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Biomechanical Analysis of Range of Motion and Failure Characteristics of Osteoporotic Human Cadaver Spinal Compression Fractures

Robert F. Heary MD; Naresh K Parvathreddy B.E., M.S.; Nitin Agarwal MD
Spine Biomechanics Laboratory, Rutgers New Jersey Medical School, Newark, New Jersey, United States of America

Introduction

Vertebroplasty is used to treat osteoporotic compression fractures. The optimal location of needle placement for cement injection remains a topic of debate. As such, the authors assessed the effects of location of two types of cement instillations as well as measured the motion and failure modes at the index and adjacent segments.

Methods

Seven human osteoporotic cadaver spines (T1-L4), cut into 4 consecutive of vertebrae, were utilized. Of these, a total of 24 specimens were utilized. Segments were randomly divided into 4 treatment groups: unipedicular and bipedicular injections into the superior quartile or the anatomic center using Confidence (Confidence Spinal Cement System®, DePuy Spine, Raynham, MA) or polymethyl methacrylate (PMMA). The specimens were subjected to non-destructive pure moments of 5 Nm, in 2.5 Nm increments, using pulleys and weights to simulate six degrees of physiological motion. A follower preload of 200 N was also applied in flexion-extension. Testing sequence: range of motion (ROM) of intact specimen, fracture creation, cement injection, ROM after cement, and compression testing until failure. Non-constrained motion was measured at index and adjacent levels.

Results

At the index level, no significant differences were observed in ROM in all treatment groups ($p > 0.05$). There was a significant increase in adjacent level motion only for the treatment group that received a unipedicular cement injection at the anatomic center.

Conclusions

Results showed that location of the needle (superior or central) and treatment type (unipedicular or bipedicular) had no significant effect on the ROM at the index site. Given the controversy about the optimal location of needle placement for cement injection into vertebrae, the authors caution that adjacent levels may be affected with therapy via a unipedicular approach.

Treatment Group	Ext	Flex	LB	RB	LR	RR	Ext with Preload	Flex with Preload
Intact	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
A	139.1	133.6	81.0	80.8	72.5	83.1	149.7	99.7
B	89.6	96.9	104.0	114.2	105.4	109.7	125.9	103.2
C	105.8	105.6	115.9	112.5	95.6	123.0	86.6	87.5
D	133.0	108.1	98.6	89.6	129.6	96.7	92.6	112.8

Table 1. Normalized to the Intact motion at the index level with and without preload.

Treatment Group	Ext	Flex	LB	RB	LR	RR	Ext with Preload	Flex with Preload
Intact	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
A	155.3	154.7	159.0	120.5	160.8	127.1	145.9	137.5
B	162.2	152.7	123.4	154.2	185.4	151.9	115.3	125.9
C	133.7	182.1	124.6	125.2	206.7	129.6	133.7	182.1
D	92.2	124.1	106.2	137.7	104.7	108.0	149.8	146.9

Table 2. Normalized to the intact motion at the adjacent level with and without preload.