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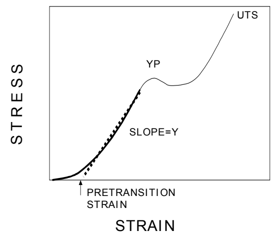
BIOMECHANICAL PROPERTIES OF THE PROLAPSED ANTERIOR VAGINAL WALL AT THE LATERAL DEFECT SITE IN POST-MENOPAUSAL WOMEN

Hypothesis / aims of study

To study the variation in anterior vaginal wall appearance and strength, we measured the biomechanical properties of freshly harvested human anterior vaginal wall prolapse samples, and initiated comparative studies of these properties with electron microscopic (EM) evidence of structural change. We hypothesized sample stiffness decreased with age and degree of tissue hydration during sample transport.

Study design, materials and methods

Post-menopausal women with Stage III or IV anterior vaginal wall prolapse who gave informed consent participated in this IRB-approved study. Controls were age-comparable women with no symptoms or clinical findings of prolapse who underwent radical cystectomy for invasive bladder cancer. A longitudinal full-thickness sample of redundant vaginal wall corresponding to the site of lateral defect cystocele was excised on each side of the midline during cystocele repair (Stage III or IV). Bilateral sections were obtained when possible. Samples (width ≥ 1cm; length ≥ 3cm) were marked to maintain proper orientation and prepared for testing within 2 hours of harvest. Samples were secured in a tensile test machine equipped with special jaws (Bionix 858, MTS systems, MN). Tissues were pre-loaded at 2.2 Newtons (N), then stretched at 0.5 mm/sec, continuing until irreversible deformation was observed. The pre-transition tensile strain, slope of the stress vs. strain curve (Young's modulus, Y), yield point (YP) and ultimate failure stress (F) were measured for each tissue strip (Fig 1,2). Two methods of tissue storage and transport were compared: method A denotes samples immersed in room temperature sterile normal saline; method B denotes samples placed on saline-soaked sterile gauze at room temperature without further hydration. To avoid bias, testing was performed independent of clinical information (age, hormonal status, stage of prolapse). EM analysis of the collagen and elastin distribution and orientation was performed for stretched and unstretched samples with the highest and lowest Y values (method B preparation).



Results

Forty-one patients over two years provided samples analyzed bilaterally (7), and unilaterally [16 (A), 23 (B)]; three control samples (B) were also analyzed. Except for one patient, closely comparable biomechanical findings (left versus right) were noted. Table 1 describes the biomechanical findings for prolapsed samples by hydration methods A and B, and for control samples. Table 2 describes the age-dependence of the biomechanical parameters obtained for storage method B samples.

There were noticeable differences in the EM appearance of stretched vs. nonstretched prolapsed tissue samples. Elastin fibers in the stretched samples appeared fragmented, with many void spaces. Collagen fibers in the stretched samples formed a complex, irregular network (compared to the coherent, oriented appearance of normal collagen fibers), but were not fragmented. Unstretched prolapsed tissue samples on the other hand exhibited homogeneous and unfragmented elastin fibers, with fewer void spaces.

Interpretation of results

The wide variety of vaginal wall appearances and thicknesses recognized during anterior compartment prolapse repair is mirrored by the observed range of biomechanics results. Our study indicates bilateral biomechanical symmetry in the prolapsed anterior wall. It identifies age-dependent trends in the biomechanics data: Samples from older patients exhibited signs of structural weakening: decrease in pretransition strain, stiffening (higher Young's modulus) and lower yield point, but no change in the ultimate tensile strength.

Table 1. Biomechanics results

	Control	**Prolapse**		
Storage/transport method	**B***	**A**	**B**	**(A vs. B)**
Sample thickness (mm)	**3**	**16**	**23**	
Sample thickness (mm)	2.8±0.4**	3.2±1.2	2.2±0.8	NS
Pre-transition strain	0.002±.015	0.019±.05	0.221±0.09	$p<0.05$
Young's modulus (N/mm^2)	10.2±3.9	4.4±2.8	8.4±4.8	$p<0.001$
Yield Point (N/mm^2)	0.1± 0.1	0.5±0.2	0.3±0.2	$p<0.02$
Ultimate tensile stress (N/mm^2)	1.4±0.4	1.4±0.2	2.1±0.3	$p<0.03$

* (A) = Immersed; (B) = Moistened

** Mean ± SD

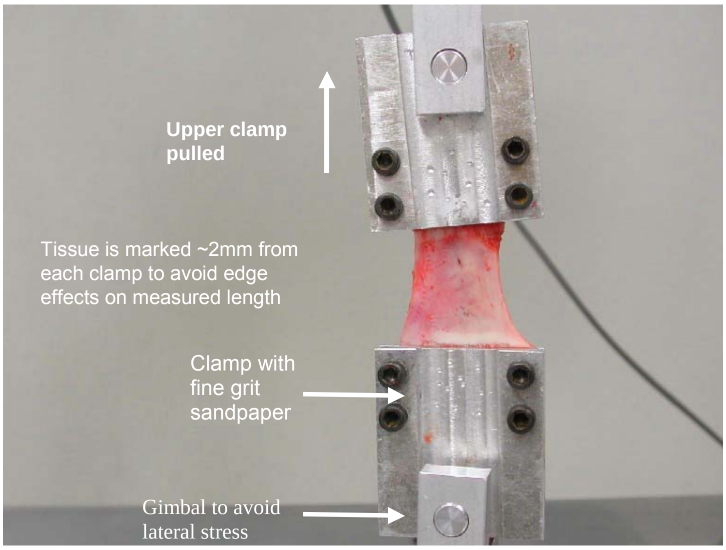


Figure 2. Sample Tensile Testing Configuration

Concluding message

This study identifies significant differences in results based on the degree of hydration of the tissue: this is an important consideration for sample collection in future studies. The wetter samples (A) exhibited signs of structural weakening (lower modulus and UTS) compared with the moistened samples (B). In our EM study, tensile loading disrupted elastin fibers, but not collagen fibers. Comparison of the EM and biomechanics results suggests that failure of elastin fibers, not collagen fibers, may account for the stiffening and weakening of prolapsed tissue. If the tensile loading in this study is indicative of impact loads *in situ,* if not more sustained loading, one can infer some features of the ageing process: stiffened and weakened tissue due to loss of resiliency (loss of elastin fiber) without loss of ultimate tensile strength (maintained by the less-disrupted collagen network). The control sample population is too small to permit conclusions *vis a vis* the prolapsed tissue. Longer clinical follow-up will be necessary to determine the predictive relevance of these biomechanical findings on recurrence rates.