

REPRODUCIBILITY OF PELVIC FLOOR MEASUREMENTS IN REST AND VALSALVA COMPARING CONVENTIONAL THREE-DIMENSIONAL ULTRASOUND WITH VIRTUAL REALITY

Hypothesis / aims of study

The levator area in magnetic resonance imaging is visualized as a non-Euclidean hyperbolic structure (1, 2). However, volume measurements of the levator area obtained with conventional three-dimensional (3D) ultrasound do not take the convex and concave shape of the levator ani into consideration. In the I-Space virtual reality system these features of the levator can be visualized and offers possibilities for measuring non-planar structures.

In a previous study we showed that levator hiatus volume (LHV) measurements using virtual reality were reliable and comparable to measurements using conventional 3D during contraction (3). For clinical use however, it has been shown that it is important to obtain measurements of the area of the LHV in Valsalva. The LHV in Valsalva is strongly associated with symptoms and clinical signs of prolapse.

This study was designed to compare and establish LHV measurements obtained in conventional 3D and virtual reality in rest and Valsalva.

Study design, materials and methods

100 Symptomatic patients visiting a tertiary pelvic floor clinic with a normal, intact levator ani muscle diagnosed on translabial pelvic floor ultrasound were selected. Datasets were analysed using a rendered volume with a slice thickness of 1.5 cm at the level of minimal hiatal dimension during rest and Valsalva. The levator area (cm²) was measured using specialized imaging software (4D View version 9.0) and multiplied by 1.5 to get the conventional 3D LHV (cm³).

Secondly, LHV measurements in virtual reality (Figure 1a and b) were performed three times by one operator (C.S.B.), semi-automatically using a segmentation algorithm in virtual reality (cm³). The interobserver and intraobserver reproducibility was calculated.

Reproducibility of conventional 3D and virtual reality LHV measurements was established using the intraclass correlations coefficients (ICC) and agreement was established by calculating the Bland and Altman statistics limits of agreement. A two-sided p-value < 0.05 was considered to indicate statistical significance.

Results

The mean age of the symptomatic patients was 54 years (22 - 79 years). Their leading complaints were urinary incontinence (21%), prolapse complaints (13%), faecal incontinence (19%) or a combination (26%).

Mean LHV measurements in rest performed in conventional 3D and virtual reality were 27.96 cm³ (SD 5.91) and 26.44 cm³ (SD 6.00). The mean LHV measurements in Valsalva performed in conventional 3D and virtual reality were 36.90 cm³ (SD 10.50) and 35.74 cm³ (SD 9.63). Table 1 represents a comparison between conventional 3D and virtual reality LHV measurements in rest and Valsalva.

Patients with prolapse complaints (n = 31) had significant larger LHV measurements in virtual reality (mean 38.74 cm³ (SD 10.11), with a mean difference of 4.34 cm³ (95% CI 0.28-8.40) versus patients without prolapsed complaints in Valsalva (mean 34.39 cm³ (SD 9.16)).

Patients with prolapse on POP-Q (≥ stage 2) (n = 39) had also significant larger LHV measurements in Valsalva in conventional 3D (mean 43.43 cm³ (SD 10.65) with a mean difference of 10.53 cm³ (95% CI 6.80-14.27) versus patients without prolapse (mean 32.89 cm³ (SD 8.02)). In virtual reality there was a significant mean difference of 8.88 cm³ (95%CI 5.38-12.39) in patients with prolapse on POP-Q (≥ stage 2) (mean 41.26 cm³ (SD 9.56) versus the patients without prolapse (mean 32.37 cm³ (SD 7.88)).

Intraobserver and interobserver intraclass correlations coefficients for conventional 3D were ≥ 0.96 and for virtual reality LHV measurements > 0.99.

Interpretation of results

LHV measurements in rest and Valsalva are significantly smaller using virtual reality than measurements using conventional 3D. Patients with prolapse complaints and clinical signs of prolapse did have significant larger LHV measurements in Valsalva utilizing both methods. Levator ani hiatus volume measurements in rest and Valsalva performed using virtual reality were reliable and comparable with measurements in conventional 3D ultrasound.

Concluding message

In conclusion we noted that the application of virtual reality is a novel method of visualizing ultrasound data with the perception of depth, which offers possibilities for measuring non-planar structures, like the pelvic floor. This study demonstrates that levator ani hiatus volume measurements in virtual reality during rest and Valsalva are comparable with measurements performed using conventional 3D ultrasound with an excellent intraobserver and interobserver reproducibility. The next step will be to establish normal and abnormal values for measurements of the hiatal area of the levator ani and/or their relation with pelvic floor symptoms in virtual reality.

Figure 1a and b A two-dimensional virtual reality image of a volume measurement of the levator hiatus area in rest and Valsalva displayed in blue. The axial (a), coronal (b) and midsagittal (c) planes are shown. The concave and convex shape of the hiatus is hereby visualized.

Figure 1a

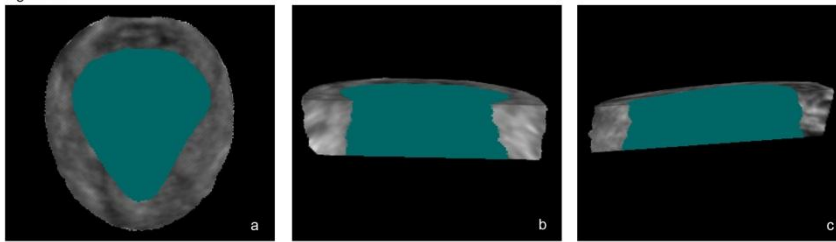


Figure 1b

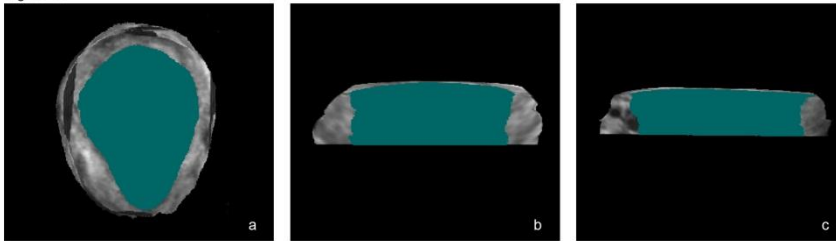


Table 1 Comparison between conventional three-dimensional (C3D) and virtual reality (VR) of levator ani hiatus volume measurements in rest and Valsalva.

Methods (n=100)	Mean difference (cm ³) (95% CI)	Limits of agreement ‡	ICC (95% CI)
C3D versus VR in rest	1.52 (1.00- 2.04)	-3.62- 7.81	0.875 (0.728- 0.934)
C3D versus VR in Valsalva	1.16 (0.56-1.76)	-4.78- 7.12	0.949 (0.914- 0.968)

• mean difference (conventional 3D ultrasound minus virtual reality) in cm³ ‡ Limits of agreement = mean difference \pm 1.96xSD.

References

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Is this a clinical trial?	No
What were the subjects in the study?	HUMAN
Was this study approved by an ethics committee?	No
This study did not require ethics committee approval because	This was a retrospective cohort study. Ethics committee approval was not necessary in our hospital for this study.
Was the Declaration of Helsinki followed?	Yes
Was informed consent obtained from the patients?	No