remain the most common indication for hysterectomy. Submucous fibroids are those that protrude into the uterine cavity. They account for 5% of all fibroids. Submucous fibroids are associated with pain, bleeding, infertility, and recurrent miscarriage. The most established classification system for submucous fibroids was developed by Wamsteker and the European Society of Gynecologic Endoscopy (ESGE) and accepted by the International Federation for Obstetrics and Gynecology (FIGO) (Munro et al. 2011). This nomenclature states that if the submucous fibroid is entirely intracavitary, i.e., attached to the uterine cavity sidewall by only a small stalk, they are classified as type 0; if a portion of the fibroid is intramural, then they are type 1 if less than 50% is intramural and type 2 if more than 50% is intramural.

Submucosal fibroids can be selectively removed hysteroscopically, which is particularly useful in women who want to preserve their fertility and avoid the complications of laparoscopic or laparotomic surgery. Types 0 and 1 are suitable for hysteroscopic resection. Removal of type 2 fibroids is more challenging because risks of perioperative bleeding, incomplete removal, and uterine trauma are significantly greater. Furthermore, the need for repeated hysteroscopic or other surgical interventions are greater to treat ongoing abnormal bleeding symptoms compared with type 0 and 1 fibroids (Vercellini et al. 1999). Another classification system has been developed to describe additional prognostic features related to submucous fibroids; in addition to depth of myometrial penetration, the STEPW classification records the size, topography (location), and extension of the base in relation to the uterine wall (Lasmar et al. 2012) .

Hysteroscopic removal is mostly done with resectoscopy, i.e., electrosurgical resection using a modified urological resecting loop. More recently, hysteroscopic morcellators, now termed tissue removal systems, have been introduced offering simultaneous mechanical cutting and tissue aspiration, and these technologies appear to be gaining increasing popularity (van Dongen et al. 2008). Some surgeons did use laser hysteroscopic myomectomy in the past, but the laser units are associated with high capital and running costs and have largely been abandoned now.

6.2 Endometrial Preparation

It is common practice to give medication to suppress the endometrium and shrink fibroids prior to surgery. It is thought that this improves visualization by thinning the endometrium and helps to ensure complete removal of the fibroid. The use of gonadotropin-releasing hormone analogues (GnRHa) 3–4 months prior to surgery does reduce fibroid size and corrects anemia prior to surgery (Lethaby et al. 2001). However, data supporting the benefits of endometrial downregulation prior to operative hysteroscopy are conflicting, and currently there are no randomized controlled studies showing surgical removal, and clinical outcomes are improved by this practice (Kamath et al. 2014). Recent work has shown that the selective progesterone receptor modulator, ulipristal acetate, is an effective alternative to reduce fibroid size and induce amenorrhea prior to fibroid surgery with fewer side effects than GnRHa (Donnez et al. 2012a, b). However, as with GnRHa, data supporting improved outcomes with hysteroscopic myomectomy are lacking.

It is important to assess the size and the degree of intramural involvement before embarking on medication to shrink the fibroids, to effectively counsel the patient and plan appropriate surgery. Transvaginal ultrasound is now common in the evaluation of women with gynecological problems, but on its own, it is not accurate enough to adequately describe protrusion of the fibroids into the endometrial cavity. The advent of the 3D ultrasound and saline infusion sonography has been shown to improve accuracy (de Kroon et al. 2003; Lee et al. 2006). Ultrasound is useful to describe the distance between the intramural component and the serosa, which can help the surgeon prevent perforation of the uterus during hysteroscopic treatment. Hysteroscopy provides the best method for assessing the degree of protrusion into the endometrial cavity and the suitability for surgery. With the advent of outpatient hysteroscopy, this can be done without subjecting the patient to general anesthesia.

6.3 Hysteroscopic Equipment for Removal of Fibroids

Hysteroscopic resectoscopes are versatile tools that consist of a movable cauterization electrode usually in the form of a loop (Fig. 3). Originally the resectoscopes used a monopolar electrode, but advances in technologies have led to the development of equally effective bipolar resectoscopes that have the increased safety advantage of using isotonic distension media with reduced risk of serious complications arising from fluid overload and hypervolemic hyponatremia

6.4 Technique

The first step is to identify all the uterine cavity landmarks, and these should continue to be visualized throughout the procedure. The surgeon should be familiar with their equipment and technology especially the angle of the offset lens, energy modality, and distension media management. The amount of fluid deficit considered reasonable, which will depend upon its nature and the patients' medical comorbidities, should be discussed between the surgical team and the anesthetist prior to commencing the procedure.

6.4.1 Electrosurgical Resection

For electrosurgical resection, the loop electrode should be extended beyond the fibroid. The activated electrode is then drawn toward the surgeon by either moving the entire hysteroscope or closing the electrode or a combination of these two movements. Usually a blended or pure cut current set at 120 W cutting is adequate. The activated electrode should never be pushed away from the surgeon as this can cause perforation. Cutting into the myometrium should be avoided, particularly near the cornua and cervix where it is at its thinnest and bleeding or uterine perforation may occur. The degree of magnification and extension of the loop from the distal lens should be adjusted according to the location of the fibroid or area

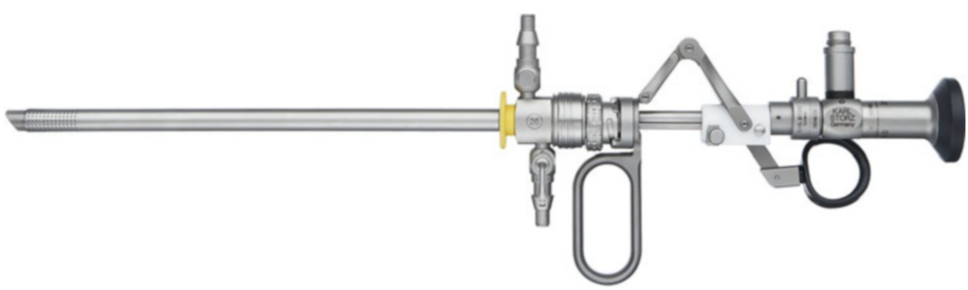


Fig. 3 Resectoscope

being resected, e.g., a higher degree of magnification (proximity of the distal lens) is needed when resecting fibroid tissue near the fundus or cornua.

One of the main disadvantages of electrosurgical resection of submucous fibroids is that as the fibroid is progressively debulked, "chips" of fibroid tissue are generated, which compromise visualization and impede the free movement of the loop electrode. One strategy to combat the impact of these fibroid chips is to push them toward the fundus to keep the view clear until enough are generated to obscure the visual field. A variety of techniques are then used to remove the chips, which include using a curette and polyp forceps or closing the inactivated resectoscope loop thus catching the chips. Also, the resectoscope can be removed from its outer sheath allowing the chips to traverse the cervical canal through the sheath.

The fibroid should be resected until it is level with the endometrium. Spontaneous uterine contractions as well as fluctuations in intrauterine pressure, e.g., increasing and decreasing the distension media pressure, can help push some of the intra-myometrial component of a grade 1/2 fibroid into the uterine cavity allowing safer resection under direct vision. Mechanical undermining of the intramural fibroid component with the passive inactivated electrode or with a firmer specially designed hook can achieve the same thing. This latter surgical approach has been described as adopting a "cold knife" technique (Mazzon et al. 2016). As the intramural extension of the capsule is reached, the myometrial sinuses are exposed which can lead to bleeding and increased and sometimes rapid intravascular absorption of fluid.

The production of fibroid chips can be avoided if grade 0 fibroids are removed en bloc by cutting through the basal attachment to the uterine side wall with miniature bipolar electrodes such as Versapoint® bipolar electrosurgical system (Gynecare™; Ethicon Inc., New Jersey, USA). These electrodes can be passed down the operating channel of a standard continuous flow operating hysteroscope, and detachment of the grade 0 fibroid can be rapidly achieved. However, given the shape and small size of the electrode, they are not generally suitable for fundally located lesions. Moreover, blind removal of the fibrous specimen from the uterine cavity is not always possible. In these cases, the fibroid will often be left in situ and subsequently degenerate and pass.

