Peer reviewed article
MRI versus 3-dimensional ultrasound: a comparative study of levator hialtal dimensions in women with pelvic organ prolapse

Abstract
Magnetic resonance imaging (MRI) has been used to identify both normal and abnormal female pelvic anatomy, permitting resolution and tissue definition not previously possible and faster acquisition times adding to our understanding of dynamic pelvic anatomy. These systems are, however, expensive and limited to tertiary centres. The alternative, three-dimensional ultrasound (3D USS), has undergone major advances in development, so that, today, dynamic axial plane imaging has become feasible.

This study aimed to compare the two imaging modalities in the assessment of the levator hiatus. Eleven women undergoing prolapse surgery were assessed using MRI and 3D USS. Data volumes were acquired at rest and on maximum Valsalva, and were stored and reviewed independently at a later date to measure the dimensions of the levator hiatus. Similar measurements were undertaken in the equivalent axial slice on MRI using fast acquisition T2 weighted scanning. Independent, clinical pelvic examination was performed using the ICS POP-Q system. The mean age of participants was 58 years, median parity was 3, with 46% (5) having had a hysterectomy. A total of 82% (9) had a sensation of a lump, 55% (6) had constipation. Clinical grading on POP-Q was 2 (median). All had rectoceles at surgery, with 46% (5) having coexistent cystoceles, 18% (2) level 1 prolapse, and 82% (9) having enteroceles. The ino-class correlations were relatively poor – 0.22 for levator area at rest and 0.47 on Valsalva. Possible explanations for the poor correlations observed were the use of different points of reference and the difficulties of obtaining equivalent Valsalva manoeuvres. In particular, it was virtually impossible to consistently image the plane of minimal dimensions on Valsalva by single-slice MR imaging. Further larger studies comparing the two imaging modalities are required before final conclusions can be drawn.

Introduction
The true prevalence of level 1 uterine or vault prolapse rectoceles in the female population is not known. However, epidemiological evidence for pelvic organ prolapse (POP) in studies from the USA suggest that one in nine women will have an operation for POP up to the age of 80 years, with 29% requiring re-operation 1. This would suggest that current treatment of POP is inadequate or that assessment of this condition is unsatisfactory. Clinical assessment can be objectively measured using the POP-Q ICS 2. However, this does not address paravaginal structural changes, cannot assess deeper support structures and, in clinical practice, is often not used, even by gynaecologists with an interest in urogynaecology 3.

Three-dimensional ultrasound (3D USS) has been developing slowly since its inception in the 1980s. However, in the last 4-5 years, improvements in software and automated acquisition devices have enabled its use for pelvic imaging with accurate tissue definition. Two-dimensional transperineal ultrasound can be used for pelvic organ assessment and correlates well with the POP-Q ICS for all three compartments 4. 3D USS permits visualisation of the axial plane and, therefore, potentially combines the advantage of dynamic, low cost ultrasound imaging with the ability to visualise the deeper levator muscle group.

This pilot study was undertaken to compare the assessment of the levator hiatus. Annotation of comparative 3D USS and magnetic resonance imaging (MR) images is shown in Figure 1.
Materials and methods

Eleven women about to undergo surgery for anterior rectocele repair were assessed using transperineal 3D USS and MRI. For the ultrasound assessment, the women were required to have an empty bladder and to lie down in the supine position. A GE Voluson 730 ultrasound system using a Kretz 7-4 MHz volume probe was placed on the perineum in the midsagittal plane. Using ultrasonic jelly at the interface, volume data were acquired at rest and on maximum Valsalva. The participants had practised the manoeuvre at least three times under close supervision.

Volume data were stored and reviewed at a later date. The diameters and areas of the levator hiatus at rest and on Valsalva were measured as shown in Figure 2. The plane chosen was symmetrical, containing the shortest distance between symphysis pubis anteriorly and levator muscle posteriorly. Validation of the measurement technique had previously been undertaken and reported.

Similar measurements were undertaken in the equivalent axial slice on the MRI scan. Fast acquisition T2 weighted scans using a Siemens Symphony Magnetron 1.5T MRI system were taken at rest and after Valsalva after using an asymptomatic nulliparous volunteer to test the settings:

- Pre-Valsalva, T2 truefisp sagittal images for 2 mins 46 secs, and 1 min 50 secs in the axial plane.
- During Valsalva, T2 truefisp sagittal images lasting 14 secs and 8 secs in the axial plane.

Ten slices were taken at 4mm for 0.4mm gaps, -1AV K=46°. Examples of images from both modalities, showing the measurements undertaken, are given in Figure 2.

