619

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IN-VIVO RECORDING OF VISCOELASTIC PROPERTIES OF HUMAN PROLAPSED VAGINAL WALL TISSUE

Hypothesis / aims of study

Improvements in surgical repair of pelvic organ prolapse could benefit from quantitative biomechanical property data to better tailor the repair in each patient. Such vaginal wall tissue property measurements have been obtained by *in vitro* uni- and biaxial tensile tests on fresh human anterior vaginal wall tissue samples [1]**.** Recently, *in vivo* biomechanical data have been obtained at the same site, adapting a cutometer-like device, the *BTC-2000*™ (SRLI, Nashville). We report here on visco-elastic properties derived from the recovery phase of the SRLI instrument measurement in patients undergoing vaginal prolapse repair.

Study design, materials and methods

Following IRB approval, women with symptomatic stage 2-3 anterior vaginal wall prolapse requiring surgical repair were consented for the study. Under anesthesia and with an empty bladder, a 10-mm diameter *BTC-2000*™ probe was applied to the prolapsed anterior vaginal wall at a fixed point (level with bladder neck area). A suction pressure ramp (0 to -147 mmHg in 6 seconds) was applied; the corresponding tissue uplift was measured by triangulation, within the probe, of a laser scan pattern (Fig. 1). The chamber was then returned to atmospheric pressure and the corresponding laser-measured tissue relaxation was recorded for 20 seconds (Fig. 2).

For the visco-elasticity calculation, we measured the tissue uplift value at maximum suction pressure (-147 mmHg at 6 sec) and also the residual tissue uplift, following 20 seconds of relaxation. We also measured the rate of tissue recovery, or recoil, immediately upon chamber exhaustion following the 6 sec pressure ramp. We compared the residual tissue uplift vs. time data over the 6–20 sec time period to a visco-elastic creep model (Voigt model), consisting of an elastic spring (spring constant E) and dashpot (viscosity η) connected in parallel. To do this, the timed recording of tissue recovery was fit to the model equation simulating the event, expressed in terms of a visco-elasticity parameter, the E/η ratio.

Results

Profiles of the time course of tissue uplift and subsequent recovery are shown in Fig. 3 for six patients. Uplift peak values at 6 sec of vacuum, and residual uplift values following 20 sec of relaxation are correlated with the Voigt model E/η ratios in Fig. 4. Patient data with *lower* peak uplift values and *lower* residual uplift values were characterized by higher E/η ratios. Patient data with slower recovery rates from tissue uplift yielded *higher* values in both peak uplift and residual uplift values, and were characterized by smaller E/η ratios.

Interpretation of results

The observed results and model predictions would be expected for tissues containing less collagen and elastin, and/or less organized collagen and elastin. The behavior under negative pressure load of such deficient tissues would be consistent with higher 6 sec uplift values, slower recovery rates and higher residual uplift at 20 sec relaxation. However such an interpretation cannot be justified at this stage, as histological verification of protein distributions is unavailable, nor is age, parity or other clinical information. We can say that correlations have been obtained aided by the Voigt model, offering a means to improve the understanding of tissue behavior.

Concluding message

Viscoelastic properties of anterior prolapsed vaginal wall tissues can be extracted from tissue uplift vs. time recordings over the 20 sec recovery phase obtained with the *BTC-2000*™. The values of peak uplift, residual uplift, and model recovery rate (E/η ratio) may allow a more objective evaluation of vaginal wall tissue damage among women with advanced POP stages. This might also influence the decision for mesh interposition at the time of repair.

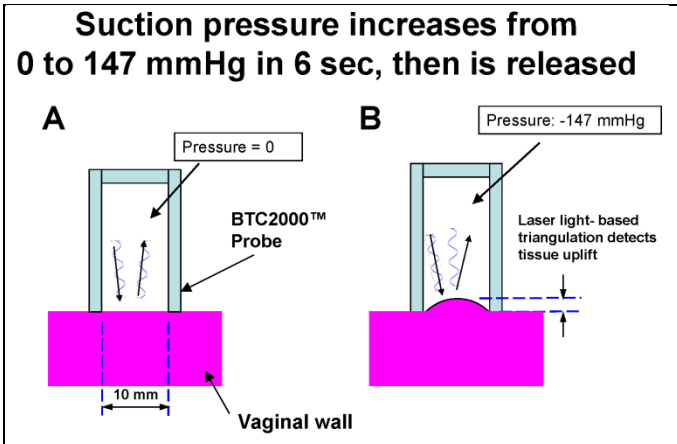

Fig.1. *BTC-2000™* measurement schematic of tissue uplift in response to suction pressure loading.

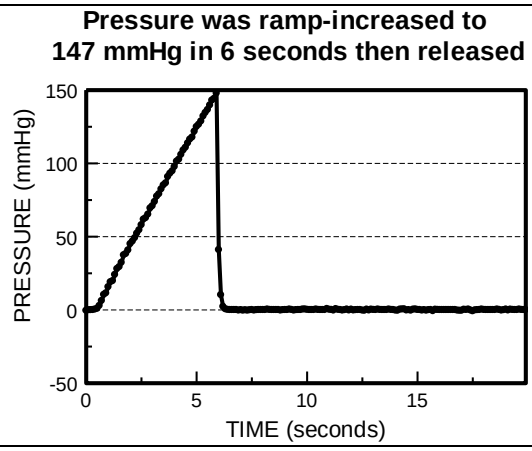

Fig. 2 Suction pressure ramp (0 to -147 mmHg in 6 sec), and the following sudden release to 0 mmHg. Residual uplift (not shown) is recorded for 20 seconds.

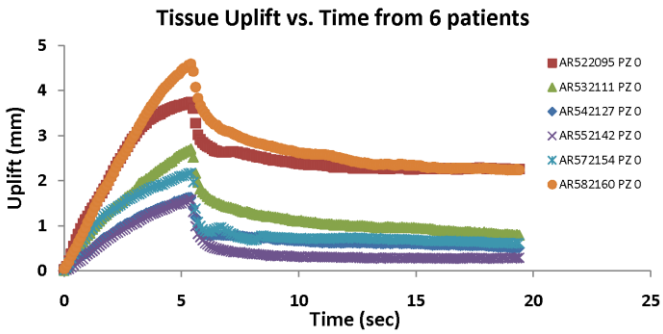

Fig. 3 Time course of tissue uplift responses recorded by the *BTC-2000™ (*6 patients).

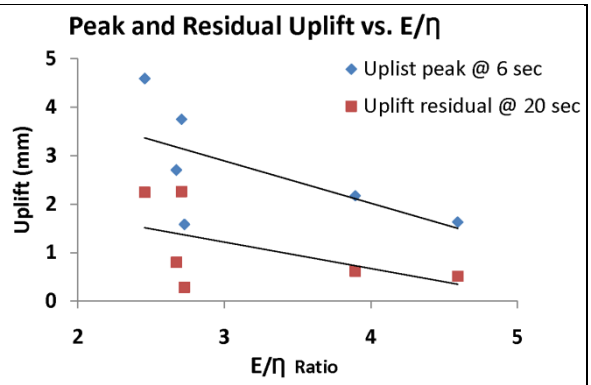

Fig. 4. The Voigt model recovery rate (E/η ratio correlates with peak tissue uplift at peak suction as we as the residual uplift during relaxation.

References
1. Zimmern, P.E., et al. Neurourol. Urodyn. 28:325-29, 2009

Specify source of funding or grant	**none**
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	**UT Southwestern Institutional Review Board**
Was the Declaration of Helsinki followed?	**Yes**
Was informed consent obtained from the patients?	**Yes**