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Do Ca^{2+}-chelating polysaccharides reduce calcium ion release from gypsum-based biomaterials?

Research Article

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Abstract: Background: Calcium sulphate, a widely used bone filler, may negatively affect human osteoblasts due to release of high quantities of calcium ions. To reduce this effect, an attempt was made to enrich calcium sulphate with Ca^{2+}-chelating plant and rhizobial exopolysaccharides (EPS). Methodology: Incubation of polysaccharide-enriched calcium sulphate composites was performed in DMEM/F12 medium. Ca^{2+} (and Mg^{2+} and Pi) levels were estimated using standardised, spectrophotometry-based kits. Composite surface morphology was tested using SEM technique. Results: Rhizobial EPS was found slightly less effective at Ca^{2+} chelation than sodium alginate. Both polysaccharides may be used as gypsum supplements in the form of setting liquids (0.3% total mass), but only sodium alginate may be used as a powder (up to 5% total mass of the composite). Polysaccharide-triggered reduction of Ca^{2+} release reached the level of 50% during the first 2.5 h of incubation, then decreased significantly. Conclusions: Both tested polysaccharides possess calcium-chelating properties. However, although alginate caused a reduction in Ca^{2+} levels in the media incubated with the gypsum samples, the reduction was too short lived to provide a long-term effect. Further modification of the composite content using calcium-deficient hydroxyapatite and low-molecular weight rhizobial EPS with higher solubility could bring more satisfactory results.

Keywords: *Rhizobial exopolysaccharides • Alginate • Calcium ion release • Ion uptake • Gypsum • Implantable materials*

1. Introduction

Various types of ceramics and glass-ceramics, used as potential implantable materials, bond to living bone through an apatite layer formed on their surfaces upon contact with ion-rich tissue liquids. The formation of an apatite layer depends on the dissolution of ceramics or glass-ceramics and the release of calcium ions [1,2]. Moreover, alkali ions released from the materials increase the pH of the surrounding liquid, thus increasing the concentration of OH^- ions, which are also a component of apatite [2]. Studies on hydroxyapatite (HAp) revealed that the negatively charged HAp surface, after exposure to simulated body fluid (SBF), interacts with calcium ions. Subsequently, the positively charged Ca-rich HAp interacts with phosphate anions and forms Ca-poor amorphous calcium phosphate which crystallises into bone-like apatite endowed with low solubility [3].

However, Ca ions, behave similarly to inorganic phosphate (Pi) and significantly influence the metabolism of osteoblast cells, crucial for bone remodelling within the implantation site. Osteoblasts and mesenchymal stem cells (MSCs) function optimally upon contact with media containing 1.8 mM Ca^{2+}. A slightly higher concentration of calcium ions (3.4 mM) released from nanoHAp into the Eagle medium was postulated to increase osteoblast differentiation [4]. However, other sources report that higher concentrations of calcium

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