ADJACENT LEVEL LOAD TRANSFER FOLLOWING VERTEBRAL COMPRESSION FRACTURES TREATED BY CEMENT AUGMENTATION

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INTRODUCTION

Osteoporosis is a common clinical problem affecting more than 24 million people in the United States [1] and is a “systemic skeletal disease characterized by low bone mass and micro-architectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fracture.” [2]. Vertebral compression fractures (VCFs), the most common osteoporotic fractures, lead to significant and progressive physiologic and functional limitations [3], that are compounded when subsequent VCF occur with serious long term consequences. There is up to a 30% age-adjusted increase in mortality and a 9% loss in lung function with each vertebral fracture [4,5]. Subsequent VCF may result from the continued osteoporotic process, from altered load transfer to adjacent levels as a result of altered biomechanics or a combination of both. This study was designed to investigate whether bone mineral density significantly alters adjacent level load transfer following polymethylmethacrylate augmentation, a minimally invasive technique used to treat VCF.

METHODS

11 spines were used to obtain 21 five level segments composed of 12 upper thoracic (T3-7) and 9 lower thoracic segments (T8-T12). The segments underwent DEXA scanning to determine their bone mineral density (BMD). The segments were divided into two groups based upon BMD, a normal group (11 segments, mean BMD 1.0 ± 0.1 gm/ cm^2) and an osteopenic/osteoporotic group (10 segments, mean BMD 0.8 ± 0.1 gm/ cm^2). The superior and inferior vertebrae (T3, T7, T8 and T12) were fully embedded in polyester resin, and strain gauges (SGs) were applied to the anterior vertebral shells of T3, T7, T8 and T12, while force sensing resistors (FSRs) were inserted into the centers of the same vertebrae. Both the SGs and the FSRs were connected to signal conditioning equipment for data collection. The multilevel segments were biomechanically tested non-destructively in compression and flexion, a defect in the intermediate vertebrae (T5 and T10) was created using either inflatable bone tamps (osteoporotic segments) or bone drill and curettes (normal segments) to ensure a reproducible location of the initial VCF, the VCF was then reduced and augmented and the non-destructive testing in compression and flexion was repeated. Measurements of stiffness, superior and inferior adjacent level strain, superior and inferior centrum load were taken from all the tests and compared using general linear modeling with two groups of multilevel segments (high and low BMD). The significance level was set at 0.05 with 95 % confidence interval limits with post hoc least significant difference tests.

RESULTS AND DISCUSSION

The osteoporotic segments had significantly lower compressive stiffness than the normal segments, but there were no significant differences between the two groups in adjacent level load transfer (Table 1). In both groups there was higher adjacent level load transfer following fracture augmentation (strain $p = 0.10$, centrum load $p = 0.41$) and flexion created a greater load transfer than compression (strain $p = 0.001$, centrum load $p = 0.54$). Osteoporosis significantly reduced compressive stiffness from the reduced bone mass and deterioration of bone micro-architecture. Osteoporosis affects trabecular bone of the centrum to a more significant degree than the compact woven bone of the vertebral shell resulting in the reduced centrum load but increased strain at the adjacent levels.

CONCLUSION

Augmentation of osteoporotic multilevel segments does not alter segment biomechanics.

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Table 1 - Biomechanical comparisons between the normal and osteoporotic segments before and after VCF

Measurement	Normal	Osteoporotic	P value
BMD (gm/cm^2)	1.0 ± 0.1	0.8 ± 0.1	<0.0001
Compressive stiffness (N/mm)	1079 ± 66	749 ± 84	0.01
Bending stiffness (Nm/degree)	6.2 ± 1.2	3.1 ± 1.2	0.78
Adjacent level strain (micro strain)	1172 ± 313	985 ± 343	0.69
Adjacent level centrum load (millivolts)	104 ± 26	87 ± 28	0.66