Another alternative to reduce the production of fibroid chips is the vaporization electrode. The first vaporizing electrode developed by CIRCON ACMI was the VaporTrode® Grooved Bar. Using the Grooved VaporTrode® and higher wattage, the device is able to vaporize tissue in contact with the electrode (Brooks 1995).

6.4.2 Tissue Removal Systems

Hysteroscopic tissue removal systems appear to have overcome the most frustrating problem with resectoscopes by avoiding the generation of tissue chips. This makes fibroid removal easier to learn than traditional electrosurgical resections (van Dongen et al. 2008). Tissue removal systems use a simultaneous mechanical cutting and tissue retrieval set up that maintains better views while operating. The tissue removal systems consist of a bespoke operating 0° hysteroscope with an operating channel through which a disposable cutting hand piece comprising two rotating hollow metal tubes with a small aperture distally. This is attached to an external suction tubing. A generator provides the electrical energy to rotate the mechanical tissue removal system.

Before the device is inserted, it is important to make sure the window lock is closed when it is not activated. Once the fibroid requiring removal is identified, the window should be aimed toward the top of the fibroid, and the tissue will be sucked inside the window and shaved. As with electrosurgical resectoscopes, the strategy for fibroid removal using these systems is to start on the periphery and move closer to the myometrium. The technique is to position the opening near the pathology, which is then sucked into the opening. Rotation of the inner metal tube then shaves away the pathology. Afterward, the pathology is sucked through the device and trapped in a tissue collector. Gentle pressure is applied with minimal movement of the hysteroscope to ensure the base of the fibroid is removed. To prevent blood and debris obscuring the visual field, it is important to keep the device activated to ensure these products will be sucked into the window. The first of these systems was the TRUCLEAR™ (Smith & Nephew, Andover, MA) which has been followed by a similar product by Hologic (Bedford, MA, USA) called Myosure™ and Karl Storz (Tuttlingen, USA) called Integrated Bigatti Shaver (IBS). More recently the SYMPHION™ (Boston Scientific, Natick, MA) has been produced which combines a tissue removal system with bipolar radio-frequency energy.

7 Hysteroscopic Polypectomy

7.1 Endometrial Polyps

Endometrial polyps are benign overgrowths of endometrium that project into the uterine cavity. Generally they are pedunculated and are attached to the uterus by an elongated pedicle, but sometimes they are sessile and have a large flat base (Fig. 4).

They can be distinguished from submucous fibroids because they are soft and can be indented by the hysteroscope, and they move with the distension media. They often have a pink-red appearance similar to endometrium, but less vascular polyps can appear pale-gray. The specific hysteroscopic appearance of polyps will vary according to the relative make up of stroma, glands, and blood vessels. Endometrial polyps are common with a prevalence of around 10% in women undergoing a diagnostic hysteroscopy (Clark and Gupta 2005). Most gynecologists recommend the removal of endometrial polyps because of their association with malignant and premalignant conditions (van Dijk et al. 2012; Timmermans et al. 2008). The incidence of polyps and risk of malignancy increases with age.

Fig. 4 Endometrial polyp as seen at hysteroscopy

Hysteroscopic visualization allows a subjective assessment of the nature of polyps, but it can also be used to direct biopsies to increase diagnostic accuracy (Birinyi et al. 2004). Indeed, hysteroscopy has the added advantage of allowing simultaneous treatment of detected endometrial polyps. Depending on the local resources and expertise that is available, polypectomy can invariably be performed in the office setting without general anesthesia (Cooper et al. 2015). Hysteroscopic techniques utilizing both miniature mechanical and electrosurgical technologies allow polyp removal under direct vision reducing the risk of incomplete removal and uterine trauma. This represents a shift in management because until recently polyps were often removed blindly using dilation and curettage (D&C) or using large diameter electrosurgical resecting loops under general anesthesia.

7.2 Hysteroscopic Equipment for Removal of Polyps

Hysteroscopic polypectomy began with a range of mechanical instruments that could be passed down the operating channel of the hysteroscope including graspers, biopsy cups, and scissors (Bettocchi et al. 2004; Nathani and Clark 2006; Timmermans and Veersema 2005). However, these instruments are flimsy, making it difficult to remove large pathology, and there have been some studies showing problems with bleeding (Clark and Gupta 2005; Garuti et al. 2008). The resectoscope was the first electrosurgical instrument described for removing endometrial polyps, but these are large diameter instruments necessitating the use of general anesthesia and potentially traumatic, blind cervical dilatation. It is well recognized that polyps are softer than fibroids such that newer miniature electrosurgical instrumentation such as bipolar electrodes [e.g., Versapoint™ bipolar electrosurgical system (Gynecare, Ethicon, Somerville, NJ, USA)] and monopolar snares have been developed that obviate the need for large diameter hysteroscopes and blind cervical dilatation.

The bipolar electrodes have been demonstrated in observational series to be feasible and safe (Clark et al. 2002a; Kung et al. 1999; Vilos 1999) and have snares. The latter technology is less widely used (Timmermans and Veersema 2005). The previously mentioned hysteroscopic morcellator devices or tissue removal systems, TRUCLEAR™ (Smith & Nephew™, Andover, MA, USA) and Myosure™ (Hologic™, Marlborough, MA USA), are utilized for polypectomy as well as myomectomy. Randomized trials have shown that when compared to electrosurgical devices, tissue removal systems which allow simultaneous tissue cutting and retrieval are quicker to learn, less painful, more acceptable, faster, and more likely to completely remove polyps (van Dongen et al. 2008; Smith et al. 2014a).

7.3 Technique

7.3.1 Electrosurgery

Resecting Loops

The main drawback to the use of large diameter resectoscopes is the need for cervical dilatation and regional or general anesthesia. As with resecting submucous fibroids, the loop is extended beyond the focal lesion and then is activated and drawn toward the operator by closing the loop using the trigger or moving the whole resectoscope or a combination of both methods. The softer, less vascular nature of endometrial polyps in comparison to submucous fibroids makes them much easier to remove. They are rapidly resected either in pieces after a few passes off the resecting loop or en bloc with a sweep of the resecting loop at the polyp base where it attached to the uterine side wall. Occasionally, the inactivated loop can be deployed as a simple snare, closing the extended loop to mechanically detach the polyp from its attachment. Retrieval from the already dilated cervical canal of compressible, glandular polyps is usually achieved under vision by trapping the tissue within the withdrawn loop and end of the hysteroscope and removing the whole unit along the cervical canal.

Bipolar Electrical Resection with Miniature Electrodes

The cutting point of the bipolar electrode works by vaporization. High-temperature Ohmic heating in the immediate vicinity of the active electrode boils the saline to create a vapor pocket. This has the advantage of minimizing bleeding by cauterization of blood vessels. The initial bipolar miniature electrodes were the Versapoint™ electrodes (Fig. 5) that were designed to be used with a bespoke small-diameter operating hysteroscope. This "Versascope™," subsequently modified and renamed the "Alphascope™," is a small-diameter 0° semirigid hysteroscope incorporating a rotating cuff to manipulate the orientation of the bipolar electrodes and other ancillary instruments which have been passed down the expandable disposable outer sheath. The bipolar electrodes can, however, fit down any standard continuous flow operating 30° hysteroscope incorporating a

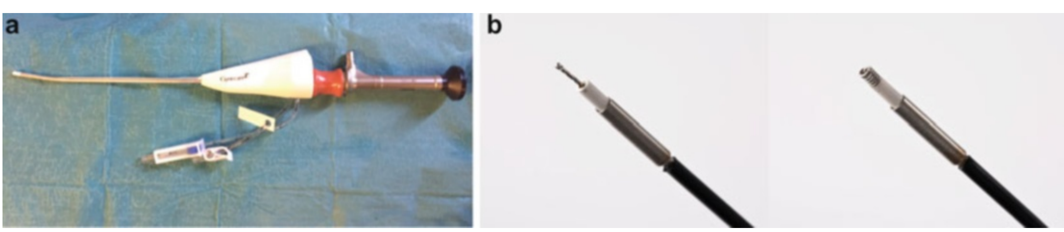


Fig. 5 Alphascope™ and Versapoint™ bipolar electrodes (**a**) twizzle electrode; (**b**) spring electrode

1.6 mm operating channel, making them highly versatile instruments. In contrast to the formal resectoscopes, use of smaller diameter electrosurgical operating set ups minimizes the need for traumatic cervical dilatation. Indeed, the development of the Versapoint™ electrode as a more effective cutting tool compared with flimsy mechanical graspers and scissors was one of the main technologies to shift polypectomy to an office setting.

