

REVIEW

## Intrauterine systems: a frameless future?

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### ABSTRACT

**Introduction:** Intrauterine devices (IUD) are viewed as important contraceptive methodologies to prevent unintended pregnancy.

**Areas covered:** This expert opinion examines the place of frameless devices for use in young women in order to minimize side effect, improve patient comfort and maximize continuation of use to help reduce unintended pregnancies.

**Expert opinion:** Frameless designed IUDs have the ability to be used in both small and large uterine cavities of varied shapes and can significantly reduce abnormal bleeding, pain, embedment and expulsion and likely account for higher continuation rates than that seen with framed IUDs.

### ARTICLE HISTORY

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Continuation of use; Copper IUD; hormone-releasing IUD; framed IUD; frameless IUD; side effects; unintended pregnancy

### 1. Introduction – the challenge

The first intrauterine contraceptive device (IUD) developed specifically for contraception was described in 1909.[1] Since then, numerous IUDs have been developed and marketed relying on size and design for effectiveness. The long duration of action coupled with ease of use made them near ideal contraceptive agents; however, they were not fully embraced around the world. These early systems, although adequate, had less than optimal efficacy, and unbeknownst to their designers at the time, had issues surrounding expulsion, infection, and pain. Since their inception improvements have been made in an attempt to increase their utilization by women worldwide. The addition of high quality polymers, reduction in size, consideration on pelvic infection serve to advance IUD development. The introduction of therapeutic agents, such as copper, progesterone, and levonorgestrel served to significantly improve the effectiveness of the IUD. As the IUD designs were perfected, the method has become one of the most effective reversible contraceptive options yet developed.

IUD use provides the most effective protection against pregnancy comparable to that seen with sterilization methods but with the advantage of reversibility. The major improvement in IUD development over the past 40–50 years has been in improvements in pregnancy rate. Historically, as well as presently, the most significant drawback with the use of IUDs has been the patient continuation rates. The two major contributors to a low continuation rate are spontaneous expulsion but more importantly patient-requested removal for bleeding and/or pain. When compared with women who use other reversible methods of contraception, those who use IUDs have the lowest mortality attributable to those methods and to the consequences of unwanted pregnancy and childbirth.[2]

As long-acting reversible contraceptive methods (LARC) are strongly promoted to reduce the high rates of unintended pregnancies seen globally, there is a widespread need for more acceptable and patient-friendly contraceptive methods in developed as well as developing countries. The high number of unwanted births and induced abortions, the high discontinuation rates of existing reversible methods confirm this unmet need. Over the years, many researchers have come forward with new technologies to reduce expulsion rates and to minimize the incidence of menstrual or intermenstrual bleeding problems. Not until recently have issues concerning patients' complaints of pain during insertion as well as over time been considered in the design of IUDs. Improvement in long-term patient tolerability will clearly serve to improve convenience of use and long-term continuation rates.

The challenge of intrauterine contraceptive researchers, notwithstanding the progress made over the past decades, still is to develop intrauterine contraceptive devices with improved uterine tolerability given the diversity in size and shape of the uterine cavity of women in order to reduce patient discomfort while obtaining higher rates of continuation. Too often IUDs are removed for side effects, such as pain, dysmenorrhea, or bleeding. Issues concerning uterine embedment/expulsion still remain a problem whether inserted at interval, post-abortion, or postpartum.

The IUD–cavity relationship and the tolerability of the device is paramount in achieving high continuation rates and overall patient tolerability. This aspect of IUD use is often overlooked by physicians whose primary concern is typical contraceptive effectiveness, not patient comfort. The great disparity of the size of uterine cavities requires patient individualization with respect to size and uterine fit. This article will review the necessity of uterine compatibility as it

**Article highlights**

- Intrauterine contraceptives should become one of the main methods to avoid unwanted pregnancies, especially among young women.
- Small-size copper IUDs have limited impact on menstrual blood loss and should therefore be the first choice.
- An IUD that does not fit (compare with shoes) will lead to premature removal of the IUD and the method will either be replaced by a less efficient method or even no method.
- Three-dimensional or at least 2D equipment should be available in all clinics to evaluate the width of the uterine cavity prior to selecting an IUD.
- Side effects of IUDs can significantly be reduced when spatial discrepancy between the IUD and the uterine cavity is avoided.
- High continuation rates will only be obtained if attention is given to geometric factors.
- The provision of accurate information about the various methods of contraception is a necessity.
- The creation of centers of experience in all cities should be considered where women can be served with properly fitting IUDs.

