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In vitro bioactivity of novel cured ionomer cement based on iron oxide

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Abstract

The effect of adding Fe_2O_3 on the bioactivity of cured ionomer cement was examined in simulated body fluid (SBF). Although the polyacrylic acid and Fe_2O_3 are known as inhibitors for apatite formation, results clearly show that exposure of the cement to the SBF lead to the formation of rough layers of carbonated-apatite (Volmer–Weber growth). Interestingly, the addition of Fe_2O_3 to the cement structure decreases the possibility of acid–base reaction in ionomer cements due to the improved chemical durability of the glass. Therefore, more calcium ions were released from the cement at the initial stage of soaking which plays an important role in forming the surface apatite layer by heterogeneous nucleation via the OH^- groups on the cement surface.

Keywords: Resin-modified glass-ionomer cement; Iron oxide; Carbonated-apatite; Simulated body fluid; Bone cement

1. Introduction

Polymethylmethacrylate (PMMA) has been widely used as bone cement. However, it does not show any bioactivity and hence its fixation is liable to degrade over a long time [1]. Accordingly, extensive attempts have been made to obtain bioactive cement with suitable properties. Glass-ionomer cements (GICs) have been widely used in dentistry [2]. Due to their excellent biocompatibility in the mouth, with no significant adverse reactions reported in over 20 years of use [3], attention was focused on the development of glass-ionomer bone cement. The past decade has given some impressive advances in the development of medical GICs; however these progresses have been matched by serious critical problems. Firstly, lower mechanical properties of conventional glass-ionomer cement. To overcome this drawback, resin-modified glass-ionomer cements (RMGICs) were developed which combine glass-ionomer chemistry with resin composite technology [4]. Second, there has been detection of aluminum in the brain, cerebral spinal fluid (CSF), urine and blood up to 77 days after surgery [5]. Concerns regarding the release of aluminum from glass-ionomers have led to the development of Fe_2O_3-based conventional glass-ionomer cement by Hurrell-Gillingham et al. [6].

Although the set glass-ionomer cements have several apatite nucleation sites (silanol and carboxyl groups) [7,8], these cements do not show bioactivity after soaking in physiological solutions [9,10] due to the release of polycarboxylic acid. It was shown that even a small quantity (0.1 ppm) of polyacrylic acid (PAA) within the simulated body fluid (SBF) inhibits apatite formation on the surface of apatite–wollastonite glass–ceramic [9]. Furthermore, silica gel which was prepared by hydrolysis and polycondensation of tetraethoxy silane in a water containing polyacrylic acid did not form any apatite layer on its surface [11]. Therefore, it seems difficult to obtain bioactive glass-ionomer cement. However, we previously showed that poorly crystallized hydroxycarbonate apatite layer can be formed on the surface of the new resin-modified glass-ionomer cement [12].

It is well known that the presence of magnetic phases in biomaterials could be used as thermoseed for hyperthermia treatment of cancer [13,14]. Thus, if we could introduce bioactivity in the new resin-modified glass-ionomer cement containing iron oxide, it can be used for wider surgical applications such as treatment of bone tumor and reinforced weakened tumorous bone. In the present study, the change in composition of resin-modified glass-ionomer cement on bioactivity was examined in simulated body fluid.

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