Quantitative Analysis of Extracellular Matrix Components and Crosslinks of Porcine Penile Tunica Albuginea

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Introduction

- Tissue engineering is a promising strategy for penile tunica albuginea (TA) regeneration as a treatment for Peyronie's disease
- Design criteria for engineered tissue must be established, but there is a dearth of information regarding the biochemical makeup of the TA
- By analyzing TA biochemistry, tissue engineers can use measurements as a gold standard for engineering tissues in animal models and the clinic

Peyronie's Disease

Peyronie's Disease (PD) is caused by scar tissue in the tunica albuginea, and causes painful, curved erections. One potential solution is to replace the tunica albuginea with a tissue engineered prosthesis.

Healthy erect penis

Bending caused by PD

Objective

To perform an initial quantitative characterization of the matrix components and crosslinks of porcine TA

- Collagen is the protein that give structure to many different collagenous tissues
- Quantification of collagen content and its crosslinks are particularly relevant to tissue engineering
- Elastin, which allows for large strains of tissues, is also necessary to quantify, because its deposition correlates to the hyperelastic nature of the tissue

Materials & Methods

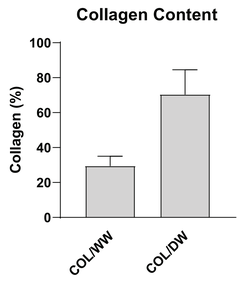
- 1 cm x 0.5 cm pieces of porcine tunica albuginea were isolated from the penises of six skeletally mature male domestic farm pigs
- Wet weights (WW) were followed by lyophilization and measurement of dry weights (DW)
- Collagen (COL) was measured with hydroxyproline assay
- Pyridinoline (PYR) and desmosine (DES) were quantified with a liquid chromatography-mass spectrometry assay
- Elastin (ELN) was estimated with a molar ratio of DES
- Three biological replicates were tested from each of the six pigs and averaged for each data point
- Hematoxylin and eosin (H&E) staining was performed following the manufacturer's instructions, and a representative image is shown under 4x magnification.

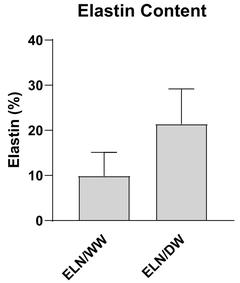
Results (Histology)

- Tunica albuginea (TA) and corpus cavernosum (CC) are visualized under H&E staining
- Both sections stain positive for eosin. Cell nuclei are present in the CC, collagen fibrillation in the TA is visible

Results (Biochemistry)

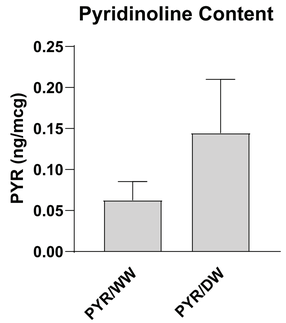
- Hydration = 58.1 ± 9.3%





- COL/WW = 29.6 ± 5.5% and COL/DW = 70.5 ± 14.1%
- One pig had significantly less collagen content than the other five pigs (ANOVA with *post hoc* Tukey test)
- Collagen was the most abundant matrix component

- ELN/WW = 9.9 ± 5.2%, ELN/DW = 21.4 ± 7.8%
- No differences in elastin content among all pigs
- The combination of collagen and elastin account for over 90% of the total dry weight



- PYR/WW = 0.06 ± 0.02 ng/μg
- PYR/DW = 0.14 ± 0.07 ng/μg

Discussion

- **This study represents the first initial biochemical characterization of the porcine penile TA and establishes the abundance of collagen and elastin in healthy porcine tissue**
- Collagen and elastin together account for over 90% of the total dry weight of the TA, providing a strong and extensible extracellular matrix
- The high presence of elastin is similar to other tissues that contract and reshape, such as arteries and skin
- Mechanical characterization will also provide gold standards to ensure that engineered implants will be durable and effective in the *in vivo* environment

Conclusions & Future Work

- The data from this work will assist with identification of a suitable animal model for penile tissue engineering and will determine standards for engineered TA
- An interspecies comparison is currently in progress that incorporates human cadaveric tunica albuginea
- Future characterization work also includes mechanical analysis of the tissue, and bottom-up proteomic analysis to fully understand all components that make up the TA

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