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IMAGE ANALYSIS, MULTI-MODAL 3D VOLUME RENDERING AND 3D PRINTING OF THE FEMALE PELVIC FLOOR FOR THE ASSESSMENT OF URETHRAL, VAGINAL AND PARA-URETHRAL LESIONS

Hypothesis / aims of study

Pelvic floor disorders can have detrimental effects on patients' quality of life (1). Physical examinations are often inconclusive, so effective imaging is important (2). Magnetic resonance imaging has enhanced the ability to visualise urethral, para-urethral and vaginal lesions which can cause symptoms associated with pelvic floor disorders. However, traditional scans are 2D in format. We assessed the feasibility of creating and printing 3D volume rendered models of the pelvic floor from MRI scans to aid understanding of the anatomical relationship between structures.

Study design, materials and methods

Anonymised MRI scans from five female patients aged 27-41 with pelvic floor disorders were used to create 3D models of pelvic structures including the bladder, urethra and any lesions present using the software program OsiriX (Pixmeo, Bernex, Switzerland). One model underwent 3D printing to form a plastinated real life structure (figure 2).

A secondary analysis was undertaken comparing our models with 3D models of the same subjects which had previously been rendered using another software program - 3D Slicer (Brigham and Women's Hospital, Harvard, Boston MA, USA). Quantitative measurements generated from 3D Slicer and OsiriX were analysed and compared. Analysis to determine the degree of agreement between data sets was conducted through Bland-Altman plots, comparison of percentage variance and calculating correlation coefficients (table 1).

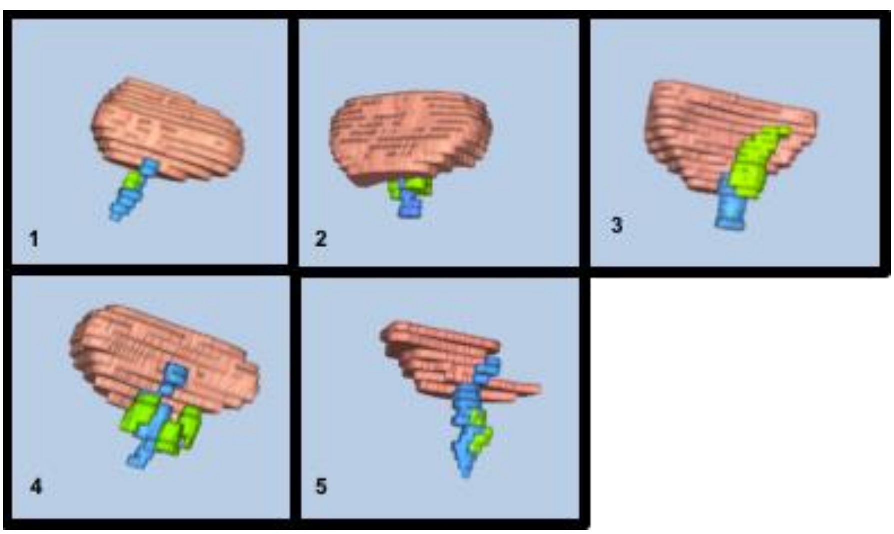

Figure 1. 3D volume rendered models in Osirix. Bladder (pink), urethra (blue), lesion (green). Patient 1 – urethral diverticulum. Patient 2 – 2 urethral bulking and a sub-urethral cyst. Patient 3 – Gartner cyst. Patient 4 – three para-urethral cysts. Patient 5 – urethral diverticulum.

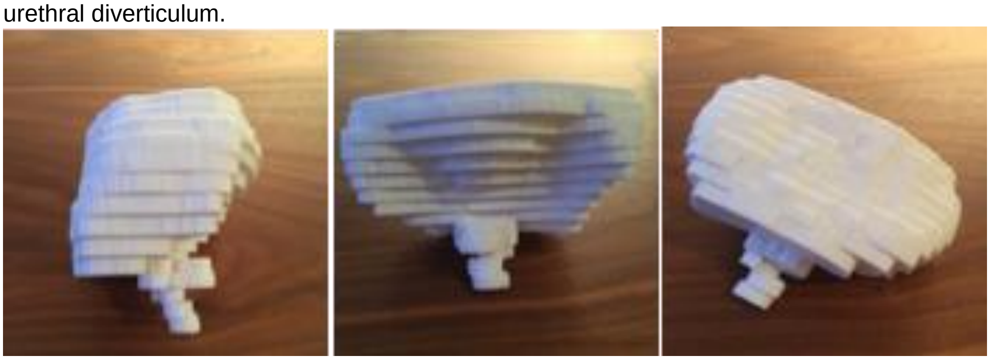

Figure 2. 3D printed model of the bladder, urethra, sub-urethral cyst and bulking in patient 2.

Results

Five 3D models were successfully rendered (figure 1). Two patients were found to have urethral diverticulum, one had undergone urethral bulking and had a sub-urethral cyst, one had a Gartner cyst, and one had three distinct para-urethral cysts. Dimensional measurements of the height, width and depth of each structure and the distance from the lesions to important anatomical landmarks were recorded on OsiriX. The data generated from these measurements underwent analysis with the corresponding data from 3D Slicer. A 3D volume rendered model from scans of one patient was successfully 3D printed.

Interpretation of results

It is feasible to produce high quality 3D models from MRI scans, which give an enhanced view of pelvic anatomy and so aid clinical interpretation of images. There was good agreement between the measurements generated in 3D Slicer and OsiriX showing that the two measurements are comparable. Graphical analysis through Bland-Altman graphs showed good agreement between data sets. In addition to this, the mean percentage variance was small - calculated to be -1.55%. Finally, the correlation coefficient showed good agreement, for example in the bladder height dimension the correlation coefficient was 0.999140, for full results see table 1. Overall it was found that 3D volume rendering of structures from MRI scans have a high degree of accuracy between both software types and can be used independently to produce similar results. The 3D printed model has applications in aiding the teaching of anatomy and pre-surgical planning.

Concluding message

3D volume rendering of the pelvic floor from MRI scans is a feasible imaging technique which may aid the interpretation of images and the diagnosis and management of patients with urethral and para-urethral lesions. 3D volume rendered models, both digital and 3D printed have applications in education, of both the clinician and patient, as well as in developing the understanding of the anatomical pathophysiology which occurs in patients with pelvic floor disorders. Further studies need to be conducted to test the feasibility of this technique across different pathologies and the affect that it has on patient outcomes.

Dimensions of each structure	**Correlation coefficient**
Bladder height	0.999140
Urethra height	0.979908
Lesion height	0.993124
Bladder width	0.970095
Urethra width	-0.120765
Lesion width	0.991119
Bladder depth	0.988288
Urethra depth	0.870585
Lesion depth	0.969278
Distance from proximal aspect of lesion to bladder neck	0.990932
Distance from distal aspect of lesion to external urethral meatus	0.973816

Table 1. The correlation coefficient (to 6 decimal places) of the dimensions of each structure calculated from the means of the dimensions recorded in 3D Slicer and OsiriX.

References

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2. Luber K, Boero S, Choe J. The demographics of pelvic floor disorders: Current observations and future projections. Am J Obstet Gynecol. 2001;184(7):1496–503.

Disclosures

Funding: None **Clinical Trial:** No **Subjects:** HUMAN **Ethics not Req'd:** This study was registered as an audit. Audit reference number (333). **Helsinki not Req'd:** no identifiable data was used. This study only required existing data available from the Electronic Patient Record and anonymised radiological data and thus did not require input from participants or alter their care pathway. No human material or identifiable data was used. **Informed Consent:** Yes