Precise measurements of intrauterine vascular structures at hysteroscopy in menorrhagia and during Norplant use

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Using currently available equipment for panoramic hysteroscopy, the size of images viewed cannot be accurately judged because of the magnifying and distorting effects of the objective lens. This study has demonstrated that magnification by the hysteroscope lens can alter the apparent size of images by up to 27%. An additional effect of lens distortion can alter the apparent size of images viewed by up to 28%, depending on the position of the image in the field of view. These effects are independent and may be additive. Thus, the apparent size of intrauterine structures at hysteroscopy may bear little resemblance to their actual size. Image-correction methods are described which reduce the effects of image magnification on the apparent size of an object viewed through the hysteroscope to 7%, and the effect of distortion to 3%. This technique can greatly improve the accuracy of measurement at hysteroscopy, and has been utilized in this study for the precise measurement of superficial endometrial vascular diameter (mean ± SEM) in 34 Norplant® users (120 ± 11.6 μm) and 20 women with spontaneous menorrhagia (74 ± 7.2 μm). It has also confirmed the presence of scattered dilated vessels (up to 777 μm in diameter) on the endometrial surface in some Norplant users.

Keywords: hysteroscopy/measurement/menorrhagia/Norplant/vascular

Introduction

Intrauterine pathology accounts for a wide variety of gynaecological symptoms, in particular disturbances of menstrual bleeding. Benign disease such as endometrial polyps or myomata commonly present with menstrual symptoms. Endometrial malignancy may present with excessive or irregular bleeding in premenopausal women (Mackenzie and Bibby, 1978). In those with infertility or recurrent miscarriage, intrauterine structural abnormality may need to be excluded.

Hysteroscopy plays an important diagnostic and therapeutic role in the clinical management of bleeding disturbances. Panoramic hysteroscopy provides a complete view of the uterine cavity, and allows directed biopsy of intrauterine lesions (Taylor and Hamou, 1983). Combined hysteroscopy and endometrial biopsy are more sensitive and specific tools for the diagnosis of intrauterine pathology than dilatation and curettage alone, as the entire uterine cavity can be inspected (Brooks and Serden, 1987; Gimpelson and Rappold, 1988; Walton and McPhail, 1988; Loffler, 1989).

The 'fish-eye' lens of the panoramic hysteroscope provides an image of the curved surface of the endometrium, and angulation of the lens allows inspection of anterior and posterior walls. As a consequence of these features, the image viewed through the panoramic hysteroscope is both distorted and magnified. The apparent size of any object viewed through the hysteroscope will vary according to the distance between the object and the lens, and to the position of the object in the field of view. Contact hysteroscopy avoids this distortion, but does not provide a panoramic view of the uterine cavity.

At hysteroscopy, it is not possible to judge the size of intrauterine structures by comparison with other landmarks since endometrial surface area varies considerably with parity and associated uterine pathology. Even if the image is captured on video or digitized, accurate quantitative data cannot be obtained since there is no structure of known size within the field of view. There is no way of accurately measuring intrauterine structures without removing the uterus for pathological inspection. Transvaginal ultrasound can measure uterine dimensions or intramyometrial pathology with reasonable accuracy, but cannot yet reliably assess endometrial pathology. In the assessment of submucous myomata size, clinicians have compared serial videos of hysteroscopic examinations to measure changes in response to treatment. This provides qualitative, but little quantitative, information.

A hysteroscopic study in women using the subdermal levonorgestrel-releasing contraceptive system, Norplant (Hickey *et al.*, 1996), has demonstrated that the superficial endometrial vasculature differs in quantity, morphology and distribution from that of non-Norplant users. In order to determine the size of surface vessels, a technique was developed to measure the diameter of intrauterine structures at hysteroscopy, and applied to the measurement of the superficial vasculature in women using Norplant. This study aimed to assess and quantify the endometrial vascular diameter in Norplant users, and to measure other glandular, stromal and vascular features. These techniques could equally be applied to the measurement of other intrauterine pathological or physiological structures.

Materials and methods

Thirty-four subjects were recruited between May 1994 and September 1995 from family planning clinics. Women were eligible for inclusion

if they were between the ages of 18 and 40 years, required long-term contraception, and reported regular menstrual cycles.

