Compression-torsion mechanical properties of the human intervertebral disc joint

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Introduction: The spine experiences large complex loads during daily activity. Together with the intervertebral disc, the facet joints play an important role in absorbing and transferring these loads, especially during axial rotation. The articulating surfaces of the facet joints act to support and protect the intervertebral disc from overloading, which may result in degenerative changes or disc injury. Previous studies suggest that facet joints absorb less than 25% of compressive loads applied to the disc joint *in situ*. With high compressive loads, the articular surfaces of facet joints might engage and constrain the motion of the disc joint under combined loading modes involving extension or rotation. Early work by Farfan et al. suggest that the facet joints provide 25-45% of the torque strength of the whole intervertebral disc joint; however, the sample size was small (n = 1) and the effect of compression coupled with torsion was not assessed.

Aim: To evaluate compression-torsion mechanics of healthy human lumbar intervertebral discs.

Materials and Methods: Motion segments were prepared from healthy L3-L4 and L4-L5 levels of human spines (n = 9, age: 43 to 80, Pfirrmann grade: I to III). Axial compression was applied at 300, 600, 900 or 1200 N for 2 hours, followed by 10 cycles of rotation (± 2°, 0.05 Hz). Additional care was taken to ensure intact facet joints and intervertebral disc. The facet joints were removed and retested under the same compression-torsion conditions. The last cycle of torque-rotation data was analysed and paired samples t-test was used to determine the effect of facet joints on torsional disc mechanics.

Results: There was 23% increase in disc height loss under creep loading after facet joint removal. Meanwhile, torsional mechanical properties (stiffness, shear modulus, torque range and energy loss) decreased significantly (Fig.). During rotation, the axial displacement was observed to follow a sinusoidal response, which was observed in our previous work with bovine discs. The axial displacement range decreased from 0.14 mm with facets to 0.08 mm without the facet joints. Similar relationships were observed for the 300, 900, and 1200 N axial compression groups (data not shown).

Conclusion: The present study investigated load distribution between the intervertebral disc and facet joints of healthy human discs under moderate loads. Our results indicated that majority of compressive loads were absorbed by the intervertebral disc. As expected, the facet joints had much more significant contribution (~70%) to the disc torsional mechanics, and acts to protect the disc from damage. Interestingly, the relative contribution by the disc joint remained constant under all axial compression loading conditions, suggesting that torsional loads are not directly transferred to the facet joints at higher compressive loads. This may provide insights into why twisting while lifting heavy objects may lead to lower back pain and disc injury. Future work will evaluate the contribution of the disc to compression-torsion mechanics with injury and degeneration.

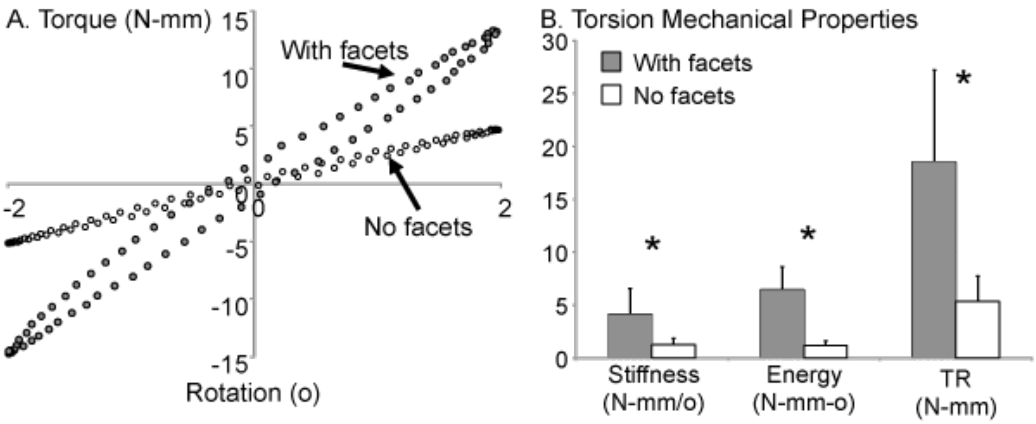

Figure. (A) Representative torque-rotation response and (B) change in torsion mechanics with and without facets. Data shown for 600 N axial compression group. * represents $p < 0.001$.