This box summarizes key points contained in the article.

relates to high continuation of use and improved patient comfort.

Currently, most intrauterine copper- and hormone-releasing devices have a conventional T-shape plastic frame which may not be suitable for use in all women because of their overall size. Frameless devices, which employ different methods of uterine retention, thus allowing for elimination of the crossarm design, have been developed as copper-releasing IUDs while frameless levonorgestrel-releasing IUDs are being developed.

## 2. Efficacy and side effects of current IUDs

### 2.1. Efficacy

#### 2.1.1. Copper IUDs

The clinical performance of plain plastic IUDs, with reported pregnancy rates of between 3% and 5%, has significantly been enhanced by the addition of copper wire or copper sleeves on the body of the IUD. In 1969, Zipper in Chile found that when copper wire was placed in the uterine horns of the rabbit, the number of implantation sites were reduced.[3] Clinical trials in women showed that the addition of copper wire with a nominal surface area of 200 mm<sup>2</sup> to a plastic T-shaped frame was shown to reduce the pregnancy rate from 18 per 100 to 1 per 100 woman-years.[4] Extensive clinical trials followed in the 1970s and through the 1980s and 1990s by the Population Council (New York) and the World Health Organization (Human Reproduction Programme) with various copper IUD designs.[5] The T-shaped Copper T380A (Paragard<sup>®</sup>) and the Ω-shaped Multiload<sup>®</sup> 375 IUD are thought of by many as the most effective copper IUDs with pregnancy rates significantly lower than the initial studies conducted with the Copper-T200 IUD. Cumulative pregnancy rates with TCu380A are around 1.0 per 100 during the first year and increase slightly up to approximately 3.0 per 100 at 10 years. Pregnancy rates between the sixth and tenth year are not different from those of tubal sterilization. Multiload 375 IUD is slightly less effective than TCu380A in randomized clinical trials (1.7 vs.

1.0/100 women at 3 years).[6] Both IUDs have very low rates of ectopic pregnancy.

#### 2.1.2. Levonorgestrel-releasing system

The release of levonorgestrel in the uterine cavity causes atrophy of the endometrial glands accompanied by stroma decidualization. These changes are the most important for the clinical performance of levonorgestrel containing intrauterine device (LNG-IUD). The contraceptive efficacy of LNG after intrauterine administration was studied in several randomized comparative clinical trials. The pregnancy rates at 5 years were found to be comparable to that seen after tubal sterilization. The reported rates are lower than the pregnancy rates observed with the copper TCu380A at approximately 0.5–1.0 per 100 women at 5 year.[7,8] The rate of ectopic pregnancy is similar to the rates with TCu380A and Multiload 375, 0.02 per 100 women, indicating the significant protection offered by these IUDs.

Thus, copper or hormonal IUDs have exceptional efficacy. The advantages of ease of use and cost make them ideal contraceptive options; however, they have several drawbacks, primarily related to side effects and patient tolerability, which likely serves to limit their utilization.

### 2.2. Side effects

#### 2.2.1. Bleeding

**2.2.1.1. Copper IUDs.** An important drawback of all IUDs is their tendency to cause sporadic spotting, and even heavy, prolonged and sometimes painful menstrual bleeding. The extent of this IUD-induced increase in menstrual blood loss (MBL) appears to be related to the size of the device. The greater the size of the device, the greater the amount of menstrual blood loss. Lippes Loop, one of the larger IUDs developed, has been shown to result in an increase of up to 140% in MBL during the first year after insertion.[9] The increase in MBL with the smaller copper-bearing IUDs, Multiload 375 and TCu380 IUDs has been shown to still be of significance to many women, varying from 40% to 84% of that seen prior to IUD insertion.[9]

IUD use may cause iron deficiency, and may lead to anemia or exacerbate existing anemia.[10] However, while some studies have observed decreased levels in circulating ferritin or hemoglobin after insertion of an IUD, other studies have shown no effect.[11] Kivijarvi et al. [12] compared the risk of developing iron deficiency and anemia in a group of Finnish women ( $n = 40$ ) when using three different copper IUDs (Nova T, MLCu-375, and Fincoind) and a control group of women without an IUD ( $n = 20$ ). About 20% of the intrauterine device users developed signs of iron deficiency and 10% had anemia after 12 months of IUD use. Interestingly, the copper surface area of IUDs has no influence on the amount of menstrual blood loss confirming that size is the primary determinant.[13]