The volunteers were fully informed about the Norplant system and the study protocol. Their informed consent was obtained before any investigations were commenced. The Ethics Committees of The Population Council (New York) and Family Planning NSW (Australia) gave approval to this study.

Twenty women referred to the hysteroscopy outpatient clinic with a complaint of menorrhagia and a final diagnosis of ovulatory dysfunctional uterine bleeding were used as a comparison group. All subjects were fully informed of the study and written consent for participation was obtained. All perimenopausal women, those with intermenstrual or irregular bleeding, those with known uterine or pelvic pathology and women who were currently taking sex steroid hormones or regular non-steroidal anti-inflammatory preparations were excluded from the comparison group. When endometrial pathology was revealed at hysteroscopy or endometrial biopsy, subjects were also excluded. It is acknowledged by the authors that these subjects do not constitute a 'normal' comparison group, since these women all complained of menorrhagia. Objective measurements (Hallberg and Nilsson, 1964) confirmed a menstrual blood loss >60 ml per cycle in 12 of the 20 women.

Menstrual bleeding patterns

The presence of any bleeding or spotting on the day of the hysteroscopy was recorded, and the number of days of bleeding and spotting during the previous 30 days. The date of the last normal menstrual period was recorded.

Hysteroscopy

Two hysteroscopies were scheduled in each of the 34 Norplant users. Two subjects declined a second hysteroscopy due to discomfort during the first procedure, making 66 hysteroscopies in total in Norplant users. Hysteroscopies were performed in approximately one-third of subjects at one month after insertion, in a further one-third at two months, and in the remaining one-third at three months. The second hysteroscopy was scheduled for three months after the first procedure in each subject. This schedule was designed to assess changes in endometrial vasculature over time within and between subjects. Only one hysteroscopy was performed in each subject in the comparison group. Twenty-four of these 66 hysteroscopies (36%) in Norplant users were performed during a bleeding episode. None of the comparison group was bleeding at the time of the hysteroscopy.

A 2.7 mm Wolf hysteroscope (Wolf, Endocorp. Pty Ltd, NSW, Australia), with a 25° objective lens angulation and an operating sheath of 15 Fr (approximately 4 mm) was used. A 7 Fr gauge (approximately 2 mm) rigid biopsy and grasping forcep was introduced into the operating sheath before the hysteroscope was inserted into the uterus. Paracervical local anaesthetic (5 ml of 1% lignocaine without adrenaline; Astra, NSW, Australia) was given. The procedure was viewed on a Sony colour monitor (Sony, NSW, Australia) via a Storz camera (Stenning and Co. Pty Ltd, NSW, Australia), using a Storz cold light source. Each examination was recorded on super VHS videotape. Normal saline was used as the distension medium, at room temperature (22°C) and at 50–150 mmHg pressure. Saline pressure was monitored with a pressure cuff.

The cavity was systematically inspected, starting at the tubal ostia and progressing to the fundal region, and the anterior and posterior uterine walls. The biopsy forceps were advanced into the field of view and the endometrial blood vessels visualized with the forceps directly adjacent to the vessels. Following inspection of the vessels, the uterine cavity was collapsed under direct vision by stopping the

inflow of saline and allowing the residual saline to drain out through the portal of the operating sheath. The quantity and source of any resultant bleeding was observed and recorded. The quantity of bleeding was assessed by the operator and again by a 'blind' observer viewing the procedure on video, and assigned to a scale of 1 (no bleeding) to 5 (heavy bleeding). The apparent source of the bleeding was classified according to the size of the bleeding vessel, from 1 (small vessel) to 5 (large vessel) in the same way. Polaroid photographs were taken of the endometrium using a Sony video laser printer (Sony, NSW, Australia). Care was taken to ensure that the biopsy forceps remained at the same orientation in the field of view. The procedure was recorded on super VHS videotape.

On entering the uterus, the superficial density and distribution of the endometrial vasculature was recorded. The morphology and branching of prominent vessels was inspected, and the presence of valves and direction of blood flow noted where possible. The characteristics of any bleeding vessels observed on entering the uterus were recorded. When bleeding was observed to start during the procedure, the site and quantity of bleeding was noted. These observations were repeated following deflation and redistension of the uterus. For assessment of the endometrial vasculature, structures were recorded as 1 (not present), 2 (present in slight quantity), 3 or 4 (present in moderate quantity) or 5 (present in large quantities).

