Effect of hydrogel injection on the biomechanical behaviour of herniated discs

Orthopaedic Biomechanics

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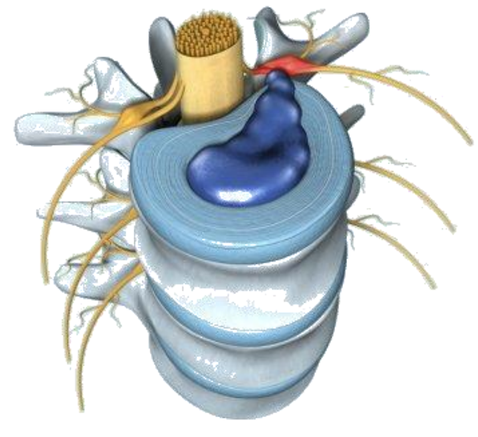


Introduction

Hydrogel-based nucleus pulposus (NP) replenishment is a promising treatment to restore the decreased NP volume in herniated discs (Fig. 1) (Kurtz, 2006).

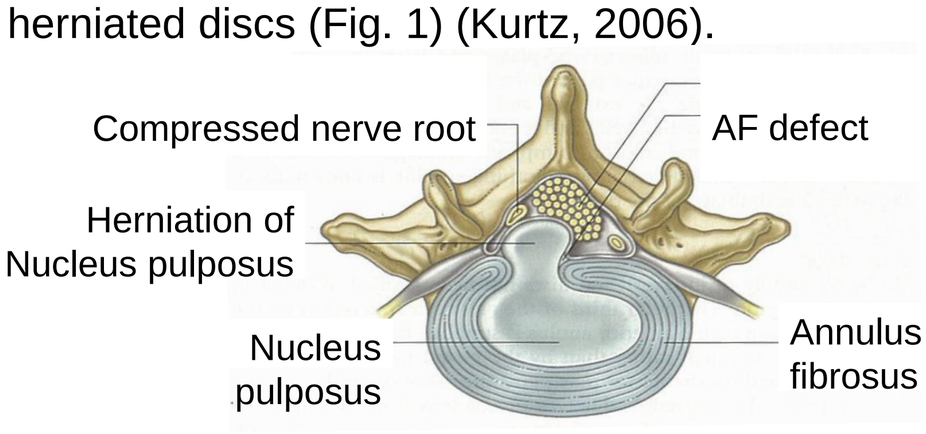


Fig. 1. Herniated intervertebral disc.

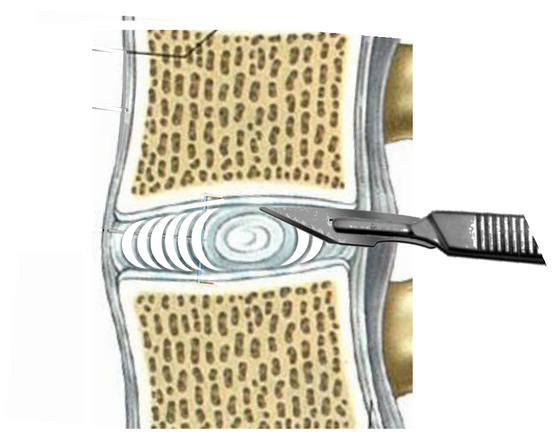
Aim: Evaluate a thermo-responsive hydrogel with similar dynamic and Young's modulus to NP tissue (Craenmehr, 2009).

Hypothesis: By replacing the herniated NP (HNP) volume with a material of similar mechanical properties, the biomechanical characteristics of the intervertebral disc would be restored.

Methods

Reproducible ex-vivo bovine disc herniation model

Herniated discs were created by stabbing the full depth of the annulus with a scalpel, and then applying a cyclic compression in a flexed position (Fig. 2) (Adams, 1985).



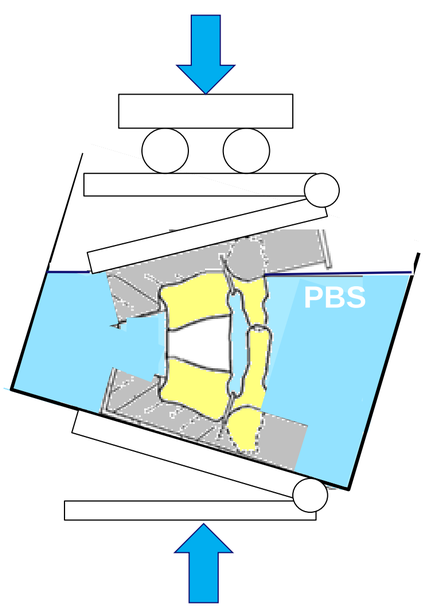


Fig. 2 *Left*: Stab incision of the annulus; *Right:* Apparatus used to apply cyclic compression in a flexed angle (adapted from Adams 1985).

