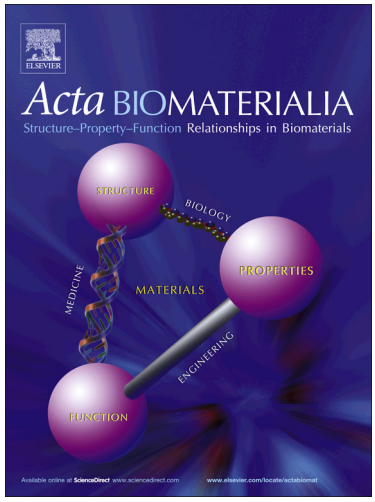

Full length article

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In vitro osteogenesis by intracellular uptake of strontium containing bioactive glass nanoparticles

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Abstract

Monodispersed strontium containing bioactive glass nanoparticles (Sr-BGNPs) with two compositions were synthesised, through a modified sol-gel Stöber process, wherein silica nanoparticles (SiO_2-NPs) were formed prior to incorporation of calcium and strontium, with diameters of 90 ± 10 nm. The osteogenic response of a *murine* preosteoblast cell line, MC3T3-E1, was investigated *in vitro* for a nanoparticle concentration of 250 µg/mL with compositions of 87 mol% SiO_2, 7 mol% CaO, 6 mol% SrO and 83 mol% SiO_2, 3 mol% CaO, 14 mol% SrO. Dissolution studies in minimum essential media (α-MEM) at pH 7.4 and artificial lysosomal fluid (ALF) at pH 4.5 showed that the particles dissolved and that Sr^{2+} ions were released from Sr-BGNPs in both environments. Both particle compositions and their ionic dissolution products enhanced the alkaline phosphatase (ALP) activity of the cells and calcium deposition. Immunohistochemistry (IHC) staining of Col1a1, osteocalcin (OSC) and osteopontin (OSP) showed that these proteins were expressed in the MC3T3-E1 cells following three weeks of culture. In the basal condition, the late osteogenic differentiation markers, OSC and OSP, were more overtly expressed by cells cultured with Sr-BGNPs with 14 mol% SrO and their ionic release products than in the control condition. Col1a1 expression was only slightly enhanced in the basal condition, but was enhanced further by the osteogenic supplements. These data demonstrate that Sr-BGNPs accelerate mineralisation without osteogenic supplements. Sr-BGNPs were internalised into MC3T3-E1 cells by endocytosis and stimulated osteogenic differentiation of the pre-osteoblast cell line. Sr-BGNPs are likely to be beneficial for bone regeneration and the observed osteogenic effects of these particles can be attributed to their ionic release products.

Keywords: Bioactive glass nanoparticles; osteogenic; strontium; intracellular uptake; endocytosis