

The Stress-Relaxation Behaviors of Collagen-Depleted Heart Valve Tissues

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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

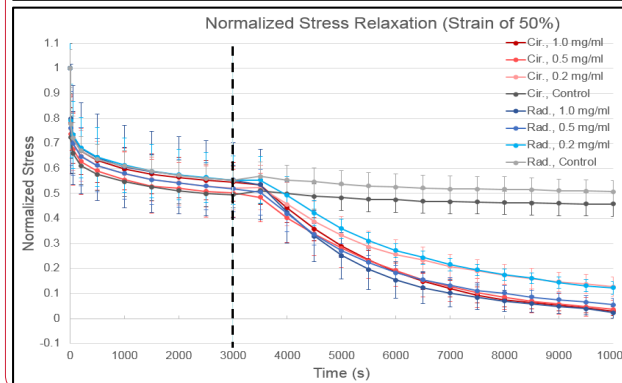
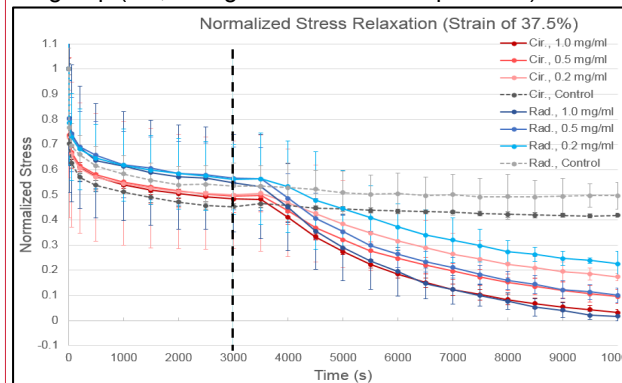
- An easy approach for the **collagen-deficient heart valve tissue** responding to **the mechanical environment** is performed via the testing of stress relaxation.
 - An application of collagenase for collagen degradation is used to simulate effects of MMPs.
 - A series of stress relaxation testing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

Strain	Collagen Concentration
37.5%	0.2 mg/ml
50%	0.5 mg/ml
	1.0 mg/ml

Methods and Results

Stress Relaxation under Stretching and Collagen degradation

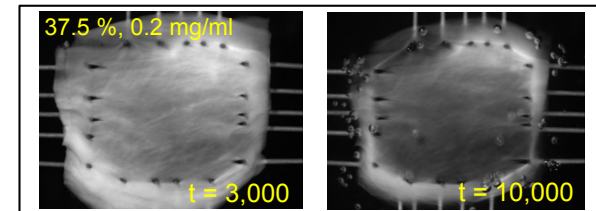
- Porcine aortic valve (AV) specimens (10mm X 10mm) are immersed in HBSS at 37°C and equi-biaxially stretched by a biaxial tester under different strain levels. (Cir.: Circumferential; Rad.: Radial).
- Specimens are hold at the assigned strain level in 10,000 seconds (about 3 hours). Collagenase is added 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.



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

