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EVIDENCE FOR THE NON EUCLIDEAN NATURE OF THE PLANE OF MINIMAL DIMENSIONS

Hypothesis / aims of study

3D transperineal ultrasound (US) imaging is an important modality used to quantify pelvic floor muscle function [1]. Biometric indices of function include hiatal areas and diameters during voluntary pelvic floor muscle movement, measured using a defined axial plane known as the 'plane of minimal dimensions'. This allows repeatable measurement of hiatal area and diameters at rest and during movement. This plane is defined from a sagittal image and is bounded by the inferior aspect of the symphysis pubis anteriorly, the ano-rectal angle posteriorly and the inner aspects of puborectalis /pubococcygeus (PR/PC) laterally. During a valsalva manouevre the posterior limit of the levator hiatus moves dorsocaudally, the anterior boundary remaining fixed. Thus relative to the anterior-posterior borders of the hiatus, the lateral boundaries, formed by the lower margins of PR/PC may move more caudally due to the anatomical configuration of the hiatus. Thus the aim of this study was to clarify whether what has been termed the 'plane of minimal dimensions' of the levator hiatus measured using a 3dimensional (3D) ultrasound axial image, accurately represents the minimal anatomical transverse hiatal dimension during a valsalva manoeuvre.

Study design, materials and methods

In this study a coronal MR scan, passing through the plane of the vagina, was used to detect if there was differential caudal movement of PR/PC. 3D US and MR images, from a previous study were used to assess the 'plane of minimal dimensions' during a valsalva manoeuvre[2]. Participants had given consent for their data to be used for future research at the time of the initial study. 3D US was performed using a GE Kretz Voluson 730/730 Expert with a 7-4MHz transducer. MR images were obtained using a Siemens MAGNETOM Avanto 1.5T scanner. Nineteen 3D US and MR images were used to measure the transverse diameter of the 'plane of minimal dimensions' of the hiatus on maximum valsalva manoeuvre. Coronal MR images through the plane of the vagina on maximum valsalva were also obtained. The term apparent minimal transverse diameter(aMTD) was used to define the transverse diameter measured using axial US and MR images. The transverse diameter measured between the caudal margins of PR/PC on the MR coronal image is denoted the true minimal transverse diameter (tMTD). Figure 1 shows the MR coronal image and corresponding axial image, used to measure the tMTD on valsalva and the classical axial 'plane of minimal dimensions' from which the US and MR aMTD were recorded.

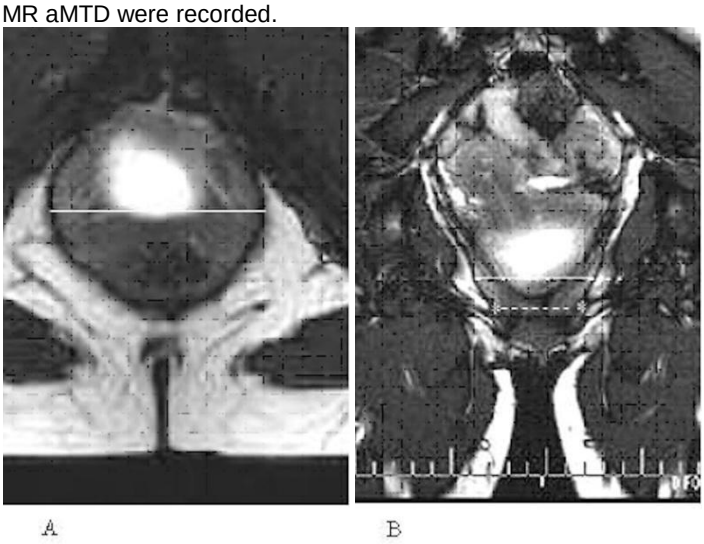

Figure 1: MR axial image on full valsalva (A). Coronal image on full valsalva(B). Solid white lines indicate the plane of measurement of the transverse diameter of the aMTD. The asterisk indicates the caudal margin of puborectalis/pubococcygeus and hence the plane of tMTD.

Results

No significant differences were demonstrated between the aMTD measured using an axial ultrasound or axial MR, on valsalva. However, there were significant differences, as shown in Figure 2, found between the aMTD and the tMTD using a coronal MR image. Mean 4.16cm (±1.05) and mean 3.24cm ±(0.50) $p<0.01$ respectively.

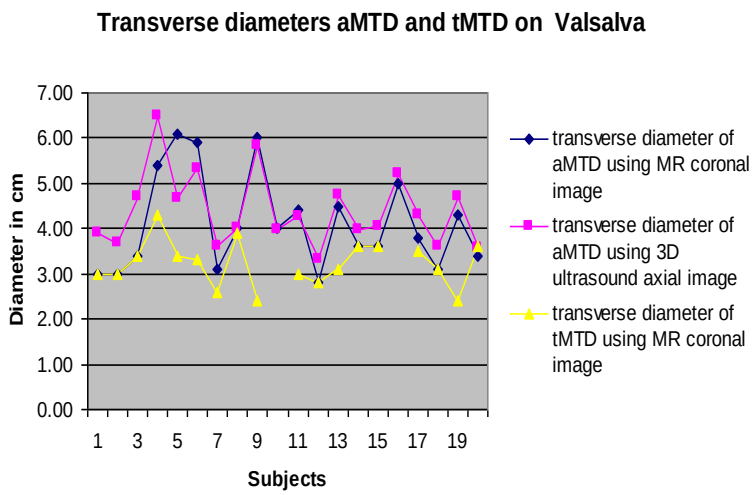

Figure 2: Graph showing transverse diameters of the aMTD measured from the axial ultrasound images and MR coronal images and the transverse diameter measured of the tMTD from a coronal MR image during a valsalva manoeuvre

Interpretation of results

The results indicate that the minimal transverse diameter of the levator hiatus on full valsalva is more narrow than previously measured using just an axial image.

Concluding message

This study highlights the complexity of the shape of the levator hiatus and pelvic floor muscles, particularly during a valsalva manoeuvre. The 'plane of minimal dimensions' has been extensively used to assess the functional parameters of the pelvic floor, and these are associated with pelvic organ descent and prolapse[3]. However these minimal dimensions of the hiatus have assumed a flat plane when in fact it becomes non-Euclidean on valsalva. Therefore hiatal measurements on valsalva may be subject to systematic error if performed in a single section, ie using a Euclidean plane.

References

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Specify source of funding or grant	**No specific funding**
Is this a clinical trial?	**No**
What were the subjects in the study?	**HUMAN**
Was this study approved by an ethics committee?	**Yes**
Specify Name of Ethics Committee	**University of Auckland Human Participants Ethics committee**
Was the Declaration of Helsinki followed?	**Yes**
Was informed consent obtained from the patients?	**Yes**