Following inspection of the endometrial vasculature, superficial vascular fragility was assessed by controlled alteration of intrauterine pressure under direct hysteroscopic observation. This was achieved by emptying the uterus of saline distension fluid by disconnecting the giving set, and allowing the remaining fluid in the cavity to drain out. As the cavity collapsed, any bleeding points were carefully observed.

The video recording of the hysteroscopy was examined in detail by the candidate after the procedure, and further Polaroid photographs taken of the endometrium. The appearance of the endometrial vasculature was scored by an observer who was 'blind' to the characteristics of the patient (treatment or control, bleeding patterns and day of cycle).

The uterus was then redistended with normal saline and the extent and source of bleeding again recorded.

Polaroid photographs were taken of all salient endometrial vascular, stromal and glandular features using a Sony video laser printer. Care was taken to ensure that the biopsy forceps remained at the same orientation in the field of view.

Method validation

In the laboratory, precise measurements were made of a number of features of the biopsy forceps (Figure 1). A grid of known internal size was constructed, and the hysteroscope was placed horizontally with the biopsy forceps just touching the grid. The hysteroscope was set at a number of (approximate) normal working distances from the grid. The apparent sizes of the grid spaces as they appeared through the hysteroscope were compared with the known sizes of the grid spacings. This allowed the calculation of the distorting and magnifying effects of the hysteroscope.

The precision of these measurements was assessed by using the coefficient of variation (CV), which is the standard deviation (SD) divided by the mean, and is expressed as a percentage. The lower the CV, the lower the measurement variability and the more precise the measurement of the actual size of endometrial structures.

Correction of image magnification

Image magnification can be obtained accurately by either capturing images at a known fixed distance or having an object of known size in the field of view. The extent of the magnification will depend upon
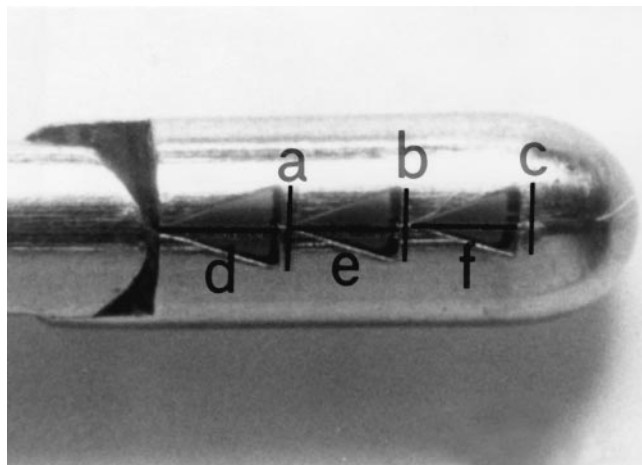
Figure 1. Detail of rigid hysteroscopic biopsy forceps showing features used as calibration standards.

the distance between the object in view and the lens, and will therefore vary during the hysteroscopic examination. It is not possible to judge accurately the distance between an intrauterine object and the lens. Measured features on the forceps were used as calibration standards (Figure 1). The forceps were kept in contact with the tissue area to be measured in order to minimize distortion due to distance between the object and the lens. With the forceps in contact with the tissue area, a constant correction factor was applied to account for the proximity of the forceps to the lens.

With the biopsy forceps held at 12 o'clock in the field of view, the image of the grid through the hysteroscope was videotaped at 'typical' working distances from the lens. The images were then digitized in an image analysis system at 512×512 pixels (TN-8502; Noran, Madison, NY, USA). Since the actual grid spacings and the dimensions of the biopsy forceps were known, the extent of image magnification could be calculated. Knowing the extent of image magnification, the actual size of structures observed through the hysteroscope could be measured. In the calculation of image magnification, the effect of image distortion was minimized by measuring images in exactly the same area of the image, the area where image distortion was least apparent.