Once a polyp has been diagnosed, the bipolar electrode is passed down the operating channel of a standard rigid operating hysteroscope. However, if using the Alphascope with its expandable plastic working channel, it is advisable to insert it into the uterine cavity without the electrode in the operating channel. This is because the Alphascope is narrower without the electrode and the operating channel also acts as the outflow so it is harder to clear the turbid fluid at the beginning of the procedure unless it is empty. However, for selected cases such as fundal polyps, it may be beneficial to insert the electrode at the beginning so that the twizzle tip can be bent across the camera lens to create a cutting hook and then allow entry into the uterine cavity. The main drawback of the miniature electrodes is the ability to manipulate them, as the cutting surface is small and fixed in contrast to electrosurgical loops.

When cutting a polyp using an Alphascope, there are three techniques that can be used. The first is to fix the electrode and hysteroscope but swivel the sheath using the rotating cuff creating an arc, which is particularly effective at cutting sidewall polyps. The second is to fix the sheath and hysteroscope and move the electrode in and out. The last technique is to fix the electrode and sheath and then move the hysteroscope and electrode as one instrument. If using the bipolar electrode down a rigid operating 30° hysteroscope, the orientation of the electrode can be altered by moving the light cable and hence the position of the distal offset lens. It is important that with all the techniques, the electrode is not activated when it is going toward the direction of the fundus, as this could lead to perforation and damage. The activated electrode should be withdrawn toward the operator, and when approaching attachments at the fundus and especially the thinner cornual aspects of the uterine side wall, higher magnification is required by ensuring the electrode is close to the distal lens.

The exact technique chosen to cut the polyp will depend on the operator preference, size, and position of the polyp. In the author's opinion, as polyps are compressible and feasible for removal in an office setting, the most efficient technique is to remove the polyp en bloc by cutting its basal attachment to the uterine side wall. This is easiest if the polyps are nonfundal and located on the anterior, posterior, or lateral sidewalls. Sometimes it may be necessary to bisect the polyps if they are large and located fundally so as to access the base. Other operators prefer to cut the polyp into segments, but this is time-consuming and either creates chips of tissue, which may obscure visualization within the cavity or repeated insertions and withdrawal of the hysteroscope. Removing the polyp in one piece avoids these problems, but the larger tissue specimen is harder to remove along the narrow cervical canal.

A variety of biopsy cups, grasping forceps, and snares are available that can be passed down the operating channel to remove the polyp fragments from the cavity. Leaving a small attachment between the polyp and the sidewall will make it easier to grab and stop it swirling around from the inflow of saline. If the polyp is completely detached, then turning off the fluid inflow and gently pushing the polyp using the opened forceps to pin it against the fundus can be used to then take a substantial "bite" of tissue. Others prefer to use inactivated snares to grasp the specimen. To give the greatest chance of traversing the cervical canal without the polyp becoming detached, a good degree of purchase on the polyp by having it firmly grasped should be ensured, and the largest part of the polyp should be brought proximally over the distal lens and then the whole unit moved slowly move backward down the endocervical canal. If this does not work because the polyps are large and fibrous or the cervical canal is narrow, then it may be necessary to break the polyp up under vision although this is rarely possible given its mobility within the cavity. More often the cervix will need to be dilated up to H6–8 and the hysteroscope and graspers inserted again. Blind retrieval using large polyp forceps should be avoided where possible.

7.3.2 Mechanical

Scissors and Grasping Forceps

Cold scissor resection can be performed using similar equipment as above to detach endometrial polyps. Scissors have the advantage of not producing bubbles that can impede the visual field, and they are also reusable. However, they are fragile, become blunt over time, and are difficult to manipulate. In contrast to the bipolar electrodes, they create bleeding and cannot cut through more fibrous polyps.

Tissue Removal Systems

The TRUCLEAR™ and Myosure™ tissue removal systems have been described in the preceding section on submucous fibroids (Figs. 6 and 7). These technologies can be used for removing uterine polyps. However, in contrast to submucous fibroids, the softer tissue constituting polyps makes them amenable to morcellation using systems with less cutting power (Myosure REACH, LITE & CLASSIC). In the case of TRUCLEAR, a much smaller diameter system is available, the OD TRUCLEAR system with a 2.9 mm rotary cutting blade. The outer diameter is 5.6 mm, and it is a continuous flow system aiding visualization even in the presence of significant tissue debris and bleeding. If the outflow sheath is removed, outflow is then provided by the negative pressure, which draws saline through the aperture and along the hollow activated device. The outer diameter is then reduced to 5 mm, which is advantageous in the office setting, and vaginoscopy is more feasible.

Fig. 6 TRUCLEAR® hysteroscopic tissue retrieval system

The technique for morcellation is similar to removing fibroids. The distal aperture incorporating the cutting edges of the rotating inner and outer hollow tubes should be embedded in the polyp tissue and not visible. As polyps are mobile in a fluid distension media, they will be seen to move when the device is in contact with the tissue, simultaneously cutting and aspirating material. Movement of the device should be kept to a minimum. Small rotations of the hand piece to redirect the cutting window are all that is generally required. As the polyp base is reached, more exaggerated vertical or horizontal movements of the hand piece will lever the cutting window up against the uterine side wall. The ease of use of these systems and short learning curve compared to traditional resectoscopy was highlighted in a recent randomized control trial (RCT) (van Dongen et al. 2008). A recent RCT showed that the TRUCLEAR tissue removal system was quicker, less painful, and more acceptable and successful compared with Versapoint™ electrosurgery for the office removal of endometrial polyps (Smith et al. 2014b).

8 Endometrial Destruction for Abnormal Uterine Bleeding

8.1 Endometrial Destruction

Heavy menstrual bleeding is one of the commonest reasons patient consult with their gynecologist. There is an increasing range of medical therapies, but most have a hormonal basis for action. Some women do not like taking hormones long term, while others suffer from side effects, and these problems can limit the application of medical therapies. Traditionally, after medical

Fig. 7 Myosure® hysteroscopic tissue retrieval system

therapies had failed, definitive treatment with hysterectomy was used, but this has the morbidity and mortality associated with a major surgery. Moreover, patient preference studies have shown that women put a high value avoiding hysterectomy and retaining their uterus. Endometrial destruction techniques, i.e., ablation and resection of the endometrium, provide a cheaper, safer alternative to hysterectomy. The first-generation hysteroscopic techniques include laser ablation, rollerball ablation, and transcervical resection of the endometrium (TCRE). The costs of laser equipment were prohibitive so that electrosurgical resection with cutting loops and/or rollerball ablation using roller ball electrodes became the preeminent technique. When comparing TCRE to with rollerball ablation, there is no evidence of difference in rates of complication or re-intervention (Lethaby et al. 2005).

The second-generation techniques were then developed. These semiautomated technologies utilized the principle of controlled, global thermal destruction of the endometrium but without the requirement for enhanced operative hysteroscopic skills. They also aimed to reduce complications, particularly those of uterine trauma and fluid overload. While evidence supports their enhanced feasibility and safety, they are generally less flexible being restricted to use in regular-shaped cavities without submucous fibroids or congenital anomalies. There have been many different devices that have come to market with some no longer in use. The most prevalent devices are based upon the application to the endometrial surface of impedance-controlled radio-frequency energy

Fig. 8 The NovaSure radio-frequency ablation system (an example of a semiautomated, global, second-generation endometrial ablation device)

(NovaSure™ Fig. 8) or conducted heat from fluid within a pressurized balloon [Thermachoice™ (Gynecare™; Ethicon™ Inc., NJ, USA); Cavaterm™(Wallsten Medical SA, Lausanne, Switzerland); Thermablate™ (Gynecare^{tm}, NJ , USA)]. The Genesys HTA™(Boston Scientific) is a hydrothermal ablation method that uses heated saline and allows for visualization of the endometrial cavity during the ablation procedure. It allows for ablation of larger and irregularly shaped endometrial cavities.

