Regional variation of vertebral endplates strength

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1. Introduction

Anterior column of the spine, especially vertebral endplates, plays an important role in intervertebral spinal reconstruction. Therefore the intrinsic benefits associated with the use of intervertebral implants, there are many complications that can be observed with the use of this support. One of the most common of those problems is subsidence of the implant into the vertebral body [1]. This can lead to pain, deformity or nerve damage and often must be corrected by revision surgery.

The vertebral endplate is the thin layer of dense, subchondral bone adjacent to the intervertebral disc. The endplates are approximately 1mm thick and contribute to the resilience of the motion segment [2]. There are only a few analysis in literature presented the regional changes in vertebral endplates [3,4] and correlation between endplates strength and bone density [5,6]. The analysis of mechanical properties of vertebral endplates is important for better understanding of their role in spine biomechanics.

The purpose of this study was to estimate the regional variation of superior and inferior vertebrae endplates strength.

2. Methods

The research was conducted on 11 vertebrae from thoracic and lumbar part of animal spine. The specimens were stored in double plastic packaging at a temperature of -20°C. Before the start of tests the research material was defrosted at room temperature and then segmented into separate vertebrae. The endplates were cleaned using a scalpel to remove the disc and cartilage tissue, leaving the body endplate exposed (Fig.1a).

Compressive tests were performed with the MTS MiniBionix 858 strength system in indentation tests. The tests were performed using 4-mm-diameter, hemispherical intender pressed into the bone at a speed of 0.2mm/s to the depth of 3mm. Both the superior and inferior endplates of vertebrae were tested. The 9 indentation tests were conducted on each endplate (Fig.1b).

![Fig. 1](image)

The failure load and stiffness values were estimated on the base of load-displacement curves generated during the tests. The stiffness was defined as the slope of the linear region of the load-displacement curve.

3. Results

The maximum value of failure load (recorded for 1mm intendment) was observed in anterior and posterior region of superior endplate (around 730N). The average stiffness value for superior vertebral endplates was 761N/mm and for inferior vertebral endplates - 647N/mm (Fig.2). In the superior endplate the posterior and anterior regions were stronger than the middle region.
The weakness point in middle region of superior part of endplate was central point. The opposite tendency was observed in inferior endplate. The stiffness in central point obtained the value higher than in anterior and posterior regions about 16% and this changes were significantly different (p<0.03).

![Fig. 2](image)

The average stiffness value in different regions of: a) superior vertebrae endplate, b) inferior vertebrae endplate.

### 4. Discussion

Both the superior and interior vertebral endplates showed local variation of vertebral endplates mechanical properties. Presented in this study results indicate significant differences in strength and stiffness of superior and interior endplates. The weakness in central area of superior endplate can be a reason of very often observed damage of vertebra body, when prolapse of intervertebral disc material into an adjacent vertebra body is observed. Recorded results shows possible way of progress in intervertebral implant design. Specially gradual change of stiffness will allow better cooperation of implant and supporting surface.

### References


