BIOMECHANICAL IMPACT OF INTERVERTEBRAL DISC SIMULATED DAMAGE

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Introduction

The intervertebral disc (IVD) has an important role in the load distribution on the adjacent vertebral bodies and in the entire spine motion [1]. Pathological lesions and injuries of the disc occurring during surgical treatment could have a mechanical impact on the spine motion, stability, and in the surrounding tissues (e.g. compression of nerve roots posteriorly). The aim of this work was to evaluate the consequences of different types of intervertebral disc lesions on the human spine biomechanics, in terms of posterior disc height, range of motion (ROM), stiffness and strain distribution.

Materials and method

Eight fresh cadaver thoraco-lumbar FSU's were prepared. The soft tissue around the disc and vertebral bodies, and the posterior element were removed, leaving the anterior ligament intact.The FSU's were horizontally aligned. The extremities were potted into acrylic cement. A white-on-black speckle pattern was sprayed on the specimens to measure displacements and strains with Digital Image Correlation (DIC). The specimens were tested in flexion and extension. Surface images were recorded by a 3D-DIC system (Q400, Dantec). Image correlation was performed using optimized parameters [2]. The displacements were analyzed to compute the change in posterior disc height, ROM, transition displacement, transition load and elastic stiffness [3]. Each specimen was tested sequentially through five conditions (Fig. 1):

- INT: with the intact disc;
- 2CUTS: two vertical incisions on the lateral side;
- 4CUTS: four incisions, forming a square, without removing any part of the annulus fibrosus (AF);
- SQR: after removing the squared plug of the AF;
- NUCL: after removing the nucleus pulposus.

All the defects were executed manually in the opposite side to that observed by DIC.

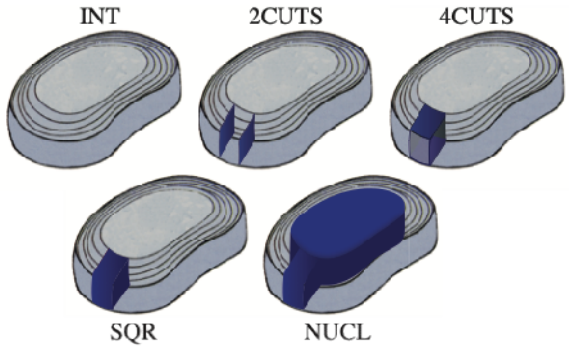

Figure 1: The IVD in the different conditions: the blue portions represent the incisions and removed material.

Results and discussion

The posterior disc height showed a significant 20% decrease in flexion, and 23% decrease in extension from INT to NUCL. These results confirmed the clinical observation [4] according to presence of nucleus inside. A general decreasing trend of the ROM was observed in both loading configurations, but there were no statistically significant differences between the five discs conditions. The level of disc damage did not significantly impact the transition displacement, transition load and elastic stiffness. Different strain distributions were observed for maximum (Ɛ1) and minimum (Ɛ2) principal strains in flexion and in extension (Fig. 2).

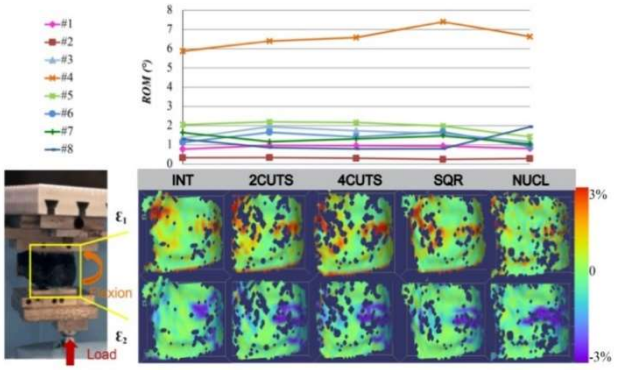

Figure 2: Results for flexion for the 5 disc conditions. Left: specimen with the speckle pattern on the testing machine. Top right: ROM (8 specimens); Bottom: distribution of $\mathcal{E}_1$ and $\mathcal{E}_2$ on the lateral side of the FSU.

Conclusions

The results have shown that sequential damage of the annulus fibrosus does not significantly alter the spine biomechanics in terms of range of motion, stiffness and strain distribution. The main effect observed was the posterior disc height reduction after the nucleus removal due to the lack of support caused by the nucleus loss.

References

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2. Palanca et al, MEP, 52: 76-83, 2018
3. Tanaka et al, J BiomechEng, 133: 074502-2, 2011
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Ethics

The study was approved by the bioethical committee of University of Bologna, prot. 76497, 1 June 2018.