BIOMECHANICAL INVESTIGATION OF AUGMENTATION IN THE LUMBAR VERTEBRAE
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Introduction
Prophylactic augmentation has been proposed to protect osteoporotic vertebrae from fracture. The aim of this study was to perform a detailed assessment of the reinforcing potential of prophylactic augmentation.

Methods
Five sets of 3 adjacent vertebrae were tested: the central one was left in the natural condition (control), while the two adjacent vertebrae were tested before and after augmentation. Augmentation was performed by injection of acrylic cement (Simplex-P) either with a unipedicular or bi-pedicular access. The quality of augmentation (volume and position of the cement mass) was documented by CT-scan. The following indicators were evaluated: sphericity and symmetry of the cement mass, and endplate contact (superior, inferior, both). A subset of specimens was prepared with 8 triaxial gauges to measure strain on the vertebral body. Axial and torsional loading was applied nondestructively to all specimens to measure the stiffness and strain (specimens with strain gauges). Then, all specimens were compressed to failure to measure the force and work to the 1st failure event, and the ultimate force and work. To enable comparisons, data from the augmented vertebrae were expressed as a % of the corresponding magnitude in the adjacent natural vertebra.

Results
A mild decrease of strain was found due to augmentation (-50% to +27%, Fig.1). Some augmented vertebrae resisted a larger load and required a larger work to failure than the adjacent natural control ones (1.2 to 45 times larger, Fig. 2). However, other augmented vertebrae withstood a lower force and less energy before failing than the natural ones (-5% to -43%). The endplate contact of the cement mass was found to significantly correlate with the ultimate load and with the works to 1st failure and to ultimate failure; correlation with the force at the 1st failure event was poorer (Fig. 3). Cement symmetry and sphericity did not correlate with any of the indicators of mechanical strength.

Discussion
Large differences were found in terms of strengthening of vertebral augmentation (some vertebrae were weaker after augmentation). While proper prophylactic augmentation can make osteoporotic vertebrae significantly stronger and tougher, suboptimal augmentation can yield the opposite effect. This finding may explain the inconsistency in clinical outcome in recent vertebroplasty studies [Buchbinder, 2009; Kallmes, 2009].

References