

# Estimation of uterine volume: a comparison between Viewpoint and 3D ultrasound estimation in women undergoing laparoscopic hysterectomy

## Abstract

**Objectives:** To assess the three-dimensional (3D) tool, Virtual Organ Computed-aided Analysis™ (VOCAL) in the calculation of pre-operative uterine volume and to correlate the measurements with those obtained with Viewpoint, using uterine dry weight (UDW) as the gold standard.

**Methods:** Prospective observational study of women consented for a laparoscopic hysterectomy (LH) at Nepean Hospital between October 2008 and November 2011. All women underwent detailed transvaginal scan (TVS) at the pre-operative assessment. Two-dimensional (D) images of the uterus were obtained both in the mid-sagittal and transverse planes. 3D volumetric acquisitions were also obtained for each uterus in the mid-sagittal plane. 2D measurements of the uterus in millimetres (Anterior-Posterior, longitudinal and transverse) were recorded in Viewpoint software package (GE Healthcare ViewPoint, Germany); which then generated an estimated uterine volume (ml) using the ellipsoid formula. The 3D uterine volumetric datasets were reviewed using SonoView Pro and uterine volumes were estimated with off-line processing using VOCAL™. The gold standard for comparison was UDW in grams (g), measured by the histopathologist at the time of analysis of the LH specimens. The relationship between the estimated uterine volumes and actual UDW was evaluated using correlation analysis. P-values were calculated to ascertain the significance of these findings; P values < 0.05 represented statistical significance.

**Results:** 76 women underwent LH during the study period. Complete data were available in 96% (74/76) of cases. The mean age of the women was 43.7 years and 92% were multiparous. The mean Viewpoint uterine volume was 283 ml, the mean VOCAL™ uterine volume was 249 ml and the mean UDW was 295 g. There was a significant correlation between UDW and estimated uterine volumes both for Viewpoint ( $R = 0.83$ ,  $P < 0.001$ ) and VOCAL™ ( $R = 0.97$ ,  $P < 0.001$ ), respectively. Viewpoint systematically overestimated weight by 43.1 g, whereas VOCAL™ underestimated by an average of 42.4 g, and this difference was statistically significant ( $P < 0.001$ ). In terms of absolute values, the mean prediction error for VOCAL™ was -18.0 g and for Viewpoint it was 27.6 g ( $P < 0.0001$ ).

**Conclusion:** VOCAL™ was found to be significantly more accurate than Viewpoint in the estimation of uterine volumes, and it was better correlated with UDW.

**Keywords:** uterine volume, uterine weight, VOCAL™, Viewpoint.

## Introduction

Hysterectomy is the most commonly performed gynaecological surgical procedure.<sup>1</sup> Of the various surgical approaches used to remove the uterus, the majority are still approached abdominally (64%); while vaginal (22%) and laparoscopic (14%) hysterectomies continue to gain popularity.<sup>2</sup> However, the prevalence of hysterectomy appears to be decreasing, possibly due to the advent of less invasive therapies for management of conditions previously treated with hysterectomy.<sup>3</sup>

The choice of surgical approach depends upon

the indications for the procedure, concomitant procedures, surgical outcomes of each approach, surgeon experience, and patient preference. In general, a surgeon should choose the procedure which maximizes patient safety and best achieves the goal of the operation. Recent developments in gynaecologic surgery have expanded the advanced endoscopic options for hysterectomy. Less invasive procedures such as laparoscopic hysterectomy (LH), when possible, are typically preferable to the abdominal approach.<sup>4</sup>

Until recently, ultrasonographic volumes were calculated by applying formulae created for

