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The Effect of Sodium Trisilicate on Bone Resorption and Healing

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INTRODUCTION: Bone is capable of remodeling itself. Silicate ions (Si $[OH^-]_4$) might be one of the main factors which make bioactive glass very effective in enhancing bone healing. Bioactive glass is used in dental and orthopedic applications as bone fillers. In this study, we set out to examine the biocompatibility of silicate ions using sodium trisilicate ($Na_2Si_3O_7$) to macrophages and osteoblasts. Silicate ions from bioactive glass are released into the body or cell media which maybe linked to the osteoproductivity of bioactive glass. Our study showed that silicate ions, 20µg/ml, do not activate macrophages in secreting peroxide, or cytokine IL-1β. This suggests that silicate ions do not stimulate the inflammatory response. We found that silicate ions stimulate osteoblastic cells to secrete cytokines TGF-β2 and OPG. This suggests that silicate enhances collagen production by osteoblasts and bone augmentation, respectively. In addition, this study demonstrates that 20µg/ml silicate increases alkaline phosphatase activity and collagen production by osteoblasts. However, the rate of silicate ions released from an implant in the body must be regulated as silicate can be cytotoxic at 100µg/ml but osteogenic at 20µg/ml.

METHODS: 1. Cell proliferation was measured using a Hoechst based DNA assay. 2. Collagen production was quantified using the sircol assay. 3. Cytokine assay was studied using ELISA kits.

RESULTS: Bone Proliferation: Silicate at 100µg/ml down-regulated osteoblastic growth. 20µg/ml silicate increased bone growth but was not as rapid as the control without silicate. Figure 1 indicates osteoblast morphology in 20µg/ml silicate.

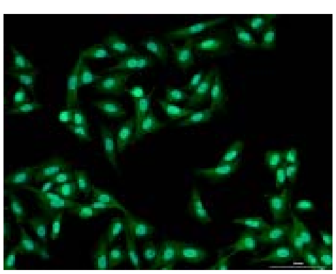

Fig. 1:Osteoblast morphology at 20µg/ml silicate Cells were stained with phalloidin for F-actin.

Bone Differentiation and Maturation Assay:

1. Alkaline Phosphatase: Throughout 3 weeks, silicate at 20µg/ml showed higher alkaline phosphatase production by osteoblasts compared to the control (without silicate). 2. Collagen production: Silicate at 20µg/ml stimulated collagen production by osteoblast more than the control throughout 24 days. Figure 2 demonstrates collagen type I production by osteoblasts after 12 days with 20µg/ml silicate.

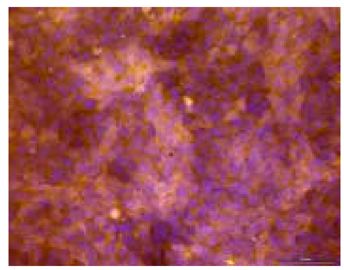

Fig. 2: Collagen type I production by osteoblasts with 20µg/ml silicate after 12 days.

Bone Differentiation and Maturation Assay:

1. IL-1β: 20µg/ml silicate showed no IL-1β production over 21 hours. 2. Peroxide: 20µg/ml silicate did not stimulate peroxide production by macrophages over 6 hours. 3. TGF-β1: 20µg/ml silicate induced TGF-β1 secretion by osteoblast within 21 hours. 4. OPG: 20µg/ml silicate up-regulated OPG production by osteoblast in 21 hours.

DISCUSSION & CONCLUSIONS: Our study confirms that silicate might be one of the main factors that is involved in the osteoproductivity of bioactive glass. Silicate down-regulates bone growth and up-regulates bone differentiation by increasing alkaline phosphatase and collagen secretion by osteoblasts. Silicate at 20µg/ml does not activate macrophages to secrete peroxide and IL-1β suggesting that silicate does not stimulate the inflammatory response. It is crucial to control the amount of silicate released at the surface of bioactive glass.