Impact of Intermolecular Crosslinking on Tendon Mechanics

Madeline K. Wagner – Weiss Biomechanics Lab, Department of Biomedical Engineering

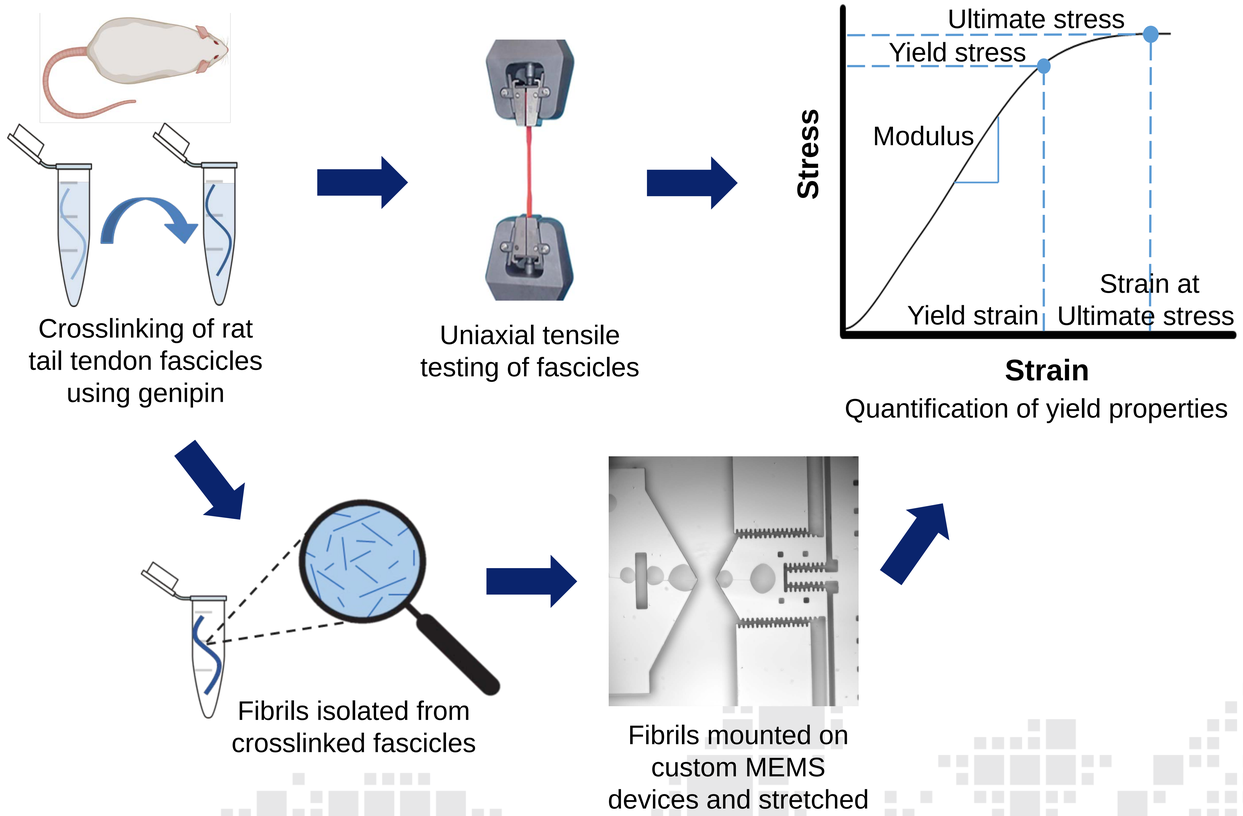
Introduction

- Collagen molecules are connected laterally by intermolecular crosslinks.
- When tendons are overloaded in tension, collagen molecules unravel, resulting in molecular denaturation [1].
- The role of crosslinks in resisting tissue damage is unclear.
- Genipin is a chemical crosslinker used in tissue engineering to augment the mechanical properties of collagenous tissues [2].

Objective

- Purpose: To better define how tendon structure, function, and failure are altered by increased crosslinking between collagen-comprising structures.
- Hypothesis: Increasing collagen crosslink density increases both tendon strength and modulus, changing collagen damage and yield behaviors.