To simulate treatment, 2 groups:

- hydrogel injected in the nucleus (n=6)
- HNP tissue reinserted (n=3)

In both cases, the annulus was glued and sutured.

Mechanical test: Disc axial displacements were measured under creep loading for the three disc conditions: healthy, herniated and treated (Fig. 3).

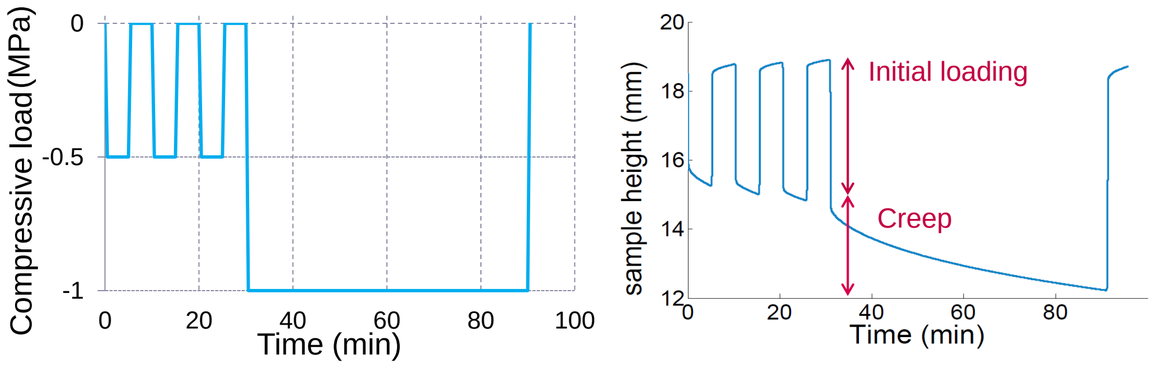


Fig. 3. *Left*: Loading protocol, *right*: Typical displacement curve.

Results

Healthy, herniated, hydrogel injected and NP reinserted discs, showed similar creep responses, whereas the initial strain for herniated and hydrogel injected discs were significantly different ($p < 0.05$) from healthy discs (Fig.4).

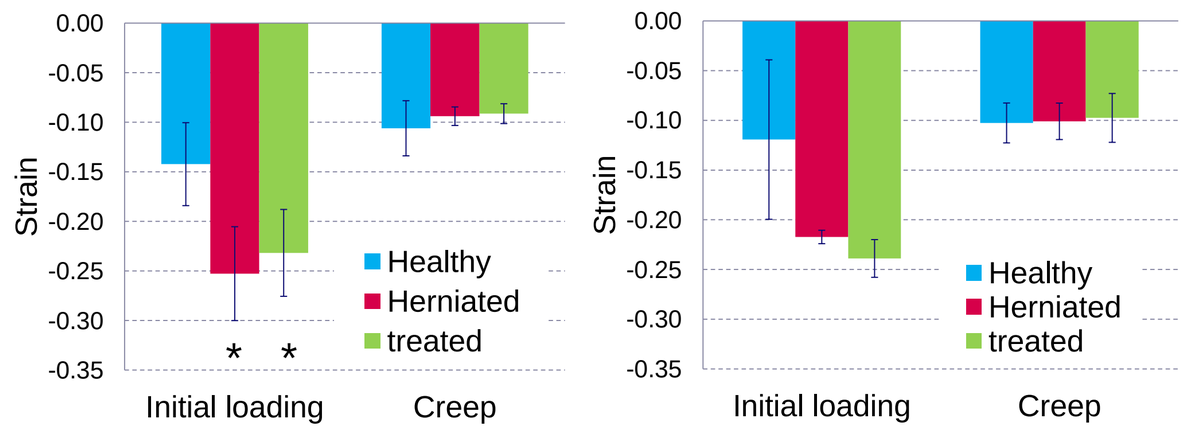


Fig. 4 Initial strain and creep strain for healthy, herniated and hydrogel injected disc (n=6, left) or NP reinserted disc (n=3, right), * $p < 0.05$.

However, no significant differences were observed between herniated and hydrogel conditions as well as between herniated and reinserted discs (Fig. 4).

Discussion

The creep testing showed no improvement of the biomechanical properties neither in hydrogel injected or HNP reinserted discs. It appears that the axial biomechanical properties of the herniated SMSs were dominated by a defect other than that of HNP tissue volume loss. Although the annular defect was sutured and glued, this appears to be insufficient.

Conclusion

Thus, in this model NP replenishment alone could not restore the healthy axial disc behaviour, and the development of better annular repair methods are encouraged.

References

Adams *et al*, Spine, 10:524-531, 1985.
Craenmehr *et al*, WO2009131454, 2009.
Kurtz *et al*, Spine Technology Handbook, 2006.