

Influence of Cement Augmentation on Intradiscal Pressure: A Finite Element Study

A. Rohlmann, T. Zander, G. Bergmann

Biomechanics Laboratory, Charité, Campus Benjamin Franklin, Berlin, GER

INTRODUCTION: Vertebroplasty and kyphoplasty are frequently used for internal stabilisation of a fractured vertebral body. Infiltration of bone cement (PMMA) into the vertebral body increases its stiffness significantly. Fractures in the adjacent vertebrae after vertebroplasty or kyphoplasty do occur occasionally. Thus cement augmentation is performed in some cases prophylactically.

The aim of the study was to determine the effects of volume and elastic modulus of PMMA and of outer loads on intradiscal pressure under physiological load that includes muscle forces.

METHODS: Using an osseoligamentous finite element model of the lumbar spine the volume and elastic modulus of PMMA inserted in the L3 vertebra were varied and the dependency on intradiscal pressure was determined. Two wedge-shaped fractures of the L3 vertebra were simulated. For the vertebroplasty (kyphoplasty) model an anterior height reduction of 35% (10%) related to the intact one was assumed. In order to simulate 'standing', the models were loaded with the upper body weight, a follower load [1] and a case-dependent force in the m. erector spinae [2]. The elastic modulus of PMMA was varied between 1000 MPa and 3000 MPa and the volume between 4 mL and 10 mL.

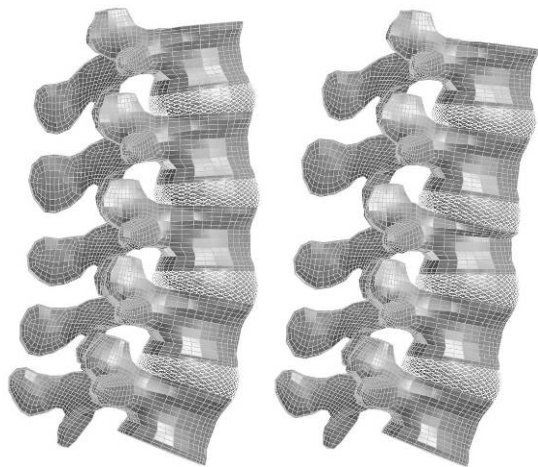


Fig. 1: Finite element model of the intact spine (left) and the fractured spine (right).

RESULTS: A wedge-shaped fracture of a vertebral body shifts the centre of gravity of the upper body anteriorly. This increases the flexion bending moment and thus the force in the m. erector spinae necessary for balancing the spine. Without compensation of the upper-body shift, intradiscal pressure in the discs adjacent to the fractured vertebra would increase by about 60% (20%) for vertebroplasty (kyphoplasty) compared to the intact lumbar spine. But even with shift compensation disc pressure is about 20% (7.5%) higher than normal.

Augmentation of the fractured vertebral body with bone cement has a much smaller effect on intradiscal pressure. The increase in that case is only about 2.4% for the intact vertebra as well as for the fractured. The effects of volume and elastic modulus of bone cement on intradiscal pressure are even smaller (1.3% and 0.2%, respectively) and thus negligible.

DISCUSSION & CONCLUSIONS: The effect of upper-body shift after a wedge-shaped vertebral-body fracture on intradiscal pressure and thus on spinal load is much more pronounced than that of stiffness increase due to cement injection. Our results do not suggest that vertebral-body fractures in the adjacent vertebrae after vertebroplasty or kyphoplasty are caused by the higher stiffness of the treated vertebra but by the anterior shift of the upper body. From the mechanical point of view a kyphoplasty is more advantageous than a vertebroplasty, especially for patients with osteoporotic vertebrae.

REFERENCES: ¹ A.G. Patwardhan, R.M. Havey, K.P. Maede, et al (1999) Spine 24, 1003-1009. ² T. Zander, A. Rohlmann, J. Calisse, et al (2001) Clin. Biomechanics 16, S73-S80.

ACKNOWLEDGEMENTS: Funding for this study was obtained from the Deutsche Forschungsgemeinschaft (Ro 581/16-1). The authors thank Jony for his support in the finite element calculations.