The main drawback of uterine sparing endometrial ablation in comparison to hysterectomy is that it cannot guarantee amenorrhea. Around 10% of patients who have endometrial ablation will go on to have a further intervention usually in the form of a hysterectomy (Peeters et al. 2013; Smith et al. 2014a). Research looking at prognostic factors have found that large uterine cavities (>9 cm), preoperative dysmenorrhea, and younger age (<45 years) are associated with a higher chance of failure (El-Nashar et al. 2009). The reasons for hysterectomy are not always confined to persistent or recurrent abnormal uterine bleeding as some women develop cyclical pain thought to be a result of iatrogenic adenomyosis or hematometra.

8.2 Equipment

8.3 Technique of Transcervical Resection of the Endometrium and Endometrial Electrocoagulation

The first-generation techniques are all done under hysteroscopic vision. This has the advantage of allowing treatment in the presence of small fibroids, endometrial polyps, uterine abnormalities, or a large cavity. Unfortunately, these techniques require more time and higher skill levels and use distension media that can lead to complications of fluid overload and electrolyte imbalances.

The technique used for transcervical resection of the endometrium (TCRE) is similar to that used for fibroid resection, while endometrial electrocoagulation makes use of a rollerball electrode instead of a loop electrode. The rollerball electrode is easier to learn and does not generate tissue chips. The rollerball cannot be used to simultaneously treat other causes of heavy menstrual bleeding such as fibroids and requires the endometrium to be thin.

It is important to visualize all the landmarks before starting, and it can also be useful to mark the point near the endocervix that you wish to resect or ablate before starting. This is because when the activated electrode is drawn toward the surgeon, it is easy to go beyond the area you wish to resect/ablate. It is important to take a systematic approach to treatment of the cavity. The cornual and fundal areas are technically the most difficult areas to treat and are resected by moving the entire hysteroscope using a forward-facing loop or rollerball. Drawing the activated electrode toward the surgeon treats the anterior and posterior walls by either moving the entire hysteroscope or closing the electrode or a combination of these two movements.

The complications of TCRE are similar to fibroid resection. The most serious complication is uterine perforation. This can be minimized by using the rollerball particularly in the cornual and fundal areas. Other serious complications include fluid overload, primary hemorrhage, and gas embolism from the bubbles produced by the electrode entering an open vessel. An important cause for treatment failure is a hematometra. It usually presents as cyclical menstrual pain after TCRE. The diagnosis is made when ultrasound or MRI shows a fluid-filled cavity. Treatment is with either hysterectomy or cervical dilatation and drainage. If drainage is attempted, then this may need to be done under ultrasound guidance due to the dense intrauterine adhesions that can form after resection.

8.4 Technique for Second-Generation Endometrial Ablation

Rates of satisfaction are consistently high for second-generation techniques, and they are now an established alternative to hysterectomy. The three most commonly used second-generation devices reported in the literature utilize energy applied via thermal balloons, bipolar radiofrequency electricity, and microwave energy. A network meta-analysis showed that bipolar radio frequency and microwave ablative devices are more effective than thermal balloon and free-fluid ablation in the treatment of heavy menstrual bleeding in terms of inducing amenorrhea (Daniels et al. 2012). However, while a new small microwave device has been introduced (Minitouch™), these data relate to the original larger diameter Microsulis™ system that has now been taken off the market for commercial rather than clinical reasons. Longer-term data comparing bipolar radio frequency and thermal balloon devices have shown no difference in re-intervention rates or health-related quality of life (Kleijn et al. 2008; Smith et al. 2014a). Table 1 summarizes the types and features of currently available ablative technologies.

9 Hysteroscopic Treatment of Acquired Uterine Abnormalities

9.1 Intrauterine Adhesions

Intrauterine adhesions are defined by scar tissue between the uterine walls. This is also called Asherman's syndrome. It was thought that it occurred following excessively vigorous curettage of the endometrium in a recently pregnant or pregnant uterus. However, it can occur after an infection of the uterus or uterine surgery. Patients rarely present with cyclical pain due to trapped menses but more commonly with amenorrhea and infertility. Hysteroscopy is the gold standard for accurate diagnosis and assessment of intrauterine adhesions. A hysterosalpingogram can also be screening test and has the advantage of being able to assess tubal patency in patients with infertility problems.

The type and extent of intrauterine adhesions have been classified according to Valle and Sciarra (Table 2). Other classification systems such as the American Fertility Society classification exist (Valle and Sciarra 1988).

9.2 Technique

Various different techniques can be employed to restore the size and shape of the uterine cavity. Where there are filmy adhesions only, balloon

Table 1 Description of currently available second-generation endometrial ablation devices and outcome data

Device	Mode of action	Source of information	Treatment duration	Heavy bleeding rate (%)	Amenorrhea rates (1 year) (%)	Satisfaction rates (1 year) (%)
Electrical						
NovaSure	Fan-shaped bipolar radio-frequency electrode	(Smith et al. 2014a)	90 s	8	56	93
Thermal balloon						
Thermablate	Balloon with heated glycine	(Penninx et al. 2016)	128 s	21	23	69
Cavaterm	Balloon with heated glycine	(Brun et al. 2006; Hawe et al. 2003)	10 min	3–7	33–36	81–93
Free-flowing saline						
Hydrothermablation	A closed system is formed with the cavity to deliver heated saline directly to the endometrium	(Corson 2001; Penninx et al. 2011)	10 min	14–18	24–38	79
Microwave						
Minitouch	Microwave energy via an induction loop placed in the uterine cavity	(Tas and Van Herendael 2014)	60 s	Not available	84	Not available

Table 2 Classification system for intrauterine adhesions

Mild	Filmy adhesions composed of basal endometrium, producing partial or complete uterine cavity occlusion
Moderate	Fibromuscular adhesions that are characteristically thick and still covered by endometrium. They may bleed on division, partially or totally
Severe	Composed of connective tissue with no endometrial lining and likely to bleed upon division, partially or totally occluding the uterine cavity

distension and insertion of intrauterine contraceptive devices have been described as non-hysteroscopic techniques. Hysteroscopic techniques have the advantage of being performed under direct vision, and various methods have been employed depending on the severity of the intrauterine adhesions. These include blunt or sharp adhesiolysis, using mechanical methods, laser instrument, and electrosurgical instruments. Simple distension of the uterine cavity during diagnostic hysteroscopy has also been described for adhesiolysis of filmy adhesions.

In some patients, landmarks remain obscure and entry into the uterus may not be possible. In these patients, it is necessary to perform simultaneous laparoscopy, fluoroscopy, or ultrasound to reduce the risk of perforation. Ultrasound is more useful for patients with lower segment scarring that have a normal upper segment. With laparoscopic guidance, the light source of the laparoscope is reduced so that the light from the hysteroscope can be observed through the uterus to locate its position and minimize the risk of uterine perforation. A uniform glow of the uterus is reassuring, while focused light indicates impending perforation. With complex cases, the risk of intravasation of the distension media is increased so, as with all operative hysteroscopy, careful fluid balance monitoring is required.

Increased uterine cavity size can be achieved by myometrial scoring with scissors or a Colling's knife electrode. Drawing the resectoscope from the fundus toward the isthmus with the knife electrode continuously activated makes the myometrial incisions. The Colling's knife electrode is used at a power setting of 100 W at pure cutting current. This is repeated around eight times so that equally spaced incisions are made around the complete radius of the uterine cavity and it opens up like an accordion. Myometrial scoring has also been described using miniature bipolar electrodes in an attempt to increase the capacity of a hypoplastic or T-shaped uterus (Di Spiezio Sardo et al. 2015).