Correction of image distortion

Images viewed through the hysteroscope are distorted by the fish-eye lens effect (causing barrel distortion) and the tilt of the lens (25° in this case). In order to correct this image distortion, an image of the grid as viewed through the hysteroscope was obtained as above, and digitized in the image analysis system. A repeat image of the grid was obtained through an undistorted camera, and software written to superimpose the distorted image on top of the undistorted image so that the two images matched as closely as possible in the area of least distortion. The undistorted image was then digitized and an equation defined to transform the distorted image to closely match the undistorted image. This effectively 'flattened' the curved image created by the fish-eye lens into a flat image (Figure 2).

This was achieved by recording x and y coordinates of the same areas in the distorted and undistorted image at 120 points. These points are referred to as 'control points'. The control points were fitted to the following third order polynomial function as follows:

$$x' = a_9x^3 + a_8y^3 + a_7y^2 + a_6y^2 + a_5y^2 + a_4y^2 + a_3y + a_2y + a_1xy + a_0$$
$$y' = b_9x^3 + b_8x^3 + b_7x^2y + b_6y^2 + b_5x^2 + b_4y^2 + b_3x + b_2y + b_1xy + b_0$$

where x' and y are the x and y coordinates of the distorted image, x

and y are the coordinates of the undistorted image, and a and b are the parameters to be derived.

The parameters were derived by importing the x and y coordinates into the statistics software package JMP (SAS) and using a non-linear fitting procedure. A custom third-order polynomial geometric transform was developed for the image analysis system to correct for this distortion. Software was written in the computer language C to apply this distortion correction. Pixel coordinates not mapping to integer values were interpolated using bilinear interpolation (a weighted average of the surrounding pixels).

This transformation was designed to correct for both the barrel distortion of the hysteroscope and the tilt. The tilt was directional, so images were always collected through the hysteroscope at the same orientation, with the biopsy forceps at the top of the image. Since the clinical situation may often include some rotation of the hysteroscope, the effects of no rotation, and rotation of 10° and 90° were assessed.

Statistical methods

Statistical analysis was performed using the programme JMP (SAS) on a Macintosh 6200/75 computer. Analysis of variance was used to compare the differences in means between hysteroscopic measurements in the Norplant groups and those of the comparison group. A P-value of <0.05 was taken to indicate statistical significance.

Results

Image magnification

A number of measurements were made of the biopsy forceps in order to determine the features which gave the least variability on repeated measurements. The biopsy forceps teeth labelled as 'a' and 'b' in Figure 1) were the features that showed the least variation on repeat measurement (see Table I). The feature labelled as 'a' measured 0.7 mm, while 'b' measured 0.63 mm and 'c' measured 0.58 mm. Without correction for image magnification, the CV of images observed through the hysteroscope at a range of normal working distances was 27.3%. If the distance between the hysteroscope lens and the object in view were fixed, the CV could be reduced to 7.7%.

Image distortion

Images collected through the hysteroscope are distorted. The fish-eye lens effect makes the apparent size of images vary, and the extent of variation is dependent on the position of the image in the field of view. Distortion is greatest at the periphery of the image, making assessment of size of peripheral features even more inaccurate than that of centrally placed features. Because of this important contribution of position to image distortion, measurements were made from the central 20% area of the image, the central 50% area and the central 70% area. Distortion will also depend upon the orientation of the image, and images were collected using 'no misalignment', with the forceps at 12 o'clock in the image, and at 10° and 90° of misalignment, allowing for rotation of the image which may occur in normal clinical practice.

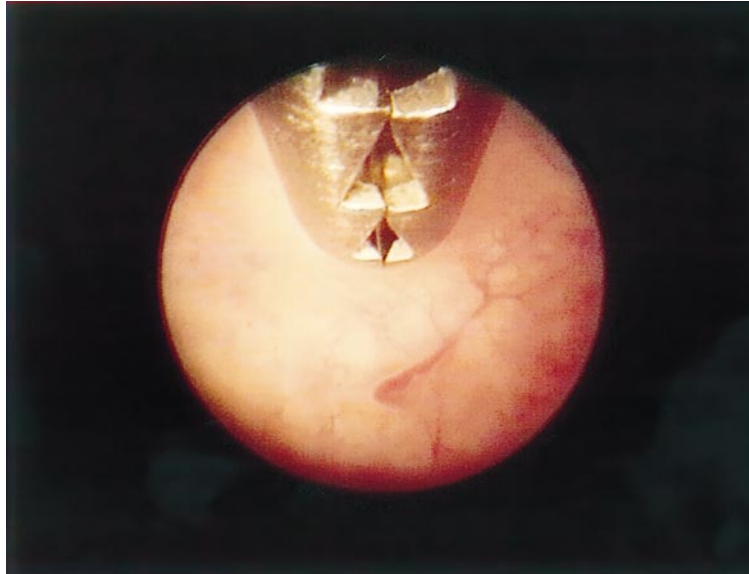Routine use of the hysteroscope, measuring clear images

Figure 2. Use of biopsy forceps for the measurement of endometrial vessel diameter in a Norplant user.

