THE USE OF INJECTABLE BIODEGRADABLE CALCIUM PHOSPHATE BONE SUBSTITUTE FOR PROPHYLACTIC AUGMENTATION OF OSTEOPOROTIC VERTEBRAE AND THE TREATMENT OF VERTEBRAL COMPRESSION FRACTURES

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Introduction. Percutaneous vertebroplasty by injection of PMMA into fractured vertebral bodies has been described for the enhancement of vertebral body strength and relief of pain [1]. Intraoperative and long-term problems with PMMA, however, include thermal damage to the neural elements during polymerization and negative effects on bone remodeling [2,3]. Recently, new biodegradable calcium phosphate (CaP) bone substitutes have been developed. Like PMMA, they can be mixed into an injectable paste. Unlike PMMA, CaP bone substitutes are nonexothermic in their polymerization. They are biocompatible and are progressively resorbed over time and replaced by normal bone tissue during remodeling [4, 5]. The purpose of this study was to determine whether an injected biodegradable CaP bone substitute can adequately strengthen osteoporotic vertebral bodies and stabilize vertebral compression fractures. PMMA-injected vertebral bodies were used for comparison.

Methods. Forty fresh cadaveric thoracolumbar vertebrae from five spines of elderly cadavers (>65 years) were selected by DEXA scanning. The study contained two parts: (1) Augmentation of osteoporotic vertebrae: intact control (N = 8), CaP augmentation (N = 8), and PMMA augmentation (N = 8) groups. Two 11 gauge spinal needles were inserted into the vertebral body through both transpedicles and verified with x-rays. CaP or PMMA was injected separately through each needle. Each vertebral specimen was placed in a bending fixture and tested with an MTS. Loads were applied to the vertebrae at a rate of 5 mm/min until failure. (2) Augmentation of vertebral compression fractures: CaP (N = 8), and PMMA (N = 8) groups. Vertebrae were reproducibly fractured by controlled anterior bending loads and then injected with CaP or PMMA according to the previous protocol. Before and after injection, the specimens were radiographed in the lateral projection to determine changes in vertebral body height and then loaded to failure in compressive bending.

Results. (1) Augmentation of osteoporotic vertebrae: The fracture strengths (mean failure loads) for intact control, CaP and PMMA groups were 527 ± 43 N, 1063 ± 127 N, and 1036 ± 100 N, respectively. Both cement groups were significantly stronger than the intact control group (p < .05); no significant difference was found between CaP and PMMA groups (Fig. 1). Stiffness for the CaP (157 ± 21 N/mm) and PMMA (156 ± 21 N/mm) groups was significantly higher than the intact control group (84 ± 11 N/mm) (p < .05) (Fig. 2). (2) Augmentation of vertebral compression fractures: Anterior vertebral height was increased an average of 58.5 ± 4.6% for CaP and 58.0 ± 6.5% for PMMA groups compared to preinjection fracture height. Both fracture strength and stiffness of the two injected groups were significantly greater than the intact control group (p < .05), but no significant difference was observed in anterior vertebral height, fracture strength, and stiffness between the CaP and PMMA groups.

Discussion. This study demonstrates that a percutaneous injection of a biodegradable CaP bone substitute into an osteoporotic vertebral body can significantly increase its fracture strength and stiffness. Moreover, its injection into a vertebral compression fracture can partially restore vertebral height and prevent further vertebral collapse while avoiding potential problems associated with the use of PMMA cement.

Figure 1. Fracture strength for intact control, CaP, and PMMA augmentations in osteoporotic and fractured vertebrae.

Figure 2. Stiffness for intact control, CaP, and PMMA augmentations in osteoporotic and fractured vertebrae.

References

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