Role of endplates in contributing to compression behaviors of motion segments and intervertebral discs

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INTRODUCTION: Intervertebral disc explants are commonly used to investigate the mechanics and mechano-biology of the disc. This study tested the hypotheses: 1) the mechanical behaviors of the intervertebral disc tested as explants are similar to those in the motion segments provided that endplate boundary conditions are similar, and
2) axial compression loading on motion segments will lead to non-recoverable damage in both the vertebral endplate and intervertebral disc. Rat caudal disc explants and motion segments were used as this is a common model for applying compression loading to the intervertebral discs in vivo, e.g., [1].

METHODS: Motion-segments (vertebra-disc-vertebra), disc explants, and single vertebrae were isolated from adjacent caudal levels of Sprague-Dawley rats (n=11). Motion-segments were harvested, potted in cyanoacrylate and tested with specially designed grips; disc explants were isolated using a scalpel and tested on rigid, porous platens; single vertebrae were potted and tested against rigid porous platens. All specimens underwent a force-controlled test protocol in PBS with protease-inhibitors and the following loading-stages: equilibration (0.5N-4hrs), 0.2MPa creep (4hrs), recovery 1(0.5N-6hrs), 1.0Mpa creep (4hrs), recovery 2(0.5N-6hrs). Elastic properties were determined from load, displacement and time data, while viscoelastic parameters were determined by curve-fitting to a stretched-exponential model.

A second series of experiments was performed to asses the influence of boundary conditions on transient behaviors of disc explants by modifying platen permeability from 3.2x10-10 to approximately zero while maintaining surface roughness (~20 um pores).

RESULTS: At 1.0MPa loading, deformations were similar in vertebrae and discs (Fig. 1). After accounting for vertebral deformations, disc deformations in the motion segments were not significantly different from explants (p=0.4). Time constants (as determined from stretched-exponential model) were significantly ($p<0.01$) larger for motion segments ($\tau=496\pm241$s) than explants ($\tau=87\pm40$s).

Permanent deformations in the motion segment and explant following the 1 MPa loading cycle and recovery were 0.6±0.6mm and 0.08±0.04 mm, respectively. Therefore, the largest permanent deformations were in the vertebrae, yet both measurements represented <10% permanent loss of height in the motion segment complex and explant, respectively.

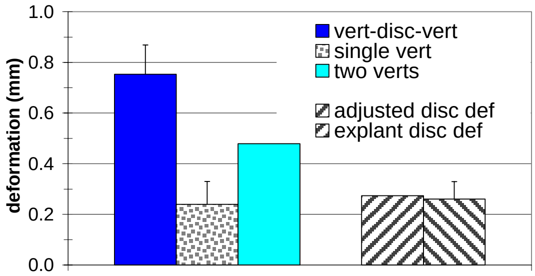

Fig. 1: Equilibrium deformations at 1 MPa for motion segment (vert-disc-vert), and 1 or 2 vertebrae (vert). Motion segment deformation was adjusted to arrive at disc deformation and compared with explant deformations.

DISCUSSION & CONCLUSIONS: Motion segment testing preserves in situ conditions most closely, however, disc explant testing provides maximum control over disc boundary conditions. Our results suggested disruption of the collagenous-network between the disc and vertebral endplate had minimal impact on disc equilibrium deformations compared to motion segments provided that vertebral deformations were accounted for. Differences in endplate boundary conditions between explants and motion segments had large impacts on transient behaviors with implications for pressurization and transport. Ongoing studies are investigating the influence of permeability and surface roughness on the equilibrium and transient behaviors of explants.

REFERENCES: [1] J.J. Maclean, C.R. Lee, M. Alini, J.C. Iatridis (2004) *Anabolic and catabolic mRNA levels of the intervertebral disc* …, J Orthop Res. **22**:1193-200.

ACKNOWLEDGEMENTS: Supported by NIH grant R01AR051146.