A novel furanone-modified antibacterial dental glass ionomer cement

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A novel furanone derivative and a polyacid constructed from it were synthesized, characterized and formulated into experimental high strength cements. The compressive strength (CS) and Streptococcus mutans viability were used to evaluate the mechanical strength and antibacterial activity of the cements. The effect of human saliva and aging were investigated. The antibacterial activity against Lactobacillus sp. and cytotoxicity to human pulp cells were also evaluated. The results show that all the formulated furanone-containing cements showed antibacterial activity, with an initial reduction in CS. The effect of the furanone derivative loading was significant. Increasing loading enhanced the antibacterial activity but reduced the initial CS of the formed cements. The derivative showed antibacterial activity against both S. mutans and Lactobacillus sp. Human saliva did not affect the antibacterial activity of the cement. The cytotoxicity study with human dental pulp cells shows that the furanone-modified cement was biocompatible. A 30 day aging study indicated that the cements may have long-lasting antibacterial activity. Within the limitations of this study it appears that the experimental cement could be a clinically attractive dental restorative due to its high mechanical strength and antibacterial function.

1. Introduction

Long-lasting restoratives and restoration are clinically attractive because they can reduce the pain and expense to the patