HISTOLOGICAL EVALUATION OF THREE SELF-SETTING CALCIUM PHOSPHATE CEMENTS IN A SHEEP VERTEBRAL BONE-VOID MODEL

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<Introduction>
Poly(methylmethacrylate) (PMMA) has been the most commonly used cement for vertebroplasty augmentation, but requires additives in order to be adequately visualized on radiographs, is exothermic, and is not resorbable. Calcium phosphate cements (CPC) in general have variable osteoconductivity, durability, and compressive strength and are not exothermic. They may also be rendered more radiopaque by added contrast media, but the histology of CPC with added barium sulfate is unknown. The aim of this study was to evaluate the histological appearances of three self-setting calcium phosphate cements (CPC) in a sheep vertebral bone void model.

<Materials and Methods>
A total of 10 skeletally mature female sheep were included in this Institutional Animal Care and Use Committee approved study. Bone voids were surgically created in vertebrae L3, L4, and L5 for each animal. One of three different cement preparations was injected into each defect. Other defects were intended to be intact controls (I) or empty defects (E). The cements were Kyphos (Kyphon Inc., CA): K, Kyphos-R (Kyphon Inc., CA): K-R or Norian SRS (Synthes Inc., PA): N. K and N are commercial available CPC, and K-R is K cement with 6% barium sulfate.

Surgery: Through a lateral retroperitoneal approach, a 6.5 mm diameter drill bit was used to create a cylindrical cavity in each vertebral body. Drill stops were used to ensure that the defects did not extend more than 15 mm into the vertebral body. The osseous defects were then filled with one of the three different cements. Histological evaluation was performed at 2 and 4 months.

Specimens handling: Thirty vertebrae were utilized for histological evaluation. Micro CT and radiographs were obtained to confirm the location of bone cement and to measure radiodensity of each vertebra. Each vertebrae body was sectioned perpendicular to the long axis of the cylinder of cement. Half of each vertebral body was embedded in plastic and hand-ground sections were stained with hematoxylin and eosin. Microscope slides were reviewed with special reference to evidence of foreign body reaction, inflammation, bone apposition to the cement and cement extravasation.

<Results>
Radiographic analysis: Plain radiographs of each animal showed better radiopacity of K-R, when compared with K and N groups. (Figure 1).

Histological analysis: Figures 2-4 show examples of histological findings. All three cements were extremely osteoconductive. The differences among these three groups were indistinguishable histologically. Macrophages were recognized more frequently in 2 month groups for all CPCs compared to 4 month groups. There was no significant inflammatory reaction to the barium sulfate (K-R).

<Discussion>
Visualizing the injected cement is important during vertebroplasty augmentation in order to minimize cement extravasation and intravascular penetration. Although large volumes of CPC can be visualized on most radiographs, the radiopacity of CPC can be enhanced by the addition of contrast media such as barium sulfate. However, the influence of added barium sulfate on the osteoconductive properties of CPC has not been previously reported.

In this study, all three CPC were extremely osteoconductive, and all three appeared to be susceptible to resorption and/or remodeling mediated by osteoclasts. The remodeling process was slow enough, however, that we could not detect a quantitative difference in the rate of resorption among these three cements, or between two and four months in vivo in this sheep model. The concentration of barium sulfate used in the K-R cement in this study enhanced its visualization and was not associated with a significant foreign body reaction.

<References>

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