It should be realized that changes in levels of hemoglobin and ferritin in women using IUDs are not simply related to the type of IUD used. Other factors, such as the levels of hemoglobin and ferritin at baseline, the amount of blood lost at menstruation and nutritional intake also determine the overall changes. Most women with normal levels of hemoglobin and

ferritin, who use a copper IUD will not develop iron deficiency anemia. However, in women who have borderline anemia levels, use of an IUD could be detrimental to their iron status and overall health, especially if iron food intake is reduced. These women would substantially benefit from use of a LNG-IUD.

**2.2.1.2. LNG-IUD.** Utilization of LNG devices reduces or masks the impact of IUD on MBL owing to its pharmacologic properties. Minute amounts of levonorgestrel have a profound impact on the endometrium causing a thinning of the endometrial lining characterized by glandular atrophy. The menstrual pattern is greatly affected by the hormonal endometrial suppression resulting in an important reduction of the amount of menstrual bleeding.[14] The strong reduction in menstrual bleeding is beneficial in women to treat heavy menstrual bleeding or who want to have bleeding-free periods. This characteristic of the LNG-IUD is extremely useful as it may be an alternative for hysterectomy as a treatment option. Secondary beneficial effects of menstrual reduction are increase in iron stores and reversal of anemia. Unfortunately, women fitted with a LNG-IUD commonly experience menstrual spotting and prolonged breakthrough bleeding which affect acceptability of the method leading to discontinuation.

### 2.2.2. Pain

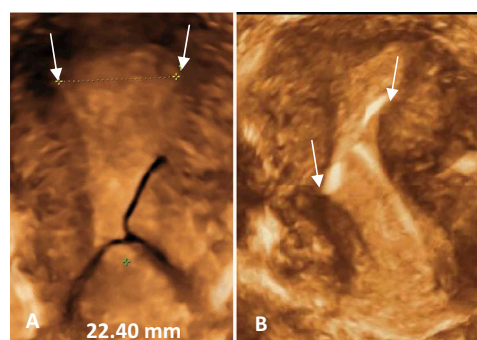
Pain, associated with or independent of erratic or heavy menstrual bleeding, is unfortunately a common side effect of current framed T-shaped IUDs leading to early removal and poor continuation rates. Typically, many women have gone through a period of months of cramping and pain, hoping that the discomfort will subside over time prior to deciding to remove the IUD as their last resort. Disproportion between the size of the IUD and the woman's uterine cavity can lead to cramping, pain, embedment, displacement, partial or total expulsion of the IUD, unintended pregnancy (due to downward displacement, partial or total expulsion), and abnormal or heavy uterine bleeding.[15] A woman complaining of cramping pain for days after insertion often has been fitted with an IUD, which is clearly not suitable for her uterine cavity.

When considering the size of the uterine cavity in young women and the size of the available framed IUDs, most IUDs are too large for the majority of nulliparous as well as parous women.[16] One needs to be aware that 50% of women have maximal uterine fundal widths of below 24 mm with some below 10 mm. Thus, it can be assumed that a very large number of women will not be able to tolerate these devices.

Figure 1 illustrates two clinical cases of severe discrepancy between the IUD and the uterine cavity. Figure 1(A) is from a woman with a Mirena IUD while Figure 1(B) is from a woman with a TCu380A inserted. Early removal due to cramping pain occurs frequently and more often in nulliparous and adolescent women than in older women. Removal rates after 6 months–1 year for bleeding/pain of 40–50% are not unusual.[17]

### 2.2.3. Expulsion and displacement

Full IUD expulsion occurs most often during the first months after insertion and is mainly due to spatial incompatibility with



**Figure 1.** (A) 3D ultrasound of a typical case of severe disproportion between the IUD and the endometrial cavity. The width of the uterine cavity in the fundus is only 22.40 mm (courtesy of Dr. Jandi). Discrepancy often leads to abnormal bleeding and cramping pain, expulsion or embedment. (B) If not expelled, a too big IUD will cause severe distortion, embedment, pain and bleeding (courtesy of Dr. Shipp).

too small uterine cavity. The uterus is capable of generating up to 50 N of myometrial force depending on internal pressure and surface area. If the IUD is not fully expelled, embedment and/or secondary perforation of the IUD may occur. The imbalance between the size of the IUD and that of the uterine cavity can result in the production of asymmetrical uterine forces, which can increase patient discomfort especially while menstruating.[15]