Table I. Variation in the apparent size of images viewed through the hysteroscope

Measurement of image without correction for magnification	Coefficient of variation (CV, %)
Image at normal working distances from lens	27.3
Image at a fixed distance from lens	7.7
Forceps length (a)	6.8
Forceps length (b)	6.7
Forceps length (c)	11.1
Forceps length (d)	12.1
Forceps length (e)	18.8
Forceps length (f)	16.7

within the central 70% of the field of view, produced a CV of 28.2%. This distortion could be reduced to 12.1% by restricting measurements to the central 20% of the image. Using the distortion correction outlined above, and with 10° of misalignment, the CV could be reduced to 3.0% in the central 20% of the image and was still <5% using the central 70% of the image (Table II). The effect of image misalignment was to reduce the effectiveness of the distortion correction, and hence increase the CV.

Hysteroscopic measurements

Superficial endometrial blood vessels were measured at 86 hysteroscopies, including 66 in Norplant users during bleeding and non-bleeding episodes, and 20 in comparison subjects during the proliferative and secretory phases of the menstrual cycle, though not during menstruation. The widest diameter and longest visible length of the superficial endometrial blood vessels were measured.

Superficial vascular width

In 46 of 66 hysteroscopies (69%) in the treatment group and in 14 of 20 (70%) in the comparison group, precise measurements were made of superficial vascular width and length. In the remaining examinations, bleeding obscured the image and measurements could not be made. The mean ($\pm$ SEM) vascular width in Norplant users (120 ± 11.6 μm) was significantly greater than that seen in the comparison group (74 ± 7.2 μm; F ratio $= 6.68$, $P = 0.01$). A wide variation in vessel width was observed in the Norplant population (range 18 to 777 μm, SD 111 μm, SEM 11.59 μm), fitting with the observation at hysteroscopy that a population of Norplant users had dilated vessels on the endometrial surface (Hickey *et al.*, 1996).

At hysteroscopy, superficial endometrial vessels were estimated to be 'dilated' or 'non-dilated'. Measurements were made of 48 dilated vessels and 72 non-dilated vessels, the results confirming that superficial vessels could be broadly grouped into these two categories according to diameter. Measurement of these vessels showed that the average width of a 'dilated' vessel in the Norplant group (140.6 ± 13.8 μm) was greater than that of a 'dilated' vessel in the comparison group (93 ± 3.5 μm; $P = 0.03$). There was no difference between the two groups in the sizes of 'non-dilated' vessels (Norplant 70.4 ± 5.1 μm; menorrhagia 60.0 ± 7.5 μm; F ratio $= 1.40$, $P = 0.24$).

Although measurements were made at different phases of the menstrual cycle in the comparison group, the sample size was too small to determine differences in vascular width or length through the menstrual cycle.

Superficial vascular length

The mean visible length of vessels in Norplant users was 922 ± 81.2 μm, while that in the comparison population was

Table II. Variation in the apparent size of image viewed through the hysteroscope after correction for distortion and magnification

Area of image	Uncorrected image (CV, %)	Corrected image 10° misalignment (CV, %)	Corrected image 90° misalignment (CV, %)
Central 20%	12.1	3.0	6.9
Central 50%	20.6	3.6	10.3
Central 70%	28.2	4.8	18.1

CV = coefficient of variation.

1055 ± 112.3 μm (F ratio = 4.88, P = 0.028). In the menorrhagia group, superficial vessel length was slightly increased in the secretory phase of the menstrual cycle (proliferative phase length 977 ± 216 μm; secretory phase length 1175 ± 107 μm; F ratio = 0.813, P = 0.37).

