Background and Introduction

- Tissue engineering is used for the purpose of restoring and maintaining tissue and/or organ function.
- Currently, tissue engineering faces obstacles from the body rejecting the engineered tissue, mass transport limitations, and growth limitations.
- In order to succeed in restoring tissue function, engineered tissue should mimic native tissue as best as possible. To achieve this, the native behavior of the tissue must be thoroughly studied.
- An important application of this is for pediatric right ventricular outflow tract (RVOT) replacements.
- Currently, children who receive RVOT replacements will need multiple replacements as they grow because the engineered tissue being used is non-living, foreign material with limited long-term function.
- What is desired is to be able to use an engineered tissue that can grow as the patient grows.
- Tissue growth can be characterized by residual strain, tissue geometry, structure, and mechanics. Residual strain is the strain present in a solid when all external loads have been removed.
- Residual strain homogenizes the stress distribution (circular, longitudinal, and radial stresses), which provides a uniform local mechanical environment for the vascular smooth muscle cells (VCSM). This uniform environment is desirable in the tissue since smooth muscle cells respond to stress and non-uniformity would cause changes in their activity.

Methods

General:
- Rings were cut from the sinotubular junction and the bifurcation region.
- Two separate experiments were performed on each ring sample.

Residual Strain from Opening Angle and Circumferential Stretch:
- Residual strain can be characterized by the opening angle, and quantified by the circumferential stretch.
- Images were taken of the tissue rings before cut and for 30 minutes after cut (to allow tissue to equilibrate).
- Opening angle was calculated using the angle feature of the program ImageJ (see Figure 2b).
- Circumferential stretch was calculated by using the equation:

\[ \lambda = \frac{l_{\text{measured}}}{l_{\text{symmetric}}} \]

Where \( l_{\text{measured}} \) is the circumferential length in the no load state, and \( l_{\text{symmetric}} \) is the circumferential length in the zero stress state (see Figure 2).

Residual Strain from Flexural Test:
- 3-point bending tests (see Figure 3) were also done on the cut ring samples.
- Bending was done both against and with curvature for each sample.

Results and Discussion

Residual Strain from Opening Angle and Circumferential Stretch:
- As seen in Table 1, the OA for the sinotubular junction ring samples was consistently greater than that of the bifurcation region ring sample.
- Residual strain was calculated from the circumferential stretch using the equation for Green Strain:

\[ E = \frac{1}{2} (\lambda^2 - 1) \]

Thus, a correlation between opening angle and residual strain can be inferred: a greater opening angle indicates greater strain.

Residual Strain from Flexural Test:
- Due to a small sample size, and the fact that they were procured from the slaughterhouse, and therefore are from varying backgrounds, it is difficult to see a clear trend.
- Preliminary data may suggest that stiffness going against curvature is greater than going with curvature, a characteristic possibly due to the mechanical makeup of the tissue.

Acknowledgements

- The national BBSI program (http://bbsi.eeicom.com) is a joint initiative of the NIH-NIBIB and NSF-EEC, and the BBSI @ Pitt is supported by the National Science Foundation under Grant EEC-0234002.
- Dr. Michael Sacks for this great opportunity.
- Bahar Fata and Chad Eckert for their guidance and assistance.
- University of Pittsburgh.

References

2. Dr. Michael Sacks for this great opportunity.