Characterizing the Mechanical Response of the Extra Fibrillar Matrix of the Annulus Fibrosus

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Background

• The Basics
  ▫ Structure
  ▫ Function

• The Problem
  ▫ Back pain

• The Solution
  ▫ Finite Element Models

http://healthpages.org/
Objectives

- Evaluate/ refine current models
- Collect data
- Test with regional distinction
- Develop parameters
Outline

- Confined Compression
- Tensile Loading

Key Terms

- Annulus Fibrosus (AF)
- Outer Annulus fibrosus in the anterior region (OAA)
- Inner Annulus fibrosus in the anterior region (IAA)
- Outer Annulus fibrosus in the posterior region (OAP)
Methods - Imaging and Motion Segments
Methods - Dissection
Methods - Dissection
Methods - Microtoming
Methods - Confined Compression

- Swelling
- Punching
- Precondition
- Ramps
Data Analysis

Ramp cycles

Curve Fitting
Results - Confined Compression

- EFM Free-Swelling Stretch
  - Direction of Swelling
  - IAA
  - OAA
  - OAP

- Stiffness due to Solid Tissue
  - Percentage of Compression

- Stiffness Due to Osmotic Pressure
  - Percentage of Compression

- Percentage of Solid Tissue Contribution
  - Percentage of Compression
Results - Confined Compression

First Ramp

Fifth Ramp

• Annulus Fibrosus (AF)
• Outer Annulus fibrosus in the anterior region (OAA)
• Inner Annulus fibrosus in the anterior region (IAA)
• Outer Annulus fibrosus in the posterior region (OAP)
Results - Confined Compression

- Annulus Fibrosus (AF)
- Outer Annulus fibrosus in the anterior region (OAA)
- Inner Annulus fibrosus in the anterior region (IAA)
- Outer Annulus fibrosus in the posterior region (OAP)
Methods- Tensile Loading

Sample Preparation

- Disc Height
- Posterior
- Radial Length
- Anterior
- Circumferential
- Axial
- Radial

Axial
Circumferential
Methods - Tensile Loading

Sample Preparation

- Microtoming
- Swelling
- Fingers and markers
Methods - Biaxial and Uniaxial Loading

Apparatus and Preconditioning

![Image of laboratory equipment]

**Strain Profile for Preload**

- **Time (s)**
- **Strain**

0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16

0 500 1000 1500 2000
Methods- Biaxial and Uniaxial Loading

Ratio Tests

1:1 Ratio

2:1 Ratio
Data Analysis - Tensile Loading

Circumferential Axis

Load (N) vs. Displacement (mm) graph.
Results - Tensile Loading

2:1 Ratio

1:1 Ratio

Degeneration Grade

Stiffness (N/mm)
Results - Tensile Loading

### 2:1 Ratio

- OAA (Circumferential)
- IAA (Circumferential)

### 1:1 Ratio

- OAA (Circumferential)
- IAA (Circumferential)
Conclusions and Future Work

- Protocol Development
- Distinction between regions
- Noticeable trends
- Limitations
- Parameters for finite element models
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% Solid Contribution vs. Degeneration

Percentage of Solid Tissue Contribution to Stiffness

Degeneration Grade
First Ramp

Percentage of Solid Tissue Contribution to Stiffness

Degeneration Grade
Last Ramp

- IAA
- OAA
- OAP