Various postoperative interventions have been described to try and reduce the likelihood of recurrence of adhesions. Insertion of inert intrauterine devices or Foley balloon catheters has been used in an attempt to help maintain separation of the uterine walls. Postoperative estrogen therapy is thought to promote endometrial overgrowth and re-epithelialization of the scarred surface. Steroids have been advocated to reduce the inflammatory response as well as antibiotics to prevent endometritis. Repeated postoperative office hysteroscopy with mechanical lysis of new, filmy adhesions, prior to them becoming fibrous, until no new adhesions form has recently been reported (Yang et al. 2016).

9.3 Retained Products of Conception

Chronically retained products of conception (RPOC) or placental remnants can occur after miscarriage, termination of pregnancy, vaginal deliveries, and cesarean deliveries. Retained products of conception can be associated with short-term problems such as infection, abdominal pain, and uterine bleeding. Long-term problems include the formation of intrauterine adhesions. The most common treatment for RPOC is dilation with suction, blunt, or sharp curettage. However, for RPOC beyond 6 weeks' duration, hysteroscopic alternatives are emerging which facilitate focused and complete removal under direct vision, potentially reducing the risk of uterine trauma and intrauterine adhesions.

9.4 Technique

The techniques described include use of a cold (inactivated) resection loop to mechanically remove RPOC by entrapment of tissue between the loop, and the hysteroscope and repeated removal and insertion of the resectoscope until the cavity is empty. The use of tissue removal systems to selectively remove tissue under direct vision has been reported and seems well suited to this task as electrosurgical energy is not needed and tissue can be simultaneously cut away and extracted avoiding repeated insertion and removal of the hysteroscope (Hamerlynck et al. 2013; Smorgick et al. 2014). There is a lack of evidence to suggest that the hysteroscopic technique is superior to blind surgical evacuation at the moment. Nevertheless, in selected cases such as previous failed surgery or where there are known structural abnormalities, the hysteroscopic approach may be appropriate. Research is required to help guide best practice.

10 Hysteroscopic Treatment of Congenital Uterine Anomalies

10.1 Uterine Septum

Hysteroscopic septoplasty describes the resection of an intrauterine septum that is a Müllerian duct anomaly. The uterus and fallopian tubes are formed as the paramesonephric ducts fuse caudally in early embryonic life forming the fallopian tubes, uterine cavity, and upper third of the vagina. During the fusion of the paramesonephric ducts, a septum is formed in the uterine cavity that is usually reabsorbed by 20 weeks of gestation. Failure of the reabsorption process results in a septate uterus, which can be either partial or complete and in severe cases can extend to involve the cervix and the top of the vagina. This can be distinguished from a bicornuate uterus, in which there is failure of the fusion of the paramesonephric ducts, because there is no effect on the uterine body.

Hysteroscopic resection of the intrauterine septum has superseded conventional abdominal approaches to metroplasty that included the John's or Tompkin's technique. Not only do hysteroscopic procedures reduce the morbidity compared to the abdominal approach, but they also produce superior reproductive outcomes. Because the integrity of the uterine cavity is not breeched, hysteroscopic procedures avoid the risks of uterine rupture during labor.

10.2 Technique

The principle of septoplasty is to divide the septum along the midpoint rather than excise the septum. The tissue is usually fibroelastic, so does not bleed. Division can be done using electrosurgery using either the Versapoint™ electrode or resectoscopic division using a Colling's knife electrode. Mechanical division can be achieved using scissors. Electrosurgical and mechanical techniques can be combined. More rarely laser such as Nd:YAG can be used. Whichever technique is used, the operator has to take special care to determine the depth and direction of cutting, especially as the division of the septum often requires hysteroscopic movements toward the fundus that increase the risk of perforation. To try and reduce the risk of the perforation, the operator should not aim to create a cavity that is arcuate. Depth of cutting can be further assessed with either simultaneous ultrasound or laparoscopy. With laparoscopy, the intensity of the light source is reduced so that the intensity of light from the hysteroscope can be monitored. If the uterus glows in a uniform manner, it is presumed that the risk of perforation is low. Laparoscopy also has the advantage of keeping bowel away from the uterus but is not as accurate as ultrasound for assessing the depth of myometrium. However, if preoperative radiological imaging with either 2D/3D ultrasound or MRI clearly distinguishes a septate uterus from a bicornuate uterus, then a purely hysteroscopic approach is feasible. The operator should look out for soft, trabeculated, pink myometrial tissue as opposed to the pale, smooth, fibroelastic septal tissue to ascertain when the limits of the septum in relation to the uterine fundus has been reached. Bleeding is not a reliable indicator of reaching myometrial tissue as the high inflow pressures of distending media may tamponade such bleeding. If both cornual recesses can be visualized with the hysteroscope at the level of the internal os and the sound length is at least 7 cm, then an adequate uterine cavity has been restored following septoplasty.

Hysteroscopic metroplasty to restore the shape of the hypoplastic or "T"-shaped uterus has been reported by scoring the myometrium with activated miniature bipolar electrodes in an attempt to increase the uterine capacity (Di Spiezio Sardo et al. 2015). The electrodes can also be used to create outflow channels in non-communicating rudimentary uterine horns with the aid of ultrasound or laparoscopic guidance. Foley catheters can then be hysteroscopically placed to allow fistulization to occur creating permanent outflow tract.

11 Hysteroscopic Sterilization

Since the introduction of hysteroscopic sterilization, it has steadily increased in popularity, although more recently the US Food and Drug Administration (FDA) has required the device manufacturer, Bayer, to conduct a post-marketing surveillance study to compare adverse events with Essure™ with those seen with tubal ligation due to complaints from some patients and recent re-intervention data (Mao et al. 2015). The benefits of hysteroscopic sterilization are that it avoids the abdominal route, it allows a quicker return to normal activities, and it can be performed without general anesthesia. These advantages make hysteroscopic sterilization a good option for women who want to avoid, or have contraindications, general anesthesia and abdominal surgery. The most commonly applied technique is Essure™, which involves the placement of a 4 cm expanding spring into the fallopian tubes (Fig. 9). New warnings must be printed on the labels of the implantable sterilization device Essure™ after reports of serious side effects.

The reported rates of successful bilateral placement vary between 81% and 98% with higher success rates in studies published since 2007 (la Chapelle et al. 2015). Following successful bilateral placement, confirmation of correct placement rates is between 90% and 100% (la Chapelle et al. 2015). Hysteroscopic sterilization with the Essure™ system is an effective method of contraception. In a case series of 4306 procedures, a total of seven women (0.16%) became pregnant. Of these seven, three ignored advice to refrain from intercourse before assessment for satisfactory placement, bringing the pregnancy rate after establishing correct placement to 0.09% (Povedano et al. 2012).

Reported serious complications are rare, and in the largest series reported to date of over 4000 procedures, the most common adverse event was vasovagal reaction, which occurred in around 2% of cases. Expulsion of the micro-insert occurred in 0.4% of women, although this occurred before the 3-month follow-up in most cases. In three cases, the micro-inserts were erroneously placed in the myometrium (0.06%), and in two other cases, there was asymptomatic migration into the abdominal cavity (0.04%). The migrated devices were left in the abdominal cavity. There were also two cases of pelvic inflammatory disease (0.02%). Longer-term complications included two allergies to nickel (0.04%) and one woman who had persistent abdominal pain (0.02%) (Povedano et al. 2012). Because the incidence of nickel allergy is so low, it has been removed as contraindication to placement. Nevertheless, it is good practice to tell patients that the micro-inserts do contain small amounts of nickel, but it is unlikely to be clinically significant. It is more difficult to treat longer-term complications which often require coil removal via an abdominal route. This can be complicated because the micro-insert may be lodged in surrounding structures and can conduct electrical energy making removal difficult.

