EVALUATION OF STABILIZATION FOLLOWING TREATMENT OF DEGENERATED INTERVERTEBRAL DISCS WITH DISCOPLASTY

Chloé Techens (1), Marco Palanca (1), Maria Luisa ruspi (1), Luca Cristofolini (1)

1.Department of Industrial Engineering, Alma Mater Studiorum – Università di Bologna, Italy

Introduction

Low back pain can be caused by nerve compression due to stenosis of the foramen associated with intervertebral disc degeneration. Invasive surgical solutions such as interbody fusions can be used to improve the patients' state, but cannot be performed on weak patients with comorbidities. A less invasive approach, percutaneous discoplasty (injection of bone cement inside the disc), has been recently developed for the elderly [1]. The mechanical impact on the spine stabilization and surrounding tissues have not been investigated yet.

The aims of this *in vitro* work are to: (i) develop a method to simulate degenerated discs and (ii) test the stabilization of spine segments through discoplasty.

Materials and method

Porcine lumbar spine FSU was obtained at the slaughter house from healthy young animals. All the soft tissues around the vertebral body were removed, leaving intact the ligaments. The specimen was aligned with the intervertebral disc horizontal; the extremities were potted into acrylic cement. In order to measure surface strains with Digital Image Correlation (DIC), a white speckle pattern of water-based paint was sprayed over the specimen previously stained by a methylene blue solution (Fig. 1). The specimen was mechanically tested in presso-flexion, extension, and lateral bending under 5.4 Nm (maximum force: 200N). Disc surface images were recorded by a 3D-DIC system (Q400, Dantec Dynamics, Denmark). Image analysis was performed with the associated DIC software using optimized parameters. The displacements and the principal strains were computed [2]. The specimen was tested in three conditions:

(i) With the intact disc,
(ii) After having manually removed the nucleus pulposus (NP) (simulated degenerated condition),
(iii) With acrylic cement injected in place of the NP (discoplasty).

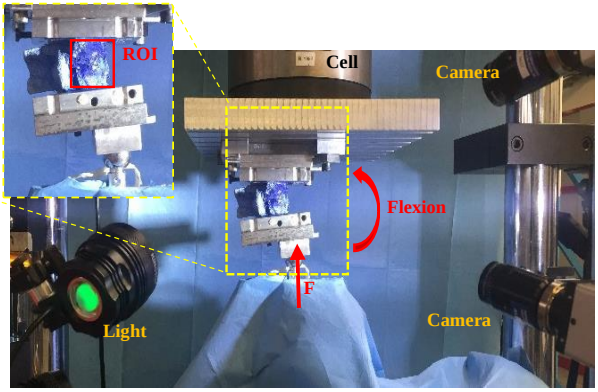

Figure 1: Experimental set-up for spine testing in presso-flexion. The Region of Interest (ROI) of DIC is located around the IVD.

Results & Discussion

Correlations and measurements were successfully performed for all loading configurations and all the conditions of the disc. The disc height has been restored by discoplasty, thus restoring the width of the foramens. While removal of the NP reduced the flexibility of the specimen, vertebroplasty restored the range of motion. The discs underwent large deformations, with different strain distribution between cases (i), (ii), and (iii) (Fig. 2). Degenerated disc exhibited the largest strains. Cement injection resulted in a wider gradient over the disc, with a mean of -50000 microstrain for the min principal strain, and some strain peaks that were different from the intact disc.

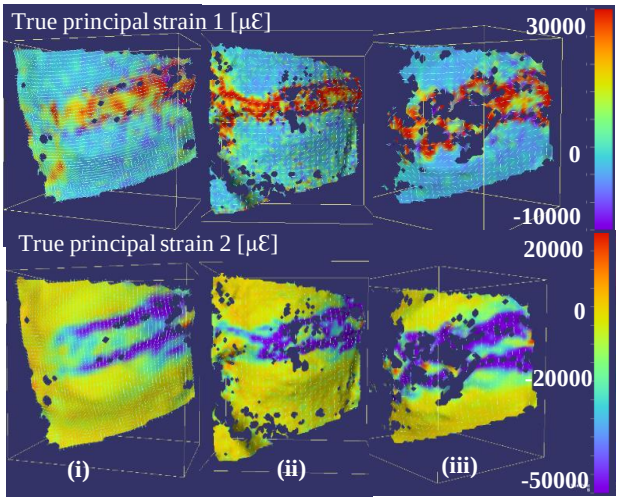

Figure 2: Strain distribution during presso-flexion on intervertebral disc surface (lateral view) in intact (i), without NP (ii), and cemented (iii) conditions for max (up) and min (down) principal strains.

Conclusions

This preliminary test has demonstrated remarkable differences before and after discoplasty both in terms of segment flexibility, and in terms of distribution of strains on the annulus fibrosus. Further tests will allow to confirm the observed trends and to establish the statistical significance of the results. The full-field strain measurement by means of DIC will allow detecting if discoplasty is inducing any concerning strain concentration on the remaining intervertebral disc.

References

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

Acknowledgement

European Union's Horizon 2020 Marie Skłodowska-Curie ITN grant SPINNER No. 766012.