Methods



Results

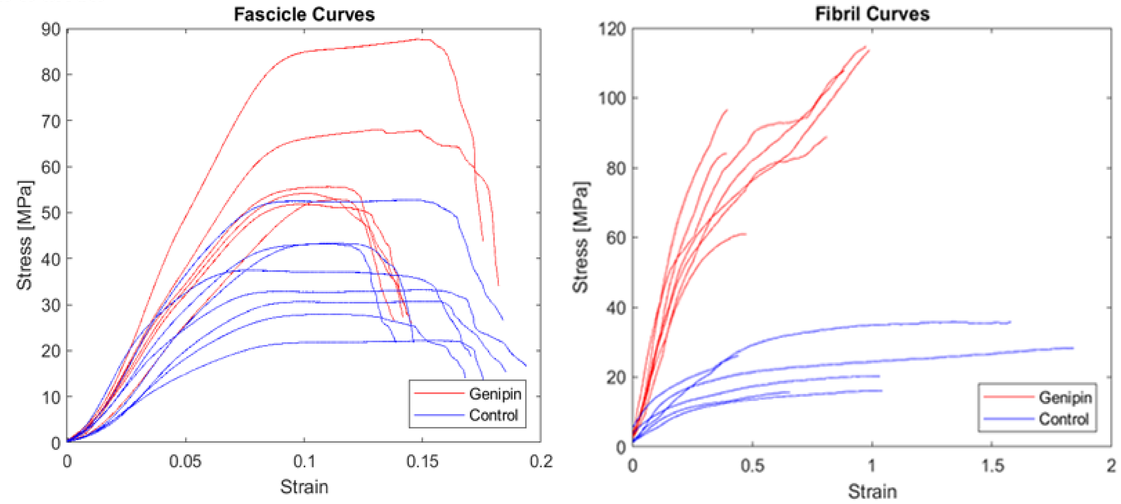


Figure 1: Stress-strain curves for fascicle (left) and fibril (right) tensile tests.

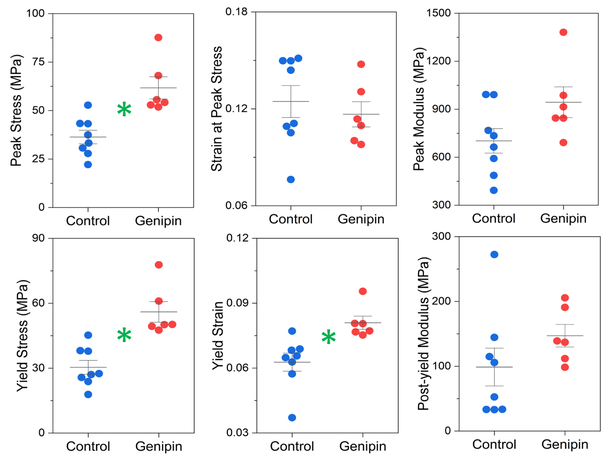


Figure 2: Results for **fascicle** tensile testing. Peak stress, yield stress, and yield strain were significantly higher for genipin group. * = $p < 0.05$.

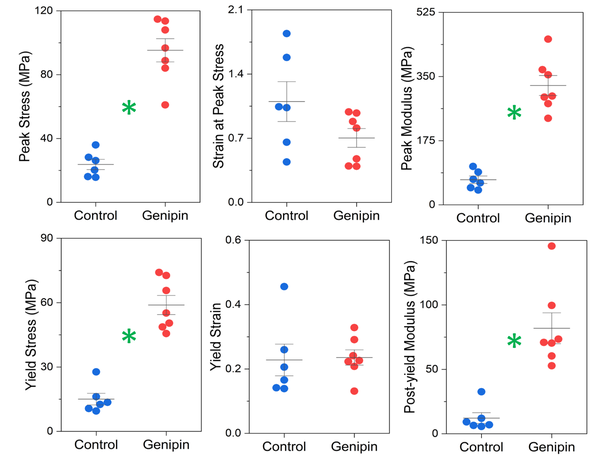


Figure 3: Results for **fibril** tensile testing. Peak stress, peak modulus yield stress and post-yield modulus were significantly higher for genipin group. * = $p < 0.05$.

Discussion

- Genipin treatment at the fascicle level increased yield stress and yield strain, increasing toughness but not peak modulus. This is likely due to fiber and fibril sliding, where their lateral distance remains unaffected by chemical crosslinking.
- Genipin treatment at the fibril level increased yield stress, pre-yield modulus, and post-yield modulus, while leaving yield strain unchanged. This suggests genipin crosslinking enhances lateral load transfer among collagen molecules within the fibril. Increase in post-yield modulus indicates that the effects of genipin crosslinking endure even as damage accumulates at the fibril level.

References:
[1] Zitnay et al. Nat. Commun. 2017.
[2] Eekhoff et al. Conn. Tiss. Res. 2018.

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