Fig. 9 Essure™ micro-insert

A recent US cohort study compared 8048 patients undergoing hysteroscopic sterilization with over 40,000 undergoing laparoscopic sterilization between 2005 and 2013, and they found, at 1 year after surgery, the risk of unintended pregnancy was around 1% and comparable between techniques. However, around 1 in 50 women undergoing hysteroscopic sterilization required reoperation to complete, reverse, or rectify complications arising from the procedure compared with 1 in 500 women undergoing laparoscopic sterilization (Mao et al. 2015). While the convenience of office-based hysteroscopic sterilization will be attractive to many women, they also need to be informed of the reoperation data to help them decide which sterilization procedure is most appropriate for them.

11.1 Equipment

11.2 Essure Technique

Prior to the procedure, nonsteroidal anti-inflammatory drugs (NSAIDs) are given to reduce tubal spasm, although evidence for this practice is not strong (Chern and Siow 2005; Nichols et al. 2006). There is no need to routinely give antibiotics during hysteroscopic sterilization.

The introducer provided is inserted to prevent retrograde leakage of distension fluid along the working channel into the working channel of the hysteroscope, which is then inserted through the cervical canal under direct vision to access the uterine cavity. This can usually be achieved vaginoscopically without the need for vaginal instrumentation or local anesthesia unless the woman is nulliparous or undergone cesarean sections or cone biopsies of the cervix. Both tubal ostia need to be visualized before beginning the procedure. This is best done by gently rotating the hysteroscope to allow the offset lens to look in each lateral direction.

The first micro-insert delivery catheter is then fed along the working channel and the offset lens of the hysteroscope closely aligned with the selected tubal ostia (Fig. 10). Close proximity of the distal hysteroscope to the tubal ostia aids precise passage of the device minimizing the risk of tubal spasm. The rigid hysteroscope can also act to splint the fragile micro-insert, preventing it bending if tubal resistance is encountered. With gentle forward movements, the micro-insert is passed into and along the tube until the black positioning marker on the insertion catheter is flush with the ostia (Fig. 11). The surgeon or assistant then retracts the outer catheter by rotating the thumbwheel until it will no longer rotate. Using careful movements, the gold marker on the micro-insert should then be aligned just outside of the tubal ostia (Fig. 12). Pressing the button on the handle deploys the micro-insert. Rotating the thumbwheel again until it will no longer rotate retracts the inner catheter. Ideally three to eight expanded coils should be seen in the uterine cavity (Fig. 13).

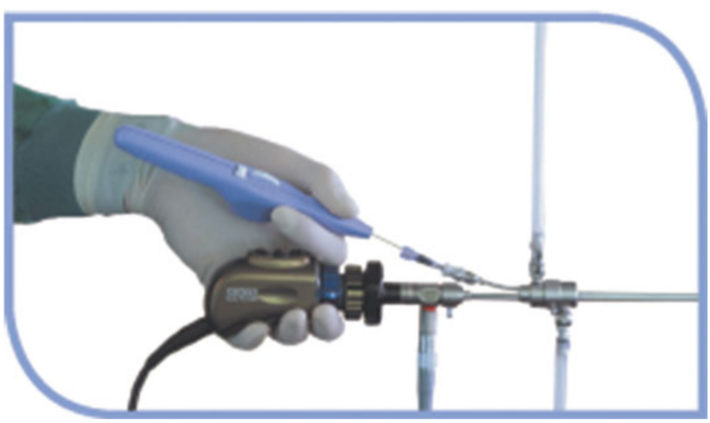


Fig. 10 Essure™ hysteroscopic system of sterilization; with the help of an introducer, the Essure catheter goes down the operating channel of a hysteroscope to allow deployment of the Essure insert in the fallopian tube

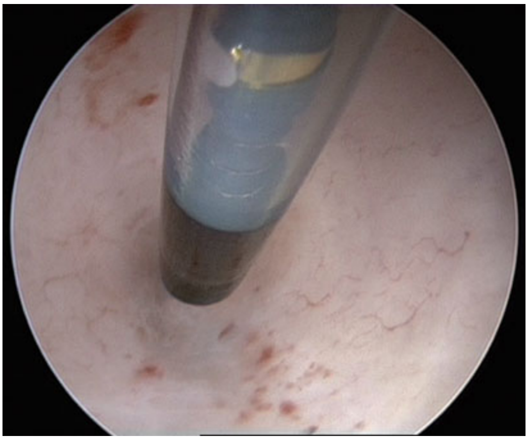


Fig. 11 Placement of the Essure™ micro-insert into the tubal ostia; the catheter tip is advanced into the fallopian tube until the black marker reaches the ostia

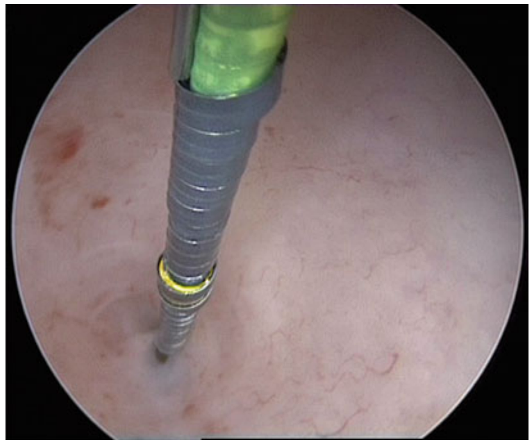


Fig. 12 Placement of the Essure™ micro-insert into the tubal ostia; the catheter is retracted, and the black positioning marker disappears. The gold band must be located just outside the ostium before the insert is detached

11.3 Confirmation of Correct Placement

The main disadvantage of hysteroscopic sterilization compared to laparoscopic sterilization is that it is not immediately effective; at least 3 months is required before tubal fibrosis and occlusion occur for the procedure to be effective. During this time, the woman needs to use alternative forms of contraception. After 3 months, post-procedure imaging is required to check for placement and occlusion. In the USA, the FDA requires a hysterosalpingogram for all patients with Essure™ sterilization to confirm tubal occlusion. In Europe, X-ray and transvaginal ultrasound are accepted, less invasive alternative radiological confirmation tests to confirm satisfactory device placement. Confirmation of the correct location has been reported to correlate well with effectiveness (Veersema et al. 2005).

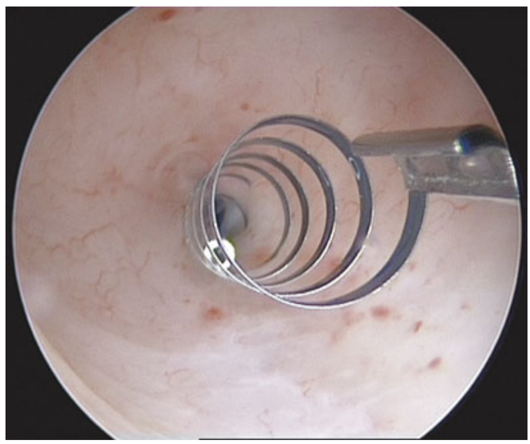


Fig. 13 Placement of the Essure™ micro-insert into the tubal ostia; the catheter tip is advanced into the fallopian tube until the black marker reaches the ostia. Once the catheter is withdrawn, three to eight coils should be seen outside the ostium

12 Hysteroscopic Tubal Occlusion for the Treatment of Hydrosalpinges

Essure can be considered in women who require tubal occlusion prior to in vitro fertilization (IVF) as treatment for hydrosalpinges. Although there may be some concern regarding the effect of a foreign body on embryo implantation, there appears to be tissue encapsulation of the device after implantation. Several small studies have reported pregnancies from IVF following sterilization with Essure. A retrospective review of all pregnancies reported after Essure in situ in the Netherlands, including unintentional (failed Essure procedures) and those that were intentional, resulting from off-label use of Essure micro-inserts for hydrosalpinx closure before in vitro fertilization, intracytoplasmic sperm injection with embryo transfer, or in vitro fertilization with embryo transfer after regret of sterilization (Veersema et al. 2014). Of the 8 unintended pregnancies and 18 intended pregnancies, all resulted in birth of a full-term healthy baby. So it appears unlikely that the presence of intratubal micro-inserts interferes with implantation and the developing amniotic sac and fetus.

12.1 Technique

The technique is as described previously for Essure hysteroscopic sterilization. Some operators advocate more distal placement of the micro-inserts so that no more than three trailing coils are within the uterine cavity. In the presence of a unilateral hydrosalpinx, a single device placement only is required.

