The Residual Strain State of the Intervertebral Disc

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We have no other disclosures
Residual stress and strain from
- Osmotic swelling
- Annulus fiber pre-strain

- **swelling-only model** with osmotic swelling
- **multigeneration model** with both osmotic swelling and generational fiber strain

Newman et. al. BMES 2020
Newman et. al. JOR Spine, 2021
Objectives

Human Disc Models:
• validated with independent disc-scale experiments (Newman et. al. BMES 2020)

The first objective of this study was to quantify the fiber residual contributions in these models to explain their different outcomes.

Bovine Disc Models:
• residual strain experiments (Michalek et. al. 2012)

The second objective of this study was to simulate this experiment with both of our finite element models and verify the outcomes against the experimental work as well as quantify the fiber residual contributions.
Human Disc Models:
- see (Newman et. al. BMES 2020, Jacobs et. al. 2014) for details
- fiber stress and strain were evaluated at a physiological, axial preload

Bovine Disc Model:
- simulated as a cylinder with the same material properties as in human disc model
- fiber stress, strain, and opening gap were evaluated
Results / Discussion (Human)

Figure 1: The fiber stress and strain distributions for the swelling-only model were highly concentrated in the inner AF (A/C) while the fiber contribution in the multigeneration model was distributed and uniform throughout the AF (B/D).
Figure 2: The fiber stress and strain distributions for the swelling-only model were highly concentrated in the inner AF (A/E/F) while the fiber contribution in the multigeneration model was distributed and uniform throughout the AF (C/D/G/H).
Summary Points

• Residual contributions were evaluated
• Swelling-only model had high, artificial concentrations in innermost annulus
• Multigeneration model had uniform distributions
• Multigeneration model had reasonable bovine opening gap

Primary mechanisms of residual strain in the disc:
  • Osmotic swelling
  • Annulus fiber strain