Total expulsion of a conventional framed IUD occurs in 5–10% of women during the first year of use, with 1–2% per year thereafter. Hubacher's review of copper IUDs revealed that nulliparous women experience higher rates of total expulsion and removals for bleeding and/or pain compared with parous women.[18] However, in a recent study IUD expulsion rates of the Mirena LNG-IUD and TCu380A were not increased in nulliparous women (8.4 per 100 women at 36 months), but 18.8 expulsions per 100 women were observed in adolescents aged 14–19.[19] It is likely that many of the IUDs that are not expelled will embed resulting in patient discomfort, bleeding and even advance to perforations. IUD users who had an ultrasound scan 'for any indication', 10.4% malpositioned devices were noted. The majority were displaced in the lower uterine segment and the cervix.[20] The usual practice is to remove these IUDs. Although full expulsions are serious when they do occur, malpositioning and partial embedment likely has greater impact on patient comfort and thus continuation rates.

### 2.3. Continuation of use

Continuation of use is the most important determinant of performance of any contraceptive method. IUD expulsion, heavy and/or prolonged menstrual bleeding and pain are the most frequent causes for IUD discontinuation. Prolonged continuation of use of a method is a critical element in the prevention of unintended pregnancy as the removal of the IUD is often followed by use of a less effective method or simply discontinued.

The majority of women using conventional IUDs discontinue IUD use long before the end of the lifespan of the IUD. [21] The average use of copper IUDs is approximately 36

months whilst the lifespan is 10 years for the TCU380A IUD. In the large studies with TCU380A, Sivin reported continuation rates of 75% after 1 year, dropping to less than 40% after 5 years.[5] Removal rates for medical reasons with LNG-IUD of 35–40% at 5 years have been reported.[7,8] Similar low rates of continuation for TCU380A and LNG-IUD were observed in the CHOICE study, which was conducted mainly in young and nulliparous women.[22] Continuation rates were higher during the first year than in Sivin's study but decreased to less than 70% at 3 years. The main reasons for discontinuation were bleeding changes, pain complaints, and expulsion of the IUD. Much of the reasons for patient discontinuation is a consequence of the uterine incompatibility of conventional T-shape devices. Elimination of the crossarms results in improved continuation. Frameless devices, which eliminate the crossarms entirely, have 5-year continuation rates of > 90% with less side effects and patient complaints as encountered with framed devices (see in the following).

### 3. Efficacy and side effects of frameless IUDs

#### 3.1. Efficacy

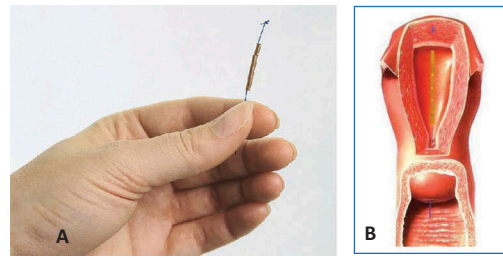
Data on efficacy of the frameless GyneFix<sup>®</sup> 330 IUD from large-scale, long-term international multicenter randomized, and non-randomized comparative studies in parous and nulliparous women covering 15,000 woman-years of experience are available. Clinical studies with the frameless concept have been conducted since 1985. GyneFix is a highly effective intrauterine contraceptive. Failures range from 0.0/100 users to 2.5/100 users (cumulative rates) during the first year up to 9 years of use (data from published and unpublished randomized and non-randomized comparative clinical trials).[23–26] The long-term efficacy has been confirmed in a WHO conducted, randomized comparative clinical trial.[27,28] These figures are lower, but not significantly lower than those of the TCU380A IUD in a major randomized clinical trial (0.4/100–3.2/100 users), which is still considered by some as the most effective copper IUD, and similar to those seen with the LNG-IUD.[29] Furthermore, annual pregnancy rates do not increase over time. This lower effectiveness of framed systems over time is attributed to the fact that these devices become displaced or partially or totally expelled in 5–10% of users, resulting in accidental pregnancies.[30]

The high initial and ongoing effectiveness of the 'anchored device' is attributed to its constant release of spermicidal copper ions in the upper part of the uterine cavity. This may explain why clinical studies with the mini version of the frameless IUD also suggest a high efficacy of this tiny IUD (Figure 2).[31]

