# Methodology

- Six porcine lumbar functional spinal units (FSUs) were used for five test specimens and one control specimen.
- FSUs consisted of two vertebral bodies and an intervertebral disc (IVD) with surrounding musculature removed.
- Four acoustic sensors and two hydrophones were attached to FSU to detect unintended bone fractures (Fig. 1).
- Specimens were loaded in an environmental chamber held at 37°C and saturated humidity to simulate in vivo environmental conditions.
- Test specimens were loaded with biaxial test fixture (Fig. 2) in constant flexion at 3° and constant compression, between 840-1345 N, until an inflection in the displacement-logtime history.
- The control specimen was not loaded or flexed but subject to the same preparation, instrumentation, and environmental conditions.
- All specimens were imaged with high-resolution (80-100 μm/voxel) computed tomography (CT) before and after testing.

# Results

- No endplate or bone fractures were observed in post-test CT in any specimen.
- The control specimen showed no differences in the structure of the annulus fibrosus (AF) of the IVD before (Fig. 3A) and after (Fig. 3B) environmental conditions.
- Post-test CTs showed novel microdamage to AF fibers (Fig. 4B) in the IVD, such as annulus separation and breakage, particularly in the anterior and lateral regions, for all test specimens when compared to pre-test images. (Fig. 4A)

# Discussion & Conclusions

- The anterior and lateral regions experience the greatest compressive strain due to applied flexion and endplate curvature.
- Clinical CT imaging (0.5-1.5 mm/voxel) would not detect this damage, with at least 200x lower volumetric resolution.
- Healthy IVDS have nerve fibers in the outer AF and studies show degenerated IVDS have increased number of nerve fibers.6
- This low-level outer AF damage may present as clinical pain.
- More investigation is needed to determine whether this AF damage is susceptible to healing in vivo and if/how this incipient damage is associated with pain.
- AF microdamage detection in this study was qualitative and further investigation is needed to develop a risk threshold.
- These results, facilitated by high-resolution imaging, may be demonstrating incipient failure due to flexion-compression loading that leads to more serious IVD injury with subsequent loading.

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