FIRST APPLICATION OF DIGITAL VOLUME CORRELATION TO STUDY THE EFFICACY OF AUGMENTATION

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Introduction
The aim of this study was to investigate the biomechanical efficacy of prophylactic augmentation in preventing fracture of non-fractured vertebral body, and the failure mechanism associated with augmented vertebrae. In order to investigate the internal strain distribution and the failure pattern generated under compressive loading, Digital Volume Correlation (DVC) was applied for the first time to μCT three-dimensional images of augmented vertebrae.

Materials and Methods
Twelve porcine thoracic vertebrae (T1, T2 and T3) were assigned to two groups: 6 were augmented with bone cement for vertebroplasty (Mendec, Tecres, including ~300 μm BaSO₄ pellets), while the other 6 were tested untreated as a control. Destroitive tests were carried out under axial compression, in a stepwise fashion (0%, 5%, 10%, 15% and 20% apparent strain). At each loading step, μCT images were acquired (isotropic voxel size 38.6 μm). The internal strain distribution was investigated by means of DVC analysis (DaVis, LaVision Ltd, Uk) [1]

Results
In the natural vertebrae a rather uniform strain distribution was identified in the whole volume (Fig. 1). The most strained region corresponded to the crushed zone. Conversely, the strain values calculated away from this zone were significantly lower. In both cases the trabecular damage occurred by means of a crack propagating through the vertebra in an approximately-transverse plane.

In the augmented specimens the cement volume underwent little deformations. Conversely, the cement-bone interface and the adjacent bone volume were the most strained regions (especially in the injection location) where the strains were found to be higher than 100 000 μS and up to 200 000 μS (Fig.2).

Discussion
This study confirmed the usefulness of DVC technique in investigating augmented vertebrae, allowing a better understanding of the failure pattern. Our findings suggested that the most critical region is the cement-bone interface where a progressive micro-damage initiated, developed and then spread across the adjacent trabecular bone.

References
1. Palanca et al, J Biomech Eng.137 (7), 2015

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