#### 3.2. Side effects

##### 3.2.1. Bleeding

Clinical trials suggest that both the mini and GyneFix 330 IUD reduce the incidence of heavy blood loss observed with framed IUDs due to the small size of the foreign body. MBL with GyneFix 330, measured over a 24-month period,



**Figure 2.** (A) Miniature GyneFix 200 IUD with effective copper surface area of approximately 250 mm<sup>2</sup>; (B) GyneFix 330 IUD with effective copper surface area of 380 mm<sup>2</sup>, attached to the fundus of the uterus.

increased but was less when compared with TCU380A. Ferritin levels with GyneFix 330 were not affected in contrast with TCU380A.[32] Research conducted with the smaller frameless IUD evaluated ways to minimize the effect on MBL and to reduce the amount of menstrual bleeding. Although the mechanism by which menstrual bleeding occurs is complex, the remedy seems to be simple. By significantly reducing the surface area of the foreign body, the impact on the amount of menstrual bleeding is minimized. Menstrual bleeding was not significantly increased with the small frameless IUD.[33] The frameless IUD may also reduce prolonged or intermenstrual bleeding due to the absence of crossarms, eliminating the risk of endometrial trauma.

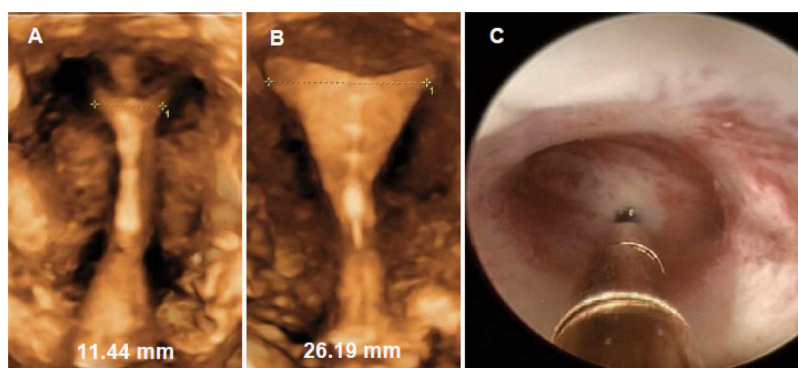
##### 3.2.2. Pain

Clinical trials suggest that both the mini and the GyneFix 330 IUD rarely cause complaints of pain due to their small size and the flexibility of the frameless IUD, in contrast with framed IUDs.[16,17] The diameter of these devices is 2.2 mm, a fraction (only 7%) of the width seen with TCU380A (32 mm). The mini IUD is convenient for young women with a small uterine cavity for whom framed IUDs are generally less suitable. Figure 3 shows three-dimensional (3D) and hysteroscopic pictures of the frameless IUD in different sizes and shapes of uterine cavities. Uterine cavities with a transverse diameter at the fundus of less than 20 mm are now seen more often. These small cavities are found frequently during ultrasound examination particularly in young women.[34] On average, the uterine cavity is substantially smaller than the width of most current intrauterine contraceptives.

##### 3.2.3. Expulsion

When correctly inserted, spontaneous total expulsion of the IUD occurs in less than 1/100 women observed over a 5-year period of use.[16] These studies also showed that the anchor knot remains affixed to the uterine wall and does not migrate over a long period of time. Any expulsions that do occur are typically encountered in the first few week following insertion and likely attributed to improper anchoring on the part of the physician. The higher expulsion rates which are typically observed at the beginning of the physician's learning curve with the anchored IUD are attributed to a lack of familiarity and comfort with the new anchoring technique. The term 'insertion failure' has a broader meaning when applied to





**Figure 3.** (A) 3-D ultrasound picture of the frameless copper IUD in a uterine cavity with width of 11.44 mm (courtesy of Dr. Jandi). (B) Same in a uterine cavity width measuring 26.19 in width (courtesy of Dr. Jandi). (C) Hysteroscopic view after insertion in nulliparous women demonstrating the optimal relationship of the IUD with the narrow uterine cavity.

the GyneFix over other framed systems, as it includes failure to implant the knot properly in the fundal myometrium.