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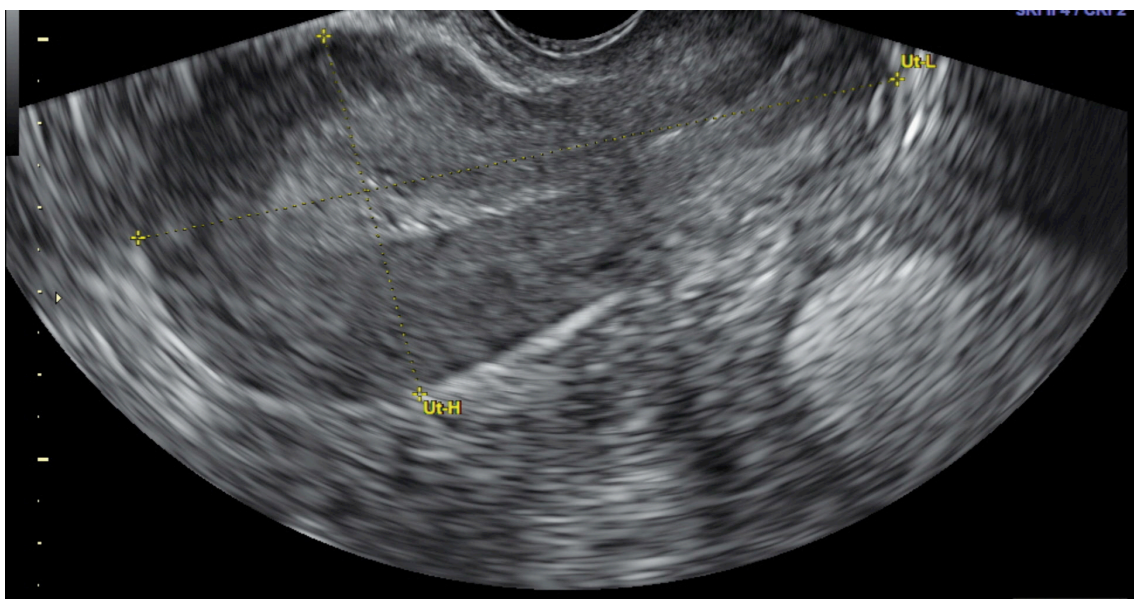
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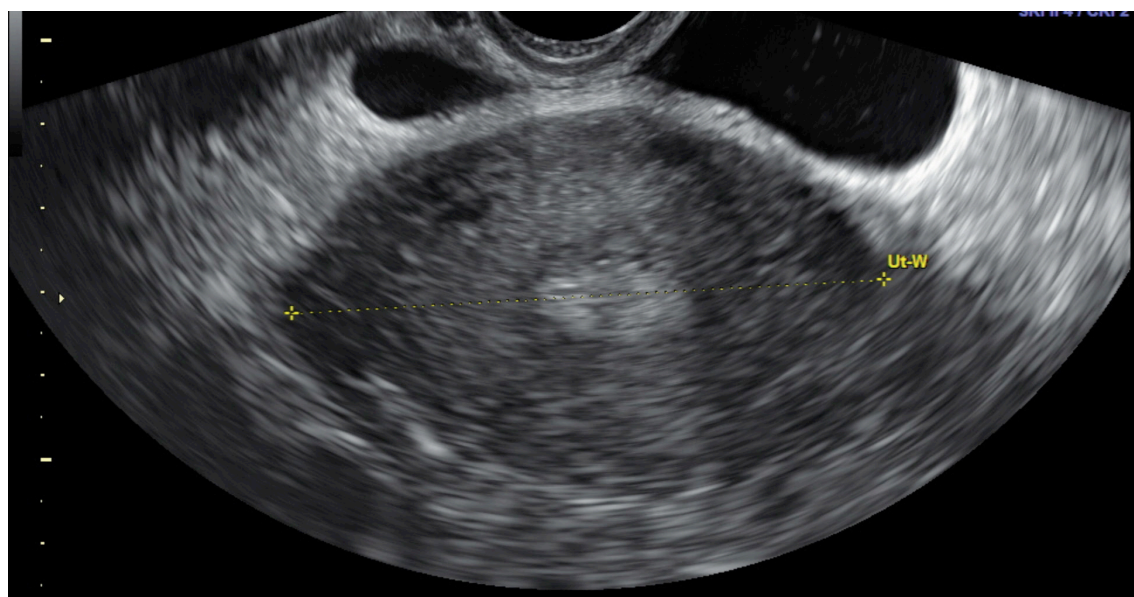
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**Table 1:** Comparison of VOCAL Vs. Viewpoint in terms of correlation, accuracy and mean prediction errors.