Information was collected on age, parity and previous surgery. Independent clinical pelvic examination was performed to assess POP-Q measurements and identification of co-existent prolapse. Patients gave informed consent and ethics committee approval was obtained (TTH 57/03). There was no conflict of interest.

Statistical analysis was carried out using Pearson’s intraclass correlation. SPSS Chicago II version 11.0 was used to estimate intraclass correlation.

Results

The mean age was 58 years, parity 3, with 46% (5) having had a hysterectomy. A total of 82% (9) had a sensation of a lump, 55% (6) had constipation. Clinical grading on POP-Q was 2 (median). All had rectoceles at surgery, with 46% (5) having coexistent cystoceles, 18% (2) uterus or vault prolapse, and 82% (9) having enteroceles. Descriptive statistical analysis is tabulated in Tables 1-2.

Pearson’s correlation coefficient were as follows:

- Levator area at rest (USS vs MRI) = 0.648 (p=0.031)
- Levator area on Valsalva (USS vs MRI) = 0.220 (p=0.515).

Correlation between levator hiatus measurements on 3D USS and MRI was poor for all parameters between observers, precluding formal analysis for agreement. Intra-class correlations were poor; 0.485 for the levator area at rest and 0.13 on Valsalva (Figures 3 & 4).

Discussions

MRI imaging has been the gold standard for clinical anatomical definition in the female pelvis. In particular, MRI imaging has been used to identify changes to the levator muscles following childbirth and in those women complaining of POP and urinary incontinence. Comparative studies with cadaveric dissection and surgical findings would suggest that correlation with MRI is good. In addition, morphometric measurements and qualitative assessment of the levator group of muscles can be studied. However, dynamic imaging requires fast image acquisition times to identify changes on Valsalva. Imaging in the upright or sitting position, can aid identification of pelvic structures but adds to the cost.

Figure 2. Dimensions of levator hiatus on Valsalva for MRI on left and 3D USS on right.

AP – Antero–posterior
TD – Transverse diameter
A – Area.

Figure 1. Comparison of anatomical landmarks on MRI and 3D USS axial images of the levator hiatus.
3D USS has seen significant advances in the last 5 years in resolution and image acquisition. The infero-levator anatomy is ideally suited to this modality due to the close proximity of tissues and pelvic organs. This has been demonstrated for assessing predictors of stress incontinence 14, the function of prosthetic implants 16 as well as the identification of lower urogenital tract abnormalities 17. Ultrasound imaging of the axial plane permits examination of the levator muscles and, more precisely, the pubococcygeus and puborectalis muscles.

Why is this important? Debate continues as to what provides support for the female pelvis. It has been suggested that there are three levels of support of the vagina utilising different structures, including condensations of endopelvic fascia 18. However, this may provide only a secondary support mechanism, with primary support being provided by the levator muscle group and, more specifically, the pubococcygeus and puborectalis complex, as evidenced by disruption on MRI imaging following childbirth 9. Attempts to quantify muscle disruption with morphometric analysis and 3D modelling using MRI have suggested, but not proven, an association with urinary stress incontinence (USI) and POP 9, 19. On 3D/4D ultrasound imaging, levator hiatal dimensions are clearly associated with prolapse 20, and childbirth-related trauma may be clearly associated with post partum de novo or exacerbate stress incontinence 11. Variations in levator hiatal size may provide indirect evidence for disruption of muscles, decreased muscle density, or altered biomechanical properties of this support structure 7, 22.

If this is the case, then imaging can help the study of aetiology of disease states particularly with strain exerted on the pelvic organs and their support structures. This is a dynamic process and needs a dynamic means of evaluation. MRI is unable to adapt its acquisition angle to compensate for alteration in the levator plate, which is easily accomplished using 3D/4D ultrasound. This difference between the two methods may explain the poor correlations documented in this study. 3D USS offers a dynamic imaging modality. This study demonstrates poor intra-class correlations between the two modalities.

**Conclusion**

This is the first study to compare 3D USS and MRI with specific reference to levator hiatal assessment. There were poor correlations found between the two modalities in this pilot study and further studies are needed to provide adequate data before final conclusions can be drawn. If 3D USS is comparable to MRI, then this may provide a more cost effective and more dynamic method of assessment, not only in women with POP, but also following childbirth and in women without evidence of pelvic floor dysfunction.

**References**


**Table 1. Descriptive statistics for 3D USS and MRI measurements of levator hiatus.**

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<th>Minimum</th>
<th>Maximum</th>
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**Table 2. Descriptive statistics for minimum and maximum area on USS and MRI.**

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