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Derpapas A[1], Vijaya G[1], Digesu A[1], Gallo P[1], Dell'Utri C[1], Hendricken C[1], Fernando R[1], Khullar V[1]
***1.** St Mary's Hospital, Imperial College Healthcare NHS Trust*

REAL TIME BIOMECHANICS OF THE PELVIC FLOOR

Hypothesis / aims of study
Pelvic organ prolapse (POP) is considered to be a multifactorial condition with high incidence and recurrent rates after surgery.[1] The failure of the endopelvic fascia, pelvic connective tissue and musculature to support the viscera in women with pelvic floor dysfunction has been attributed to various predisposing and promoting factors.[2] However, little is known about the biomechanical properties of the tissues composing the pelvic floor functional unit. Tissue deformation forces can be evaluated by measuring changes in the vaginal structures in response to pressure changes.[3] The mechanical properties of the pubovisceral muscle are responsible for the pelvic floor tissue stiffness in order for continence and support of the viscera to be maintained and the elasticity at the time of childbirth to facilitate vaginal delivery. These properties can be explored by studying the behaviour of the pubovisceral muscle in vivo during contraction and straining, as well as at rest.
The aim of this study is to calculate the stress and strain exerted on the pelvic floor during deformation of the pubovisceral muscle with the use of 3D/4D translabial ultrasound.

Study design, materials and methods
Twenty-three consecutive women presenting for urodynamic investigation were recruited. All women underwent a detailed clinical interview, vaginal examination and either conventional or video-urodynamics. At the end of the pressure-flow study, women underwent translabial 3D/4D ultrasound scanning of the pelvic floor, with the rectal fluid-filled catheter in situ to allow measurement of gradually increased abdominal pressure. Women were asked to blow four times with increasing force on a VLPP mouthpiece (Laborie Medical Technologies, Canada) and hold for 3-5 seconds to standardise the Valsalva manoeuvre. The abdominal pressures generated by each Valsalva manoeuvre were measured through the rectal line and recorded on the urodynamics monitor as Pabd. Ultrasound images of the pelvic floor were taken at rest and at Pabd of 10, 20, 30 cm H2O and at the pressure level generated at maximum Valsalva effort. Measurements of the levator hiatus anterior-posterior and transverse diameter at the level of the urethra and the vagina, as well as the hiatal area were taken in the axial plane. All measurements were taken at the level of the minimal hiatal dimensions. The strain of the levator hiatus area (ε-area), anterior-posterior diameter (ε-AP) and transverse diameter at the level of the urethra (ε-urethra) and the vagina (ε-vagina) was calculated with the formula derived by Hooke's Law, $\varepsilon = Dh / ho$ (Dh=the difference between measurement of biometric index at Valsalva and at rest, ho=the measurement of the biometric index at rest). Ethical approval was obtained by the local REC and all participants signed a consent form.

Results
Mean age and parity was 51 (26-78) and 2.3 (0-5) respectively. Four women excluded from further analysis due their inability to perform Valsalva manoeuvre sufficiently. Among parous women, 12 out of 15 (80%) had had one or more vaginal deliveries, whereas 3 out of 15 women (20%) had delivered by emergency or elective caesarean section. Forty-five percent of the women studied were found to have moderate to severe prolapse. The strain of the levator hiatus in the cranio-caudal diameter and lateral diameter at the level of the urethra showed a linear rise with higher pressures (stress) exerted on the pelvic floor (Fig 1). However, interestingly the deformation curve of the hiatus at the level of the urethra is biphasic, with a steep rise from rest to 30cm H20, followed by a decline as the stress levels increase significantly (Fig 2). Linear regression analysis demonstrated a moderate to strong correlation between strain of the pubovisceral muscle and stress exerted on the pelvic floor (Spearman's correlation 0.65, $p<0.001$).

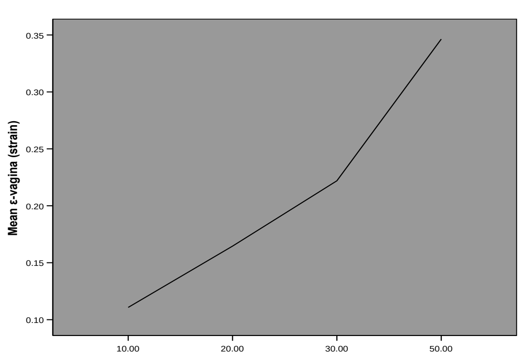

Figure 1

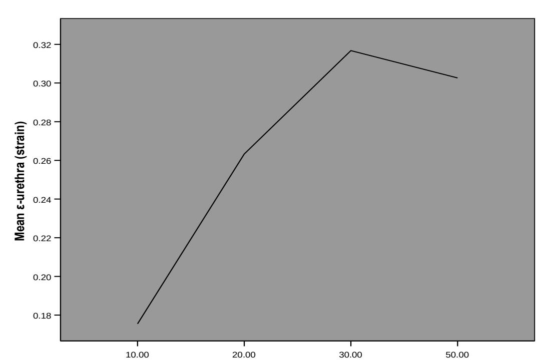

Figure 2

Interpretation of results
Biomechanics of the pelvic floor can be studied with the use of applied physics and real time ultrasound scan. In non pregnant women, the pubovisceral muscle allows an uneven deformation of the levator hiatus when gradually increased pressure is exerted. The viscoelasticity of the levator ani allows only limited stretching around the urethra. This special biomechanical property may be a contributing factor to the development of stress urinary incontinence.

Concluding message

Studying the biomechanics of pelvic floor by real time 3D/4D ultrasound scan could broaden our understanding of the pathophysiology of the genital prolapse and stress urinary incontinence. Further research on the biomechanical properties of the pelvic floor tissues in larger cohorts will possibly identify the reasons for the high recurrence rates in POP and perhaps elucidate new methods of surgical repair.

References

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2. Am J Obstet Gynecol. 2005 May;192(5):1488-95
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Specify source of funding or grant	**No funding or grant received**
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	**London-Surrey Borders REC (10/H0806/21)**
Was the Declaration of Helsinki followed?	**Yes**
Was informed consent obtained from the patients?	**Yes**