Evaluation of the impact on spine biomechanics of percutaneous cement discoplasty procedure as a treatment for degenerated discs

C.Techens[1], S. Montanari [1], F. Berzcki [2], P.E. Eltes [2], A. Lazary [2], L. Cristofolini[1]
[1] DIN, University of Bologna, Bologna, Italy [2]In silico laboratory, National Centre for Spinal Disorders, Budapest, Hungary

Introduction

Spinal nerve compression is often due to stenosis of the foramen, associated with intervertebral disc degeneration. Percutaneous cement discoplasty (PCD) is a recently developed minimal invasive surgical procedure for the polymorbid ageing population with vacuum disc degeneration [1]. The mechanical impact of PCD on the spine stability and the surrounding tissue have not been investigated yet. After an encouraging preliminary work on porcine spines, this study aimed at: (1) testing the stability of human spine segments after discoplasty by monitoring the disc height and the range of motion, (2) assessing the strains on the disc surface for potentially dangerous peaks, (3) relating the biomechanical behaviour to surgical procedure parameters.

Methods

27 fresh-frozen human thoraco-lumbar FSUs were obtained from 15 cadaveric spines (35-86 y.o.). The specimens were aligned with the intervertebral disc horizontal; the extremities were potted with acrylic cement. In order to measure surface strains with Digital Image Correlation (DIC), a white water-based speckle pattern was sprayed on the specimens previously stained with methylene blue. The specimens were tested in flexion and extension under 50% body weight axial load combined to an offset. Images were analysed by a 3D-DIC system (Q400, Dantec) using optimized parameters. The Range of Motion (ROM) and the Posterior Disc Height (PDH) were derived. The displacements and principal strains were also computed [2]. Each specimen was sequentially tested under two conditions: (1) simulated degeneration: the intervertebral disc was manually emptied through a hole in the annulus, (2) after acrylic cement (Mendec Spine, Tecres) injection (discoplasty). Cement distribution in the intervertebral space was investigated in term of thickness, volume and surface from CT scan images.

Results/Discussion

The injected cement volume was averaged at 4.5 mL with similar shapes as those of PCD performed on patients *in vivo*, confirming the reliability of the in vitro model. The PDH was significantly restored by discoplasty for both flexion and extension, increasing by 41% and 35% respectively with respect to the degenerated condition. The rise of PDH significantly correlated with cement thickness. The ROM was significantly reduced in flexion due to the action of the posterior elements, but not significantly in extension although post-surgery ROM positively correlated with cement thickness. Discoplasty decreased the average strain and shifted the peaks of first principal strains towards the mid-height disc, while the second principal strain was clearly located along the endplates (Fig. 1). Additionally, strain peaks were smaller after discoplasty, reducing the risk of local tissue damage.

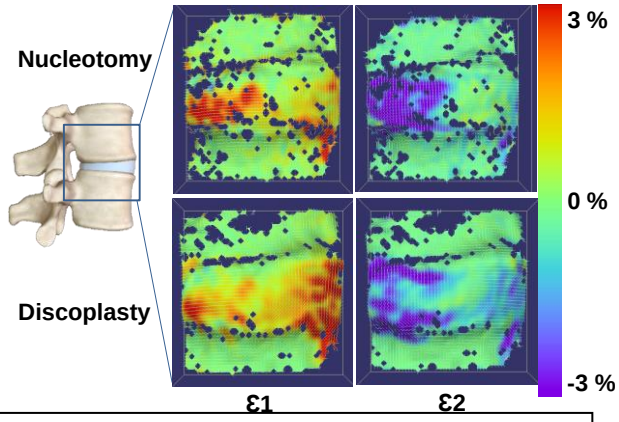

Fig.1: True principal strains (Ɛ1 and Ɛ2) in extension after nucleotomy, and discoplasty.

Acknowledgement

European Union's Horizon 2020 Marie Skłodowska-Curie ITN grant SPINNER No. 766012 and the Hungarian Scientific Research Fund (OTKA FK123884).

References

1. Varga P. et al. *Der Ortho*, 2015, 44:1-8.
2. Palanca et al, *MEP*, 2018, 52: 76-83.