The Stress-Relaxation Behaviors of Collagen-Depleted Heart Valve Tissues
Siyao Huang and Hsiao-Ying Shadow Huang
Mechanical and Aerospace Engineering Department, North Carolina State University, Raleigh, NC

Introduction and Background

Current Knowledge
- Severe collagen depletion caused by matrix metalloproteinases (MMPs) pathologically induces matrix destruction, changed viscoelastic property of the heart valve.
- Collagen degradation further affects cellular regulations mediated by heart valve cells, and even leads to heart valve diseases.

Current Limitations
- How viscoelastic properties of valve leaflet tissues may change during physiological or pathological remodeling is unknown.

Objectives and Approaches
- An easy approach for the collagen-deficient heart valve tissue responding to the mechanical environment is performed via the testing of stress relaxation.
  * An application of collagenase for collagen degradation is used to simulate effects of MMPs.
  * A series of stress relaxation testing are conducted under different strain levels and collagenase concentrations:

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Methods and Results

Stress Relaxation under Stretching and Collagen degradation
- Porcine aortic valve (AV) specimens (10mm X 10mm) are immersed in HBSS at 37°C and equi-biaxially stretched by a biaxial tester under different strain levels. (Cir.: Circumferential; Rad.: Radial).
- Specimens are hold at the assigned strain level in 10,000 seconds (about 3 hours). Collagenase is added at t = 3,000.
- Stress apparently drops in each condition after adding collagenase compared to the stress in the control group (i.e., collagenase-untreated specimen).

Discussion and Conclusion

Influence of Collagen Degradation on Mechanical Properties of Heart Valve Tissues
- From images of the specimen during stretching, the degree of transparency is different between the initial stage and the final stage during stress relaxation. Collagenase digests collagen and its concentration affect the degree of transparency of the tissue.

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- Dependencies of fiber orientation, stretching, and collagenase concentration are discovered:
  * Normalized stress relaxation in the circumferential direction is greater than in the radial direction.
  * With larger strain levels, larger normalized stress drops are observed.
  * Normalized stress relaxation is increased with collagenase concentration.