Effect of axial compression on intervertebral disc torsional mechanics

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INTRODUCTION

The primary function of the intervertebral disc is to absorb and transfer large complex loads placed on the spine, including combinations of compression, tension, bending, and torsion. Collagen fibers in the annulus fibrosus are oriented at ±30^{o} to the horizontal plane, suggesting an important role in load distribution during torsional loading. However, there is little data on the torsional mechanical function of the healthy, injured or degenerated disc. The objective of this study was to evaluate the effect of axial compressive preload on torsional mechanics of healthy discs.

METHODS

Motion segments were prepared from bovine caudal spine sections. Axial compression (20 – 750N) was applied, followed by 20 cycles of torsion (±5^{o}, 0.5Hz). Torque-rotation data from the final cycle was analyzed. A Pearson's correlation was performed to determine the effect of axial compression prestress on torsional mechanics.

RESULTS

The torque-rotation response was slightly nonlinear (Fig. 1A). There was a strong linear correlation between torsional stiffness, shear modulus, and energy loss per volume with respect to axial compressive load (Fig. 1B-D). Within the physiological range of axial compressive preload (≤ 1.0MPa), there was up to a 5-fold increase in torsional mechanical properties.

DISCUSSION

Evaluating the combined effect of axial compression with torsion is important for understanding common disc injuries, such as herniations and annular tears. The findings reported here demonstrate a strong correlation between physiological levels of axial compressive prestress and torsional mechanical function of the disc. Future work will evaluate the effect of axial compression prestress on healthy and degenerated human discs. In conclusion, this preliminary data with healthy bovine discs provides a baseline understanding of disc function under axial rotation with applied axial compression, which will be useful for validating finite element models of the disc joint.

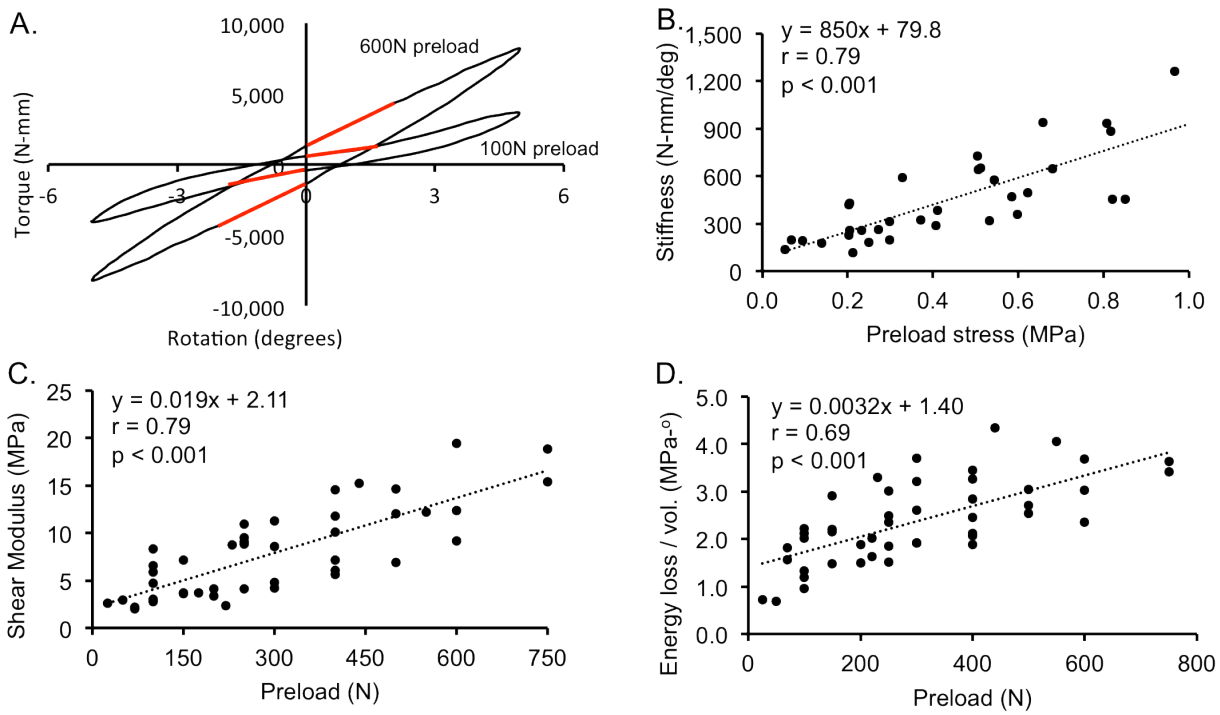

Fig. 1: A.) Torque-rotation behavior for a representative sample preloaded at 100N and 600N. B.) Torsional stiffness vs. preload stress. C.) Shear modulus and D.) energy loss per volume with respect to axial compression preload.