Once properly attached to the uterine musculature migration of the device and possible embedment are all but eliminated. Recently, the anchoring knot was provided with a tiny stainless steel marker, which is highly visible on ultrasound. This visualized anchor allows precise placement of the anchor in the tissue of the uterine fundus and prevents insertion failure and perforation of the IUD in the abdominal cavity as the IUD can be removed immediately if the anchor is not correctly placed.[35]

### 3.3. Continuation of use

Continuation rates over 90% at 5 years have been reported with frameless IUDs in clinical trials conducted in parous, nulliparous and adolescent women, irrespective of the size and shape of the uterus.[16,17] Successful insertion of the devices has been accomplished in women with uterine widths of as small as 6 mm with minimal patient discomfort at insertion as well as after follow-up. In terms of IUD tolerability and continuation of use, from a practical perspective, the worst case is to insert an IUD which is much too large for the uterine cavity. To achieve high patient comfort, an IUD should cause minimum distortion of the endometrial cavity during insertion as well as over time, during the maximum degree of contraction typically encountered during the menstrual phase. [36] In theory, 1D frameless IUDs probably provoke the least interaction from the uterus, which explains its adaptation in cavities of every size and shape. Furthermore, unlike rigid or semi rigid framed devices, GyneFix utilizes a series of free moving small copper cylinders as its copper source, surrounding a thin non-dissolvable suture string. Copper release readily occurs from both the exterior and interior surfaces of the cylinders allowing for much smaller devices to be designed yet having a copper release rate equal to or greater than that seen with conventional wire based framed IUDs. Its lack of a rigid structure affords these frameless devices a high degree of flexibility even when implanted within the cavity. The flexible nature also allows the devices to easily react to uterine contraction and movements. Its small size, lack of a crossarm, and overall flexibility contribute to the high patient acceptance and continuation rates women experience when using the device. These features do not allow the uterus

to exert expulsive forces on the IUD, in contrast with conventional IUDs.

## 4. Conclusion

In many ways, IUDs are the near ideal form of long-acting reversible contraception and are strategically important for family planning in general and for preventing unintended pregnancies in particular. Their ability to reduce unintended pregnancy is governed by women *continuing* to use them, whereby the *tolerability of the device* has shown to be paramount to achieving this objective. Long-term use of the same device is only accomplished if health care providers give specific attention to the size and shape of the uterine cavity prior to insertion of a 'standard size IUD'. This can be accomplished by using ultrasonography, either 2D or 3D. Maximum comfort during prolonged IUD use and a high continuation rate can clearly be achieved by using an IUD of which the greatest transverse dimension of the IUD is equal or slightly in excess of the fundal transverse dimension.[37] These geometric relationships promote IUD retention and stability while minimizing endometrial/myometrial trauma. Use of frameless IUD that eliminate the need for a crossarm entirely are suitable for use in all women irrespective of the size or shape of their uterine cavity. In our opinion, assessment of a patient's uterine cavity is required prior to the insertion of any framed device. Knowledge of the patient's uterine dimensions and geometry will allow physicians the ability to select devices that are optimal for each patient. Until new clinical guidelines are implemented that utilize ultrasound assessment, IUDs such as frameless intrauterine devices hold significant clinical advantages. Every woman should come to expect, and is entitled to pain free contraception. Although improvements in IUD design are still needed, the frameless systems afford patients and physicians significant options and alternatives when considering LARC.

## 5. Expert opinion

### 5.1. Key findings

It is clear that contraceptive methods which are dependent on memory and motivation, such as the pill, are not the ideal

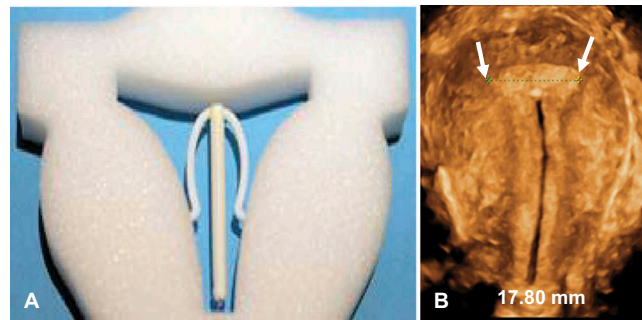
solution in all women but especially younger age groups. For years, the pill has been synonymous with contraception. This has regrettably helped to maintain ignorance of contraceptive alternatives beyond condoms and sterilization. The impact is even more dramatic when one realizes that most if not all of these alternatives have demonstrated superior effectiveness over the pill.