13 Hysteroscopic Tubal Cannulation

Tubal catheterization is a technique used to treat a proximal fallopian tube blockage (PTB) diagnosed following hysterosalpingogram (HSG). It is thought that the narrow and thick, less ciliated proximal segment of the fallopian tube is particularly prone to obstruction, initially by material that can flow back from the uterus, and then in the luteal phase of the cycle by secretions produced locally. As PTB generally occurs in otherwise undamaged tubes, tubal catheterization can potentially successfully re-cannulize the tube.

Data for hysteroscopic treatment of PTB is scarce especially in the ambulatory setting. Tubal catheterization is reported to be successful in approximately 50% of patients (10), and 20–40% of these women have been reported to become pregnant either spontaneously or after ovulation induction or intrauterine insemination (Robinson et al. 2013).

13.1 Equipment

The tubal catheterization system is shown in Fig. 14. The cannula and guidewire fit down the standard 5Fr-working channel of an operating hysteroscope. Procedures can be performed in both the inpatient and outpatient setting.

13.2 Technique for Tubal Cannulation

The radiological procedure of selective salpingography and tubal catheterization has

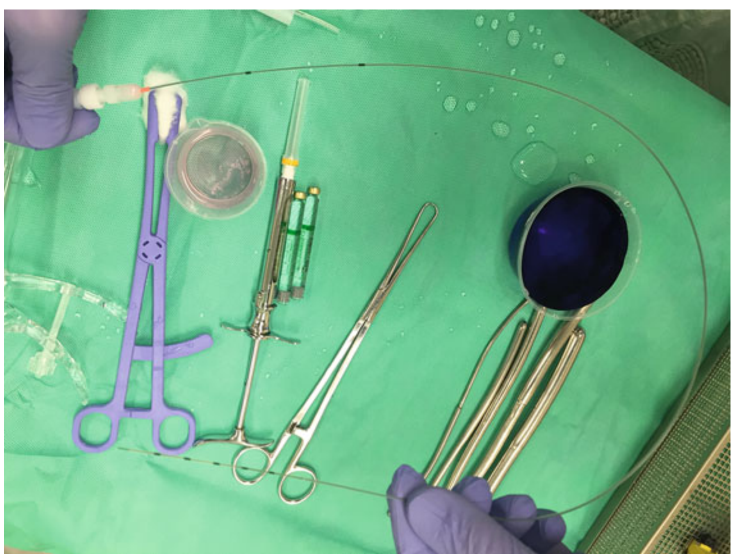


Fig. 14 Tubal catheter system for hysteroscopic tubal cannulation of proximal tubal occlusions

been adapted for use under direct hysteroscopic vision thereby avoiding exposure to ionizing radiation. A 5–5.5 mm 30°continuous flow operative hysteroscope is inserted. A fine catheter is passed down the 5-7Fr working channel of the hysteroscope and guided toward the tubal ostium. The catheter is pushed gently under vision into the tubal ostium and methylene blue dye instilled via a syringe, through the lumen of the catheter. If this does not overcome the obstruction, i.e., the catheter cannot be passed into the tubal ostium or retrograde spill of dye is noted despite forward instillation pressure, a guidewire is railroaded through the lumen of the catheter. The guidewire is pushed gently into the cornual portion of the tube and the instillation of dye repeated.

Hysteroscopic tubal cannulation can also be done in theater as a day case under laparoscopic guidance and a dye test performed at the end of the procedure to assess tubal patency. In the ambulatory hysteroscopy setting, confirmation that PTB has been overcome can be inferred by ease of passage dye without retrograde spill, pre- and post-procedure transvaginal pelvic ultrasound (TVS) to look for free fluid within the pelvis, and hysterosalpingo-contrast sonography scanning or follow-up HSG arranged to confirm restoration of tubal patency.

Risks of the procedure include pelvic infection and uterine trauma. Excessive forward pressure must be avoided, especially if using a fine guide wire, as this risks tubal perforation. This complication should be suspected where the patient experiences acute, sharp, localized pain as the serosal surface of the uterus is breached. The risk of tubal perforation during the procedure is approximately 2%.

14 Outpatient Procedures

Initially hysteroscopy was developed as an inpatient procedure, but advances in equipment, in particular the reduction in size of optics, have allowed first diagnostic and now a range of minor operative procedures in the outpatient setting (Clark and Gupta 2005; Clark et al. 2002b, Kremer et al. 2000). Outpatient hysteroscopy, ambulatory hysteroscopy, and office hysteroscopy all describe procedures that are done without general anesthetic and avoid admission to hospital. Women value the convenience of an immediate diagnosis and treatment. Not only is office treatment well-accepted and convenient, but it also has been shown to be more cost effective (Cooper and Clark; Moawad et al. 2014).

14.1 Equipment and Technique

Office hysteroscopy has the potential to perform the following minor hysteroscopic procedures without the need to readmit the patient to hospital:

- Localization and removal of a missed intrauterine contraceptive devices
- Endometrial polypectomy
- Resection of small type 0 submucous fibroid/ office preparation of partially intramural myomas (OPPIuM) – mucosal incision
- Minor adhesiolysis (filmy adhesions)
- Endometrial ablation using second-generation devices
- Outpatient sterilization
- Tubal catheterization

The equipment and operative techniques have been provided in the preceding sections. One of the biggest challenges in office hysteroscopy is pain relief. National, evidence-based guidelines have been published for best practice when conducting office hysteroscopy to minimize adverse outcomes and optimize the patient experience (Clark et al. 2011). As with any procedure that involves the instrumentation of the uterus, this can be associated with pain, anxiety, and embarrassment. Thus, in addition to a gentle, atraumatic, proficient, and expeditious surgical approach utilizing small-diameter instrumentation, communication with the patient becomes paramount, and this can be promoted by having a member of staff dedicated to providing reassurance and support in what has been termed the vocal-local. In women without contraindications, analgesia should be taken 1 h before the procedure to reduce postoperative pain. Conscious sedation with inhalational agents such as nitrous oxide may be useful in patients who are very anxious. There is not sufficient evidence to recommend routine use of cervical preparation, but all women who require cervical dilation should receive local anesthetic.

15 Safety of Operative Hysteroscopy

15.1 Complications

All procedures have risks of complications, and hysteroscopic procedures are no exception. There are general risks associated with anesthesia, and there are risks associated with the specific procedure. With hysteroscopic procedures, there are particular risks of inserting and activating electrosurgical, thermal, or mechanical instruments within the uterus, and there are risks associated with the distension media. Insertion of the instruments is often made more difficult because of the cervical dilatation needed to accommodate the larger diameter operating instruments. Intravasation of distension media is also more of a problem due to longer operating times and opening up of deep myometrial vessels during resection of type 1 and 2 submucous fibroids. Other perioperative complications include hemorrhage, cervical trauma, uterine perforation, and electrosurgical burns. Postoperative endometritis or ascending pelvic infection can occur although the routine use of prophylactic antibiotics is not recommended (Van Eyk et al. 2012; Thinkhamrop et al. 2007). Rare late complications can include intrauterine adhesions, uterine rupture, and hematometra after endometrial destruction techniques.

In a prospective multicenter study of 13,600 women looking at complications of hysteroscopic procedures, diagnostic procedures had significantly fewer complications (0.13%) than operative procedures (0.28%). The most common complication for operative procedures was uterine perforation (0.76%). Four cases of perforation resulted in heavy bleeding that required treatment by laparoscopy (n = 2), laparotomy (n = 1), or hysterectomy (n = 1). Fluid overload, defined as the absorption of more than 1500 mL of distension media with clinical consequences for the patient, occurred in 0.2% of operative procedures. Four of the five cases occurred during fibroid resection and one during an endometrial resection. The operative procedure associated with most complications was adhesiolysis, risk of complication 4.5%, compared to the least risky operative procedure polypectomy, risk of complication 0.4% (Jansen et al. 2000).