Method	Mean estimated volume(ml)	Correlation with UDW	Mean error (SD) in grams	Mean % error (SD)
VOCAL	249	R = 0.97, P < 0.001	-42.4 (72)	-18.0 (23.2)
ViewPoint	283	R = 0.83 P < 0.001	43.1 (160)	27.6 (58.4)
			P < 0.001	P < 0.0001



**Figure 1:** 2D midsagittal image of uterus by transvaginal ultrasonography.

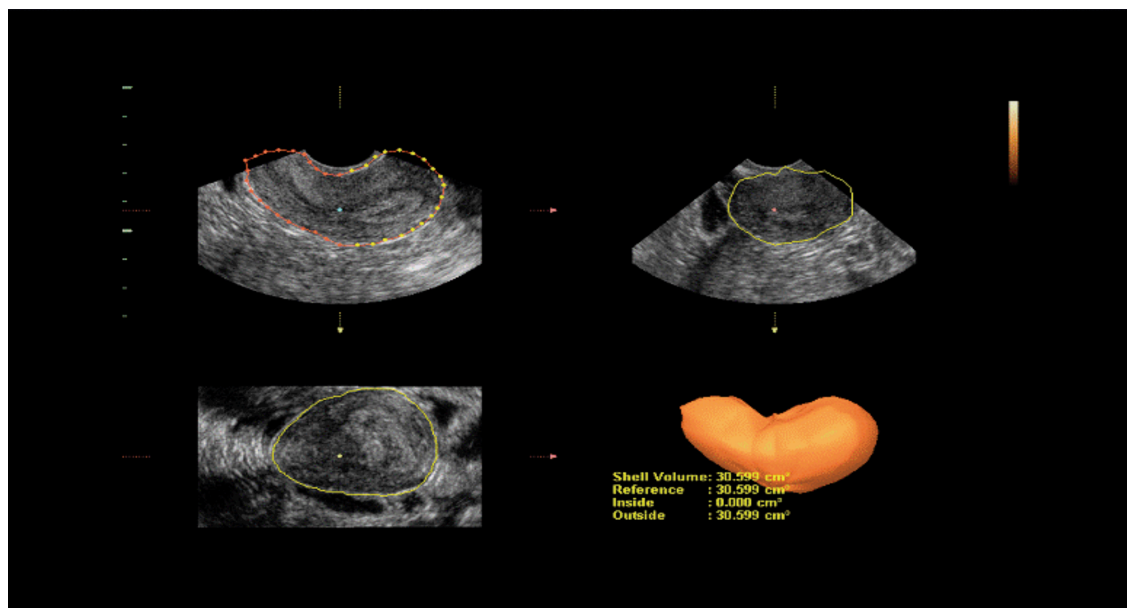


**Figure 2:** 2D transverse image of uterus by transvaginal ultrasonography.

regular geometric shapes (such as an ellipse or a trapezoid) using measurements obtained by 2-dimensional (D) ultrasonography. These formulae involve multiplication of the main diameters of the object (length, depth, and width) by a constant.<sup>5,6</sup> These formulae are incorporated into sonology software programs such as Viewpoint which are commonly used in clinical practice to automatically calculate the uterine volume. More recently, 3-D ultrasonography has proven to be more accurate in the evaluation of objects with irregularities, as well as providing

more reliable volume estimates than 2D ultrasonography.<sup>7,8</sup> Reproducibility of Virtual Organ Computed-aided AnaLysis™ (VOCAL™) as an accurate modality to determine volume has also been extensively researched.<sup>9,10</sup>

