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CHANGES IN TISSUE DIFFUSION AND ANISOTROPY FOLLOWING MECHANICAL LOADING OF OVINE ANULUS FIBROSUS: A PILOT STUDY USING MAGNETIC RESONANCE IMAGING

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Introduction
The current pilot study sought to explore the functional micro-mechanics of the anulus fibrosus using both imaging and experimental methods, in order to better understand the underlying mechanisms which govern the interplay between disc mechanical function and microstructure.

Methods
Six axially-aligned samples of anulus fibrosus were obtained from a merino sheep disc (L5-L6). Each sample consisted of vertebral bone-disc-vertebral bone. The samples were mechanically loaded in unconfined axial compression, at a rate replicating physiological loading. A maximum strain of 50% was reached during 5 cycles to capture the tissue response following initiation of damage.
Magnetic Resonance Diffusion Tensor Imaging (DTI) can be used to measure the restricted diffusion of water molecules in biological tissues and tissue alignment can be inferred. Here, DTI was conducted for each anulus sample before and after mechanical testing. From the principal eigenvectors (PEV) and eigenvalues of the resultant diffusion tensors, the direction and average magnitude of water diffusion (mean diffusivity, MD) and the degree of diffusion anisotropy (fractional anisotropy, FA) were calculated for each imaging voxel.

Results
The mechanical response of the anulus fibrosus samples in unconfined compression was nonlinear. A comparison of MD, FA and PEV maps for each sample before and after mechanical testing showed:

- Diffusion of water molecules was less restricted following mechanical testing.
- The displacement of water molecules was more directional following mechanical testing.
- Analysis of the PEV showed clear striations representative of the different collagen directionality between adjacent lamellae.
- PEV in each lamellae become more closely aligned following mechanical testing.

Conclusion
A comparison of DTI of anulus fibrosus samples before and after mechanical testing showed clear changes in diffusivity, indicating the tissue becomes more anisotropic following mechanical testing. This increase in anisotropy is possibly due to the collagen fibres becoming more aligned.

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