The Effects of Vertebroplasty on Endplate Subsidence in Elderly Female Spines

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Disclosures:

Introduction: There are safety concerns that stiff bone cement (approximately ten times stiffer than osteoporotic vertebral bone) injected during vertebroplasty acts as a rigid pillar within the treated vertebra causing abnormal transfer of forces to adjacent spinal structures [1]. Finite element analyses of vertebroplasty treated spines have shown increased stresses by up to 17% in endplates adjacent to the treated level [2]. Clinically, fractures in vertebral endplates have been observed post vertebroplasty in the area immediately surrounding the augmented vertebra [3]. This may be an important mechanism for adjacent vertebral fractures, especially in women who suffer from a higher rate of compression fractures [4]. Therefore, the objective of this study was to quantify the effects of vertebroplasty on endplate subsidence in both treated and adjacent vertebrae and its relationship to endplate thickness in elderly female spines.

Methods: Five level segments (T11-L3) from female cadaveric spines (ages 51-88) were prepared for mechanical testing. A simulated wedge fracture was created in the L3 vertebral body (treated level) of all specimens. Micro-CT and DEXA scans were performed to quantify bone quantity and quality. These parameters were then used to assign specimens into either control or vertebroplasty groups (n=8/group) such that BMD, trabecular micro-architecture, and age were statistically similar between groups (p>0.5). For the vertebroplasty group, PMMA bone cement was injected (22 +/- 3% cement fill) into the fractured VB under fluoroscopy. Cyclic compression (685-1370 N sinusoid) was performed on all spine segments for 115,000 cycles at 2 Hz. The chosen cyclic loads correspond to approximately 1-2 times the body weight of a 70-80 year old female and are in good agreement with previous observations of lumbar compressive loads up to 2.5 times body weight during brisk walking [5,6]. Micro-CT scans (51 µm/voxel) were performed before and after cyclic loading to quantify endplate subsidence. Subsidence was calculated based on pre and post testing micro-CT images in the caudal endplate of superior adjacent vertebra (SVcau), cranial (TVcra) and caudal (TVcau) endplates of the treated vertebra, and the cranial endplate of the inferior adjacent vertebra (IVcra). To calculate subsidence, endplates were rotated three-dimensionally (i.e. in the x, y and z axes) to create a horizontal plane between the endplate’s anterior rim and posterior horns. Once aligned, an algorithm was developed to calculate the maximum depth of endplate. In addition, maximum endplate subsidence was correlated with average endplate thickness. To accomplish this, trabecular bone beneath the endplate was separated from the surrounding endplate and cortical shell. The average endplate thickness was then correlated to the maximum endplate subsidence.

Results: The maximum subsidence in SVcau endplate for the vertebroplasty group (0.12 ± 0.20 mm/mm) was significantly greater (p=0.05) when compared to the control group (-0.05 ± 0.08 mm/mm, Figure 1). Maximum subsidence in both the TVcra and TVcau endplates were on average greater in the vertebroplasty group; however, there was substantial variability in the treated level leading to non-significant differences (p=0.16-0.19). There was also no difference in IVcra endplate subsidence between vertebroplasty and control groups. The greatest subsidence occurred in the TVcra endplate for both groups; however, this was not significantly different (p>0.12) when compared to other endplates within a group. There was no correlation between subsidence and thickness in the SVcau for either vertebroplasty or control groups (R² <0%). For the treated level endplates (TVcra and TVcau), there was a small negative correlation for both the control (R² = 19-28%) and vertebroplasty (R² = 6-14%) groups (Figure 2).

Discussion: Vertebroplasty increased endplate subsidence in the superior adjacent and treated levels of injected vertebrae. These data add experimental evidence to previous finite element studies that demonstrated vertebroplasty alters load transfer resulting in increased stresses in adjacent endplates. With approximately 1-2 months of simulated physiological loading, we observed up to 33% subsidence of endplates within the treated level and up to 12% in the superior adjacent level with vertebroplasty. We hypothesize with longer cyclic loading some of these endplates would fracture as has been observed clinically. The endplate deformations in this study, however, were only weakly correlated with the average thickness of the endplate. More localized correlation may be necessary to determine the importance of endplate thickness in subsidence.

Significance: Bone cement injected during vertebroplasty increases subsidence in the endplate superior to the treated level. These results suggest that vertebroplasty may negatively impact endplates by increasing the risk of subsidence and fracture. Taken together, these data may elucidate the mechanism behind subsequent compression fractures post vertebroplasty, especially in vertebrae superior to the treated level.

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**Figure 1:** Endplate subsidence (mm/mm) for control and vertebroplasty groups in the superior caudal (SVcau), treated cranial (TVcra) and caudal (TVcau), and cranial (IVcra) endplates.

**Figure 2:** Correlation of endplate subsidence with average endplate thickness in the superior caudal (top left), treated cranial (top middle) and treated caudal (bottom).

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