To date, there are no studies which have compared the accuracy of these commonly used modalities to obtain uterine volume prior to hysterectomy. The aim of this study is to determine whether VOCAL™ is more accurate in the calculation of pre-operative uterine volume than traditional ellipsoid



**Figure 3:** Uterine volume estimation with off-line processing using Virtual Organ Computed-aided AnaLysis™ (VOCAL).

formulae uterine volume estimation obtained with Viewpoint in women undergoing LH, using uterine dry weight (UDW) as the gold standard.

## Methods

Prospective observational study of women consented for a LH at Nepean Hospital between October 2008 and November 2011. Ethics approval was obtained from the local Human Research Ethics Committee prior to commencement of the study (Ref: 08/044). All women underwent standardised history and detailed transvaginal scan (TVS) using a 4-9 MHz transducer and the Accuvix V20 Prestige (Samsung Medison, Seoul, South Korea) or a Medison X8 (Samsung Medison, Seoul, South Korea) ultrasound machine. During this visit, the attending physician collected baseline clinical data including age, socio-demographics, symptoms, and previous obstetric and gynaecological history. At the pre-operative assessment, 2D images of the uterus were obtained both in the mid-sagittal and transverse planes (Figures 1, 2). 3D volumetric acquisitions were also obtained for each uterus in the mid-sagittal plane. 2D measurements of the uterus in millimetres (Anterior-Posterior, longitudinal and transverse) were recorded in ViewPoint (GE Healthcare Viewpoint, Germany); which then generated an estimated uterine volume (ml) using the ellipsoid formula:

$$\text{Uterine volume} = \text{AP diameter} \times \text{sagittal diameter} \times \text{transverse diameter} \times 0.0005236$$

(please note that the number 0.0005236 corresponds to  $\pi/6$ )

The 3D uterine volumetric datasets were reviewed using SonoView Pro and uterine volumes were estimated with off-line processing using VOCAL™. The 3D uterine volumetric datasets were reopened using SonoView Pro software and the outline of the uterus was traced manually using VOCAL™ with six steps of rotation 30 degrees apart. After manually outlining the uterus, the VOCAL™ program automatically displayed the 3D reconstructed uterus with its volume (Figure 3). All the off-line analysis of 3D volumes was carried out by same operator (GC) with experience in this technique.

The gold standard for comparison was UDW in grams (g),

measured by the histopathologist at the time of analysis of the hysterectomy specimens.

## Statistical analysis

The relationship between the estimated uterine volumes and actual UDW was evaluated using the coefficient of correlation (R). If  $R = -1.0$  to  $-0.5$  or  $1.0$  to  $0.5$ , there was strong correlation; if  $R = -0.5$  to  $-0.3$  or  $0.3$  to  $0.5$ , there was moderate correlation; if  $R = -0.3$  to  $-0.1$  or  $0.1$  to  $0.3$ , there was weak correlation; and if  $R = -0.1$  to  $0.1$ , there was no or very weak correlation. Differences between groups were assessed using the paired sample t-test. P values  $< 0.05$  represented statistical significance.

## Results

During the study period, a total of 76 women were consented for LH and completed their surgery laparoscopically. Complete data were available in 96% (74/76) of cases. The mean age of the women was 43.7 years and 92% of women were multiparous.