With IUDs, the inherent efficacy is so high, and proper and consistent use is almost guaranteed. A multitude of studies have demonstrated the extremely low pregnancy rates associated with copper and hormonal releasing devices. Sadly, only limited progress has been made in making conventional IUDs more acceptable to women. Many IUDs still have unacceptable high discontinuation rates. Recommendations by experts have been neglected, sometimes in favor of the interests of industry. Many women are, therefore, still underserved in most parts of the world as there are still no suitable intrauterine contraceptives to fulfill the needs of women.

Almost 50 years ago, a study in 60 nulliparous women found an average uterine cavity width of  $23.5 \pm 0.94$  mm. [38] The authors stressed the importance of an optimal inter-relationship between the IUD and the uterine cavity as fewer side effects and greater acceptability would thereby be promoted. They found that pain during use of the IUD is related to the disparity between the size of the uterine cavity and that of the IUD. Particularly a too wide IUD was found to be cumbersome. In later years, additional studies were conducted that examined the uterine width at the fundal level (fundal transverse diameter) in parous as well as nulliparous women using a measuring instrument. These studies found that the mean width of the uterine cavity in 795 nulliparous and parous women between 15 and 40 years of age is approximately 24–26 mm. [39] These early findings have since been substantiated using less invasive external modern uterine imaging techniques that allow for precise and accurate uterine measurements *in vivo*. [40] The uterine cavity width was recently measured with 2D ultrasound in a study in Finland conducted in 165 young nulliparous women, and found a *median* transverse fundal diameter of the uterine cavity of 24.4 mm. One hundred and one (62.7%) women had a transverse diameter at the fundus of less than 24.4 mm. [41] Thus, a very large segment of the female population have substantially smaller uterine widths. The width of the normal uterine cavity was also assessed through three-dimensional ultrasonography, as illustrated in this report. This technique allows for multiple images to be collected along with precise uterine dimensions of not only the width but also the length of the uterine cavity itself.

## 5.2. The biggest challenge

From a technical perspective, the biggest challenge is to design intrauterine contraceptive devices that fit like a shoe. [42] IUDs can be designed to fit uterine cavities of virtually every size and shape. The frameless IUD is an example as this device is suitable for insertion in all women regardless that their uterine cavity is small or large. The device is frameless lacking any crossarm, is flexible and when inserted properly,



**Figure 4.** (A)  $\Omega$  LNG-IUD with flexible transverse arm allowing adaptation to different cavity widths; (B) 3D ultrasound of FibroPlant<sup>®</sup> LNG illustrating the harmony with the very small uterine cavity in a young woman which is only 17.80 mm wide (courtesy of Dr. Nolte).

the majority of women will keep the IUD for the full lifespan of the IUD. Research is underway to make frameless devices that will last for more than 10 years, which could be used from adolescence until the woman is ready to have her first child which is around the age of 30 in Europe on average. Frameless devices do not penetrate the market quickly as thorough training is required. Therefore, other IUD options are also being developed that take into account the various widths of uterine cavities and have the ability to adapt without causing trauma to the uterus. Figure 4 shows a  $\Omega$ -shaped IUD which can adapt to the width of the uterine cavity without distorting the cavity; and the frameless Fibroplant LNG-IUD which is anchored to the fundus of the uterus using an identical anchor as GyneFix.

This report suggests, in agreement with others, that measuring of the uterine width should be considered prior to selecting an IUD for insertion. [43,44] Frameless IUDs hold promise as no considerations of uterine width or shape is necessary. Insertion is simple and easy to learn by skilled providers. New framed IUDs that can adapt to various sizes of uterine cavities are currently under development and could be suitable for many women. The main focus of researchers should be on tolerability and at the same time optimal retention should be realized. Furthermore, new drug delivery systems should be developed, both frameless and framed that release active ingredients providing contraception and treatment of various conditions such as heavy menstrual bleeding, dysmenorrhea, adenomyosis, or fibromyoma simultaneously. Other challenges are the prevention of sexual transmission of infectious diseases (e.g. HPV and HIV) in conjunction with the provision of contraception.

## Declaration of interest

D Wildemeersch has conducted research in the field of non-hormonal and hormonal, framed and frameless intrauterine devices, including in nulliparous and adolescent women, for 30 years. N Goldstuck conducted research in intrauterine device use, including adolescents, for over 30 years. T Hasskamp is an endoscopist with substantial expertise in problems occurring with IUDs. The authors have no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript apart from those disclosed.

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