Tensile Strength of Penile Tunica Albuginea in a Human Model

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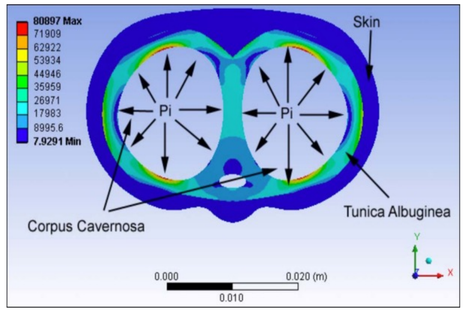
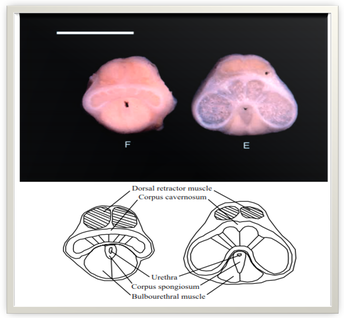
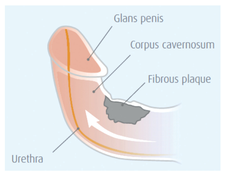
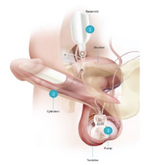
Introduction





- The penis is fundamentally a biomechanical implement – penile load-bearing is assumed by the tunica albuginea.
- Tunica biomechanics have been directly measured in human cadavers and cingulates but never fresh human specimens.

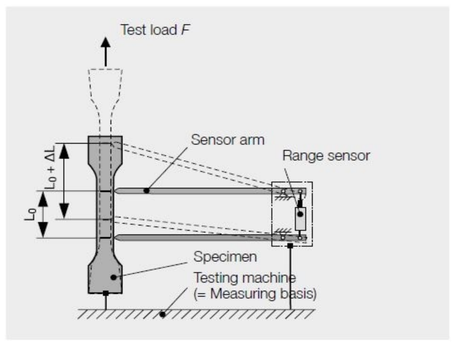




Quantifying the tunica's biomechanical properties helps us:

- understand disease states of the penis
- apply to tissue engineering and medical devices

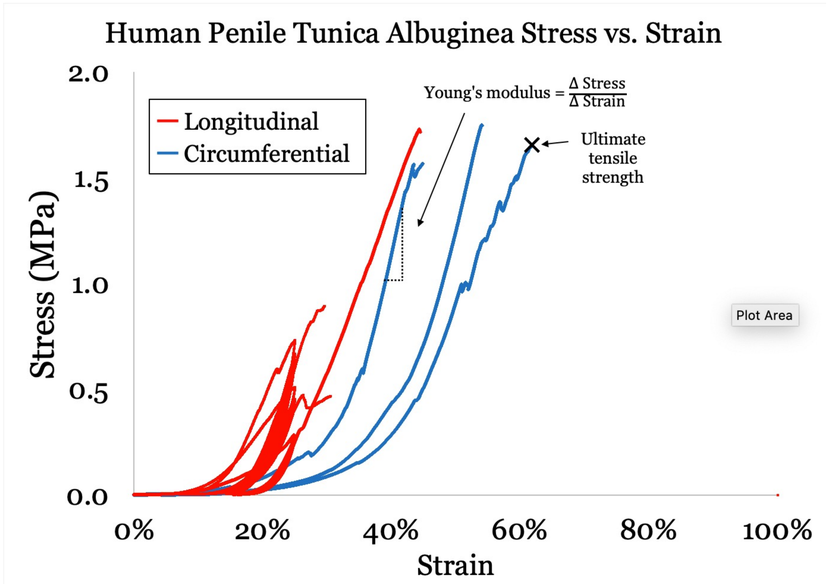
Methods



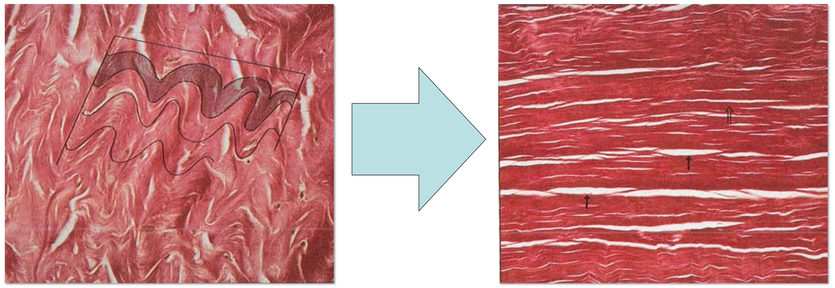
Procured penile tissue from patients undergoing penectomy

- To generate experimental samples, strips of tunica were prepared in both longitudinal and circumferential orientations.
- To calculate the elasticity and failure strength of a sample, we generated a stress-strain curve via mechanical extensometry.
- From this curve the Young's modulus and ultimate tensile strength were calculated.

Results



Stress-strain curves obtained via mechanical extensometry of tunica albuginea in both the longitudinal and the circumferential directions.



- Initially, the tissue is very compliant and stretches easily without having much stress applied to it; this is when elastin fibers in the tissue are starting to stretch and uncoil.
- At the inflection point, the elastin reaches the maximum stretch, and the collagen fibers begin to stretch. Eventually at the point of ultimate tensile strength, the tissue fails.

Homo sapiens	Mean ultimate strength, MPa (SD)	Mean Young's modulus, MPa (SD)
Longitudinal	1.8 (0.6)	8.1 (1.7)
Circumferential	1.7 (0.1)	10.3 (3.1)

Papio anubis	Mean ultimate strength, MPa (SD)	Mean Young's modulus, MPa (SD)
Longitudinal	4.3 (1.8)	34.0 (19.2)
Circumferential	2.0 (1.0)	11.7 (4.6)

- In comparison with baboons (*Papio anubis)*, human samples had a lower Young's modulus longitudinally (8.1 vs 34.0, p<0.01) but not circumferentially (10.3 vs 11.7, p=0.32).
- Additionally, the human samples had a lower maximum stress longitudinally (1.8 vs 4.3, p=0.01) but not circumferentially (1.7 vs 2.0, p=0.29).
- These data show that baboon TA is stiffer and stronger longitudinally than human TA.

Conclusion

- Knowing the mechanical properties of the tunica albuginea will be useful in designing penile models, such as dynamic 3D finite element (FE) models.
- Application to developing *in silico* models for disease modeling and technology: Peyronie's disease, penile trauma, erectile dysfunction and penile prostheses.
- The variation shown between human and primate models support the need for fresh human tissue measurements to characterize the mechanical properties of the penis.

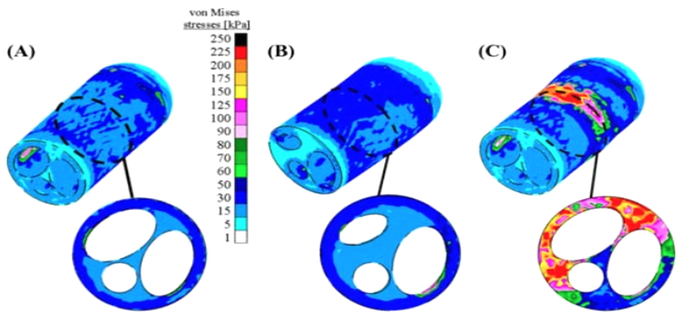


FIGURE 4. Distribution of von Mises stresses in **(A)** the normal penis model, **(B)** penis with asymmetrical geometry, and **(C)** Peyronie's disease. A central cross-section is magnified on each stress diagram to show locations where maximal internal stresses occur.