Using good equipment and attaining surgical proficiency through adequate training and an appropriate caseload in clinical practice as well as considering the potential causes of operative difficulties can minimize complications. Possible causes for common problems during operative hysteroscopy include:

- Difficulty with dilation of cervix – scar tissue, acutely anteverted or retroverted uterus, formation of a false passage
- Poor vision – inadequate distension, out of focus, debris (increase suction, open outflow, clear blocked suction holes)
- Bleeding during hysteroscopy – low distension pressure, inefficient coagulation, cutting too deeply
- Rapid fluid absorption – high distension pressure, transecting deep myometrial vessels, uterine perforation

15.2 Case Selection

Case selection is important to minimize complications, particularly when learning new techniques. For example, when learning fibroid resection, it is advisable to master the resection of small type 0 or 1 submucous fibroids attached to the uterine sidewalls before moving onto larger, deeper type 2 or fundal fibroids. Theoretically type 2 fibroids can be hysteroscopically resected if they are not transmural. However, there are some cases that even experienced surgeons should not attempt. Although counterintuitive, the highest complication rates were in those surgeons performing >50 procedures. This may be because the more experienced surgeons are doing the most difficult cases, but it also emphasizes the importance of audit and careful consideration before procedures are performed (Jansen et al. 2000).

Not only is it important to consider the complexity of the case but also pain relief and embarrassment with procedures done in the ambulatory setting without anesthesia. Various strategies can be employed to reduce pain, but some patients will find these procedures very embarrassing or painful, and it can be difficult to predict. Important clues can be gained by how the patient has tolerated other uterine procedures such as endometrial biopsies or diagnostic hysteroscopy. If dilation of the cervix is needed, local anesthetic should be used. Analgesia and antiemetics can also be given prior to the procedure. It is important to have a low threshold for stopping the procedure in the ambulatory setting.

16 Teaching

National training bodies, such as the Royal College of Obstetricians and Gynaecologists (RCOG) and American Association of Gynecologic Laparoscopists (AAGL), are providing structured training and accreditation packages for hysteroscopic training. The RCOG has provided a list of procedures stratified by complexity and therefore risk (Table 3).

Operative hysteroscopy skills are difficult to learn, and structured training and mentorship is required for competencies to be achieved. The rapid increase in the number of procedures done while patients are awake along with decreased training hours has led to legal and ethical concerns about training on real patients. Many minimally invasive training programs around the world have tried to tackle this by incorporating training outside the operating room. There are models and computerized simulators that are now available to help performance. However, the application of hysteroscopic models appears to have lagged behind the use of their laparoscopic counterparts.

Table 3 RCOG classification of operative hysteroscopy levels

Level 1	Diagnostic hysteroscopy with target biopsy Removal of simple polyps Removal of intrauterine contraceptive device
Level 2	Proximal fallopian tube cannulation Minor Asherman's syndrome Removal of pedunculated fibroid (type 0) or large polyp
Level 3	Division/resection of uterine septum Major Asherman's syndrome Endometrial resection or ablation Resection of submucous fibroid (type 1 or type 2) Repeat endometrial ablation or resection

Despite this, a wide variety of models have been used although few of them have been validated. Animal tissues such as pig bladders have been used as "wet" models. Pig bladders can be used to simulate endometrial ablation, and by using stitches, they can also be used to simulate polyp and septum resection (Hiemstra et al. 2008). Animal hearts have also been used to simulate endometrial ablation and resection. Training on vegetables offers a cheaper and more readily available method. Reports of peppers and squash being used to practice biopsy and tissue removal have been stated (Hiemstra et al. 2008; Kingston et al. 2004).

Training using plastic models or box trainers has been shown to improve resident performance (Burchard et al. 2007). Tactile skills can be improved performing abstract tasks such as removal of pin from the sidewall of plastic uterus, or models with fake pathology for resection have been made (Burchard et al. 2007).

Virtual reality simulators create a safe and controlled environment, but more importantly, they create standardized environments that allow the objective performance of the trainee. The VirtaMed HystSim™ (Hysteroscopic Surgery Simulator System) (Zurich, Switzerland) is the only hysteroscopic simulator available, and it has a large number of stored cases and pathologies with different levels of difficulty. The disadvantage of the simulator is the high cost and the lack of haptic feedback.

17 Clinical Governance and Audit

An important part of clinical governance is risk management. Periodic assessment of infection control, staff training, equipment condition, patient information leaflets, and local protocols should be performed.

Audit is an essential tool to improve and maintain standards especially when setting up new services. Areas suggested for audit include:

- Complications of hysteroscopic surgery (e.g., uterine perforation, fluid overload, infection, vasovagal reactions, heavy bleeding, and cervical trauma)
- Failure rates of operative hysteroscopy
- Standards of documentation
- Use of perioperative and postoperative analgesia
- Patient satisfaction in terms of pain experienced, acceptability, and quality of services

18 Future Developments

In the past, new developments in operative hysteroscopy have been dominated by miniaturization of equipment. With an increasing number of procedures being performed in the office setting, it is likely that future developments will also focus on miniaturization. Essential to the miniaturization of equipment are improvements in optics and exciting developments are expected from optical chip technology in hysteroscopy, such as the Invisio Digital Hysteroscope (GyrusACMI/Olympus, Tokyo, Japan). Portability is also becoming increasingly important such that hysteroscopy can be performed in a variety of community settings. The Endosee® office hysteroscopy system incorporates a disposable inflow cannula light lead and camera and a reusable lightweight handset incorporating a tiny touch LCD screen. Other similar and totally disposable systems are likely to be developed or ones compatible with smart devices to provide imaging and data recoding.

One of the biggest challenges in hysteroscopy is to improve pain relief and acceptability of procedures in the outpatient setting. Not only is research needed to improve the technology, but also research is needed to optimize technique and patient selection. The further refinement of tissue removal systems and evaluations of how they compare with bipolar electrosurgery for polyps and fibroids will be forthcoming. The Symphion™ system (Boston Scientific) is a new, tissue removal system utilizing radio-frequency energy and direct intrauterine fluid pressure monitoring.

For endometrial ablation, future developments will focus on improvements to existing technologies, such as miniaturization, portability, disposability and shortened treatment times, and the development of new technologies with utilizing a variety of previously tried and new energies such as cryotherapy, microwave energy, and steam.

The main disadvantage of hysteroscopic sterilization is that women need to find an alternative form of contraception for at least 3 months while the fibrosis and occlusion of the tubes occur. Even after 3 months, occlusion will not occur in 1–12% of women (Duffy et al. 2005; Levie and Chudnoff 2006; Sinha et al. 2007). Future developments will focus on techniques that will occlude the tubes in such a way as to provide immediate contraception.

19 Conclusion

Operative hysteroscopy has an increasing role in the management of uterine problems causing abnormal uterine bleeding and reproductive failure and can be used to provide sterilization. Treatments have shown to be safe, effective, and an acceptable replacement to more invasive surgery such as hysterectomy, and this is increasingly the case with the development of new operative hysteroscopic technologies such as tissue removal systems and bipolar electrosurgery. There has been an increasing movement, driven by the miniaturization, feasibility, and portability of new endoscopic technologies as well as patient expectations, toward performing procedures, while patients are awake in an office setting. This helps to reduce cost and complications of general anesthesia. Surgeons undertaking operative hysteroscopic procedures should ensure they have a sufficient caseload to maintain their skills and audit performance and outcome. Best practice guidelines should help inform practice. In addition, valid and structured training and accreditation packages for hysteroscopic training need to be implemented and keep pace with contemporary technologies and the evolving evidence.

20 Cross-References

▶ Basic Management of Infertility
▶ Diagnosis and Management of the Cancer of the Uterus
▶ Laparoscopic Hysterectomy
▶ Laparoscopic Myomectomy: Best Practices
▶ Management of Abnormal Uterine Bleeding: Later Reproductive Years
▶ Management of Pelvic Pain, Dyspareunia, and Endometriosis
▶ Management of Recurrent Pregnancy Loss
▶ Management of Uterine Fibroids
▶ Pathology of the Uterine Corpus
▶ Treatment of Gynecological Congenital Anomalies

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