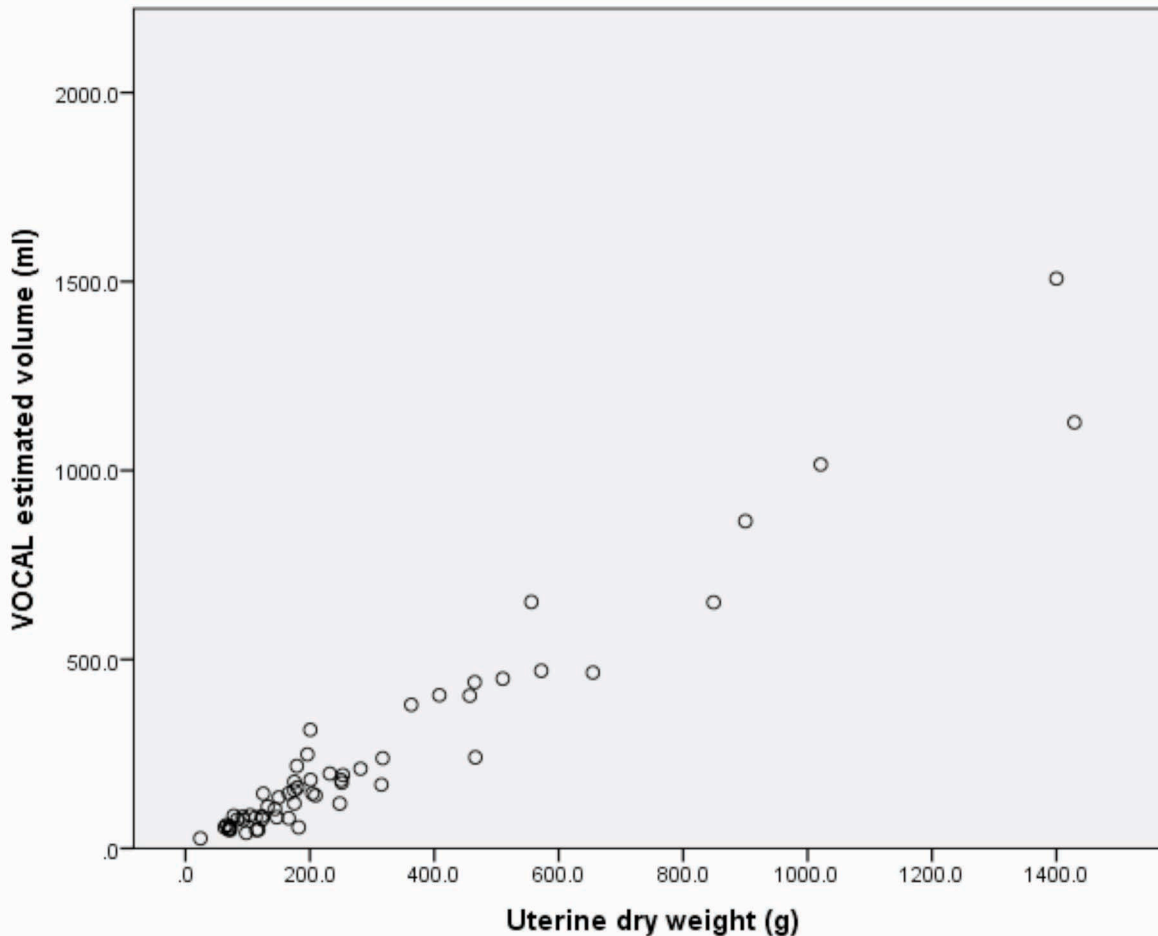
The mean Viewpoint uterine volume was 283 ml, the mean VOCAL™ uterine volume was 249 ml and the mean UDW was 295 g. There was a significant correlation between UDW and estimated uterine volumes both for Viewpoint ( $R = 0.83$ ,  $P < 0.001$ ) and VOCAL™ ( $R = 0.97$ ,  $P < 0.001$ ), respectively.

ViewPoint systematically overestimated weight by 43.1 g, whereas VOCAL™ underestimated by an average of 42.4 g, and this difference was statistically significant ( $P < 0.001$ ). In terms of absolute values, the mean prediction error for VOCAL™ was -18 g and for Viewpoint it was 27.6 g ( $P < 0.0001$ ) (Table 1).

