INTRODUCTION: Bone growth into porous materials has proven to be very effective for attaching orthopaedic implants to the skeleton. There remains a need, however, to develop methods for increasing the rate and extent of biologic fixation, particularly in situations where bone stock/healing is compromised or initial implant stability is tenuous. The purpose of this study was to investigate the potential for a new potent bisphosphonate compound, zoledronic acid (ZA), to enhance bone growth into porous intramedullary implants.

MATERIALS AND METHODS: Cylindrical implants (50 mm long, 5 mm diameter) were fabricated from a porous tantalum biomaterial (1) possessing an average pore size of about 550 micrometers and a volume porosity of about 80% (Figure 1). A bilateral canine ulnar model was utilized in which the porous tantalum implants were surgically inserted into the intramedullary canal of both ulnae (study approved by institutional review board). All dogs were skeletally mature and weighed between 25 to 30 kilograms. Control animals received no additional treatment after surgery. Test animals were administered a single intravenous dose of 0.1 mg/kg ZA in sterile saline immediately after surgery. Zoledronic acid is a known potent bisphosphonate (2,3) and previous studies have shown this dose to be effective for enhancing bone healing in studies of distraction osteogenesis(4).

RESULTS: New bone formation within the pores of the tantalum implants was observed in all cases to varying degrees. There was a general tendency for more bone ingrowth at the implant periphery although bone trabeculae were often present throughout the implant cross-section, particularly with the ZA-treated cases. Trabeculae within the depths of the porosity also appeared to be thicker with ZA-treated implants (Figure 2). The extent of bone ingrowth with the control implants was 6.2 ± 2.2% (mean ± standard deviation). The extent of bone ingrowth for the ZA-treated implants was 12.7 ± 2.3%, a 105% enhancement that was statistically significant at p<0.001. The additional bone ingrowth with the ZA-treated implants was readily apparent upon visual inspection of the backscattered scanning electron micrographs (Figure 2). The bone response amongst the different animals was quite consistent as evidenced by the relatively small standard deviations in the bone ingrowth data.

DISCUSSION AND CONCLUSIONS: Many different modalities have been investigated for their potential to augment the rate and extent of bone growth into porous implants (5). Compared with most other modalities, the 2-fold increase in bone ingrowth with ZA represents a vastly superior response. The rationale for the present study was based on recent work demonstrating that bisphosphonates can lead to both anti-resorptive and pro-osteoblastic effects (2,4,6,7). The increased potency of ZA relative to other bisphosphonates such as pamidronate makes it a logical choice for enhancing bone ingrowth. The marked enhancement of bone ingrowth afforded by this simple, single dose therapy could have very important benefits in a variety of clinical applications. This includes primary and revision arthroplasty surgery with compromised bone. Further studies of this type are required to ascertain the optimum dose/time response in the context of porous biomaterials or orthopaedic devices in both unloaded and loaded models.

REFERENCES:

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