Bleeding vessels

Although 24 hysteroscopies in Norplant users were performed during a bleeding episode, measurements could only be made of actively bleeding vessels at 11 hysteroscopies. In the remaining subjects, photographs of adequate quality for measuring bleeding vessels could not be obtained. In the comparison group, six subjects began bleeding during the hysteroscopy and, again, adequate measurements could not be made. The mean width of the bleeding vessels in Norplant users was 398 ± 222 μm and the mean exposed area of the vessel was 1.6 ± 0.88 mm^2. These vessels showed a bimodal distribution in size, corresponding to the observation at hysteroscopy that bleeding in Norplant users arose from both large and small vessels on the endometrial surface (Hickey *et al.*, 1996). In those subjects who presented for hysteroscopy during a bleeding episode, the measured width of bleeding vessels tended to be wider (509 ± 346 μm) than in those whose bleeding was seen to start during hysteroscopy (214 ± 109 μm), though this difference was not statistically significant.

Subepithelial haemorrhages

Petechiae and ecchymoses were commonly observed in Norplant users. These purpura are discolorations of the epithelium due to subepithelial haemorrhage, and may arise from disturbances in clotting mechanisms or vascular integrity (Rook *et al.*, 1986). In Norplant users, these purpura appear to indicate capillary fragility (Hickey *et al.*, 1996). Endometrial petechiae were measured in 32 of 66 (48%) Norplant hysteroscopies, and in three of 20 (15%) among the comparison population (χ^2 = 37.9, P <0.0001). The average width of a petechia was 341 ± 32.2 μm and the average length 366 ± 32.4 μm. The average area covered by each collection of petechiae was 3.8 ± 0.75 mm^2. The size of individual petechiae, or collections of petechiae did not differ between treatment and comparison groups.

Endometrial ecchymoses (coalescent areas of petechiae or larger areas of subepithelial bleeding) were measured in 38 of 66 (57%) hysteroscopies in Norplant users and in four of 20 (20%) among the comparison population (χ^2 = 42.4, P = 0.0001). The average horizontal diameter of an ecchymosis was 1638 ± 160 μm, and the average vertical diameter

was 1810 ± 221 μm. The average area of an ecchymosis was 3.9 ± 0.64 mm^2. There was no difference in the mean size of ecchymoses between treatment and comparison groups, though these purpura were measured in only four of the comparison group.

Following collapse and redistension of the uterine cavity, the average width (horizontal diameter) and length (vertical diameter) of endometrial ecchymoses was increased (F ratio = 4.96, P = 0.03 and F ratio = 6.18, P = 0.01, respectively).

Endometrial polyps

Endometrial polyps were observed in five Norplant users at hysteroscopy. No polyps were seen in the comparison group, as subjects were excluded if there was any gross or histological abnormality of the endometrium. The polyps were small, with an average width of 941 ± 236 μm and an average length of 1605 ± 422 μm. The average area of the polyp was 1.6 ± 0.66 mm^2.

Discussion

To our knowledge, this is the first study to describe a method for making accurate intrauterine measurements at hysteroscopy. The results from this study indicate that the estimation of object size through the hysteroscope is likely to be inaccurate by as much as one-third in normal clinical practice. It is possible that many surgeons are not aware that their estimates of size at hysteroscopy bear little resemblance to the actual size of objects viewed and size may easily be over- or underestimated. Using the techniques described above, precise in-vivo measurements of small structures can be made on a research basis. Endometrial vessels and small polyps were chosen to illustrate the precision of this technique.

There are a number of clinical situations where intrauterine measurements would be valuable at hysteroscopy: for example, in the assessment of submucous fibroids for hysteroscopic resection, and their response to medical shrinkage; to measure endometrial polyps and relate their size to symptoms; to measure uterine septa and small tumours; to measure areas of endometrial regrowth following ablation techniques and to relate these to symptoms; and to measure normal anatomical structures such as Fallopian tube ostium diameter.

An increase in endometrial vascular density (Rogers *et al.*, 1993) and an apparent dilatation of the superficial vessels (Maqueo,1980; Ludwig, 1982; Hourihan *et al.*, 1991) have been observed in biopsy specimens from some women exposed to steroid contraceptives, and the authors speculated that these

vessels might be the source of breakthrough bleeding (BTB). Several factors interfere with the accurate assessment of endometrial vascular diameter in biopsy specimens. Biopsy causes substantial disruption of tissue architecture and collapse of some vessels, while varying conditions when obtaining tissue, such as general or local anaesthesia, may substantially alter endometrial blood flow and hence change vascular diameter (Markee, 1940).