Comparison between VOCAL™ estimated volume and UDW is shown in Figure 4 while comparison between Viewpoint estimated volume and UDW is shown in Figure 5. The relationship between VOCAL™ estimated volume and UDW appears to linear.

## Discussion

The objective of this study was to compare the 3D tool VOCAL™ in the calculation of pre-operative uterine volume and correlate the measurements with those obtained with Viewpoint; using



**Figure 4:** Comparison of VOCAL estimated volume Vs uterine dry weight.

UDW as the gold standard. In this study, we have demonstrated that there was a significant correlation between both Viewpoint and VOCAL<sup>TM</sup> volumes and UDW. However, we also observed that where Viewpoint systematically overestimated by 43.1 g, VOCAL<sup>TM</sup> underestimated by 42.4 g and this difference was statistically significant. According to our results, VOCAL<sup>TM</sup> was significantly more accurate than Viewpoint in the estimation of uterine volumes; and it was better correlated with UDW (Table 1).

Attempting to calculate pre-operative uterine volume and correlating it to UDW is not a novel study. Kung, *et al.* assessed the correlation between the estimated volume based on ultrasonic measurement in vivo and the actual weight of the diseased uterus after hysterectomy, and then retrospectively tried to establish a simple equation to convert the volume into the weight in grams. They utilised linear regression analysis to develop an equation which incorporated the volume of the uterus taken in three planes by 2D ultrasonography. With a close positive correlation between estimated uterine volume and actual weight, they concluded that using their equation, the uterine size could be expressed as an objective value in weight, rather than comparing it to a gravid uterus as is traditionally done. While no clinician would discredit the importance of clinical assessment by bimanual examination, ultrasound appears to be a relevant adjunct in assessing uterine volume and size.<sup>11,12</sup>

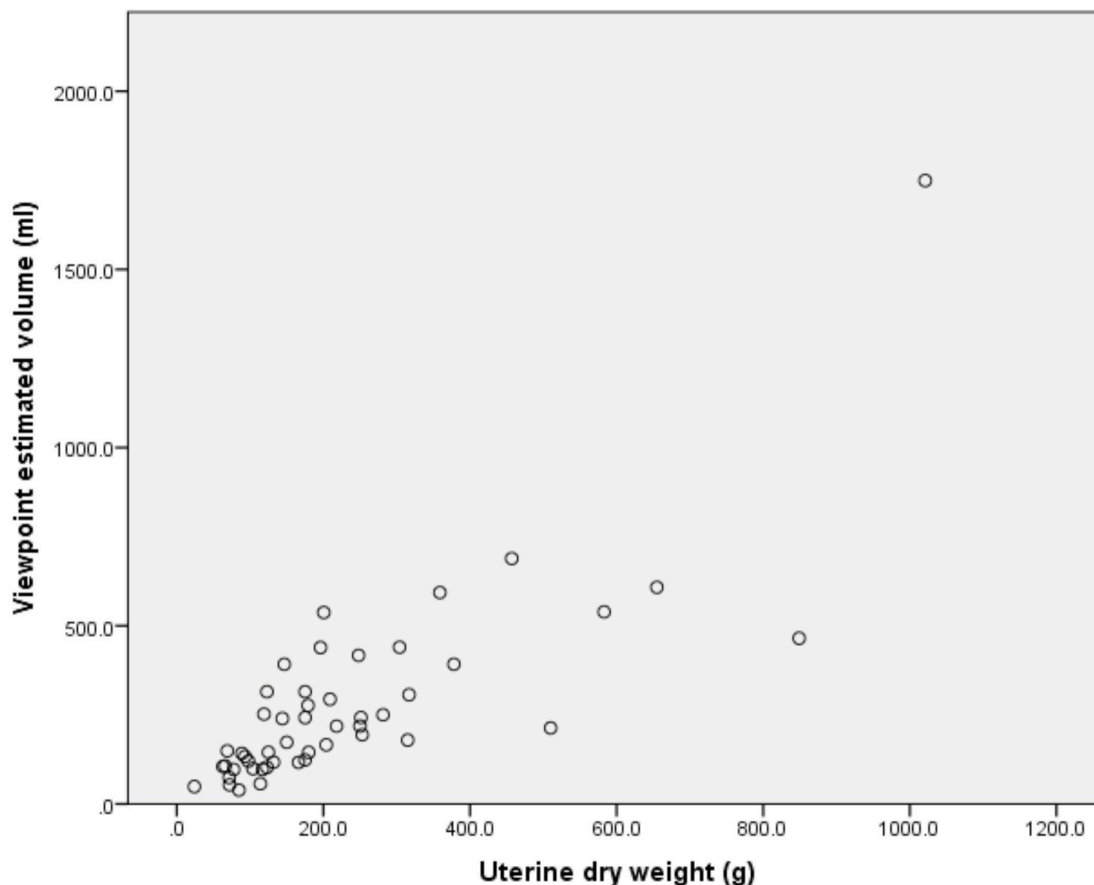
Volume of the uterus can be measured more accurately by TVS, utilising 3D rather than 2D ultrasound technology.<sup>13</sup> The clinical applicability of 3D ultrasound to assess fetal organs is well demonstrated.<sup>14-19</sup> The validity and reliability of different

