INTRODUCTION

The facet joint capsule (FJC) is innervated with mechanically sensitive neurons and is a source of low back pain (LBP) (Cavanaugh, 1995). An approach to studying the lumbar spine and its components contributing to LBP is to develop computational models (e.g., FEM). However, existing FE models (Gilbertson et al., 1995) of the human lumbar spine have not used realistic geometry and material properties of lumbar FJC, modeling it as uniaxial springs rather than as an anisotropic, viscoelastic 3D material. The purpose of this study was to determine the material properties of the FJC, both parallel and perpendicular to the dominant orientation of the collagen fibers.

METHODS

Intact, unembalmed lumbar spines (n = 8) were procured using an institutionally approved protocol. Specimens were dissected and the laminae of the superior and inferior facets were transected to free the intact joint and capsule from the spine. The sides of the capsules were trimmed, allowing the facet joint to be opened flat. The geometry of the specimens was controlled to produce specimens with the collagen fiber orientation aligned either “parallel” or “perpendicular” to the axis of loading (n = 25 and n = 10, respectively).

Capsules were tested using a uniaxial ramp-hold (R-H) protocol (15% strain/s to 10-50% strain with a 300 s hold) or a haversine displacement protocol (10-50% strain at 0.2, 1.0, and 2.0 Hz; parallel only). During R-H trials, a viscous stress calculation was made at the peak force, and an elastic stress was taken from the average of force values during the last 5 s of the hold, after relaxation occurred. Eulerian plane strain was measured optically (Little et al., 2003).

RESULTS AND DISCUSSION

During R-H trials, the stress-strain relationship parallel to fiber orientation was exponential in form. The “parallel” $E_V$ was significantly larger than $E_E$ for all strains (Fig. 1; Wilcoxon, $p < 0.001$, for all). $E_V$ was similar in magnitude to values previously reported for the cervical spine. The perpendicular $E$ was linear in nature, reaching a mean value of ~ 2 MPa from 20-50% strain. The perpendicular $E_V$ was larger than $E_E$ at all strains, but statistical significance was not detected (Wilcoxon, $p > 0.05$). The parallel $E$ was larger compared to the perpendicular $E$ at 50% strain (Mann-Whitney, $p < 0.001$).

During dynamic trials, the mean stress-strain...
relationship was also exponential in form. 

$E^*$, $E''$ and $E'$ were unaffected by changes in cycling frequency, but did significantly increase with increasing haversine strain (2F-RM ANOVA, $p > 0.05$ and $p < 0.001$, respectively). $E^*$, $E''$ and $E'$ were maximum at 50% haversine strain and were similar to $E_V$, $E_E$, and $(E_V - E_E)$, respectively.

Lumbar facet joint capsules exhibited stress relaxation (SR). Perpendicular capsules had an SR rate independent of peak strain magnitude, typical of linear viscoelastic materials. Parallel capsules had a non-linear SR rate, as it was dependent upon the peak strain magnitude.

**SUMMARY**

The mechanical behavior of the FJC was non-linear, viscoelastic and anisotropic, and was consistent with the anatomical data of the dominant orientation of collagen fibers in the FJC perpendicular to the long axis of the spine. The data supports the concept that in order to fully elucidate the FJC’s role in LBP, it should be modeled as a 3D material with appropriate characteristics.

**REFERENCES**


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