Using this measurement technique we were able to confirm the presence of superficial dilated vessels in Norplant users, with a mean diameter exceeding that of a comparison population. We were unable to confirm whether these vessels are always the source of BTB. The comparison group used in this study were women complaining of menorrhagia, and in 12 of 20 cases this was confirmed with a measured menstrual blood loss (Hallberg and Nilson, 1964) of >60 ml. It is certainly possible that the endometrial vasculature in this population is not representative of that in the normal population. Local vasoactive substances affecting vascular tone are known to be altered in dysfunctional bleeding (Smith *et al.*, 1982; Marsh *et al.*, 1995). Similarly, measurements were made in both proliferative and secretory phases of the menstrual cycle in these subjects. Endometrial vascular morphology is known to vary during the normal menstrual cycle (Markee, 1940). Hysteroscopy of the treatment group during the pretreatment cycle would have provided a larger and more legitimate control population. However, ethical difficulties arise with hysteroscopy of a normal population for research.

The mechanism of vascular dilatation is unknown. Changes in endometrial blood flow, in vascular resistance and in structural integrity could all lead to dilatation. Hysteroscopy of Norplant users under local anaesthesia before insertion of the implants may have provided more accurate control data, but three hysteroscopies in a volunteer study were not considered to be ethically acceptable during the planning of this study.

Subepithelial haemorrhages were commonly observed in the Norplant users, but not in the comparison group. These purpura may indicate increased capillary fragility. Mechanical stress testing of endometrial vessels in Norplant users has confirmed that these vessels appear to be fragile with profuse bleeding following mild mechanical stress (Hickey *et al.*, 1996). The mean size of petechial aggregations and ecchymoses was similar to the surface area recorded by Bartelmez (1937) as that served by a single spiral arteriole. Spiral arteriole development is known to be deficient following prolonged progestogen exposure (Hourihan *et al.*, 1991).

An increase in the size of ecchymoses observed on redistension of the cavity suggests that these purpura occur in response to mechanical trauma in the endometrium. When the epithelium is breached by a subepithelial haemorrhage, frank bleeding will be observed. The strength of the epithelium may dictate whether BTB is seen by the patient. Further understanding of factors maintaining endothelial and epithelial integrity might indicate potential methods for the control of BTB in users of progestogen-only contraception.

The small endometrial polyps observed in Norplant users were of an unusual appearance. They appeared to have a single fine vessel in the pedicle, and were transparent. Bleeding was not observed from or near these polyps, and the surrounding endometrium was significantly 'regressed'. Directed biopsies of polyps may provide further information.

The technique of intrauterine measurement used in this study has a number of limitations. Biopsy forceps are not the ideal calibration standard, they cannot be held in the same plane as the vessels, and their edges are not clearly defined. These forceps were chosen because they fitted down the hysteroscope, had several surface features which could be accurately measured, were sterilizable, and could be used for tissue collection. However, while this method was designed for the precise measurement of small endometrial blood vessels, such precision may not be required with larger structures, for example fibroids and polyps. The biopsy forceps could be used as a standard by any practitioner, but will produce an image distortion of up to 27% if the image is not subsequently corrected. Difficulties occurred with vessel measurement in approximately 30% of hysteroscopies, mainly due to bleeding. This may suggest that the vessels measured are not representative of all superficial endometrial blood vessels in these subjects, and may also undermine the value of this method in clinical practice

Hysteroscopy may also alter the appearance of the superficial vessels. The pressure, temperature and constituents of the distending fluid, and the use of local anaesthesia may affect the diameter and perfusion of the vessels (Keatinge and Harman, 1980). Observation and measurement of superficial endometrial vessels in Norplant users has indicated that these vessels show marked size and shape differences from those seen in a comparison group with spontaneous menorrhagia. These vascular features may contribute to BTB.

The ability to make accurate intrauterine measurements *in vivo* will improve the quality of diagnostic information obtained at hysteroscopy, and may provide new information about physiological and pathological structures within the uterine cavity and superficial endometrium.

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