3D modalities (VOCAL<sup>TM</sup>-multiplanar and rotational methods, IX VOCAL<sup>TM</sup>) for assessment of volumes has been well demonstrated. Regardless of the object examined, the various 3D ultrasound modalities to estimate volume appear to have good intraobserver and interobserver reproducibility.<sup>20-23</sup>

Our study was not intended to be another demonstration of the latest ultrasound modality to calculate volume. Instead, we have attempted to use relatively basic and commonly used ultrasound techniques in the calculation of pre-operative uterine volumes. The rationale for this is to increase the applicability and relevance of our findings in the general gynaecology setting.

The importance of being able to estimate uterine volume prior to a hysterectomy has significant benefits. The relationship of uterine size to risk of complications; the relationship of size to choice of surgical route (also related to complications) are well established.<sup>23</sup> Traditionally, bimanual examination has been used to assess uterine size. This is a relatively subjective method by which the size of the uterus is expressed as “weeks size” compared with a pregnant uterus. Therefore, a more objective method to determine uterine size is by ultrasound.

We believe that the estimation of uterine volume has the potential to be clinically applied in the context of women undergoing a hysterectomy. The rising popularity of LHs has increased the need for uterine morcellation. The larger the uterus, the more likely it is that morcellation will be required at the time of hysterectomy. Whether morcellation is performed either vaginally or laparoscopically with electromechanical or manual morcellators, it may impact significantly on the



**Figure 5:** Comparison of Viewpoint estimated volume Vs uterine dry weight.

operating time and is not without complications. Morcellation also adds significantly to the operating time of the case. Earlier knowledge of the need of morcellation at the time of LH would not only be relevant for the pre-operative counselling of women, but also potentially enable the surgical team to plan their operating list according to the preoperative likelihood of morcellation, thus avoiding hasty arrangements in the operating department during surgery. Pre-operative knowledge of the need of morcellation may also help establish which women with gynaecologic oncological conditions (such as endometrial cancer) would not be eligible for laparoscopic approach, as morcellation is contraindicated in these women for the risk of peritoneal seeding.

### Conclusion

We have successfully demonstrated that VOCAL™ was significantly more accurate than Viewpoint in the estimation of uterine volumes, and it was better correlated with histological UDW. The clinical relevance of this study lies in our ability to use commonly available ultrasound modalities to accurately estimate uterine volume preoperatively. In the future, it may be possible to use this volume to calculate uterine weight and therefore be able to predict the need for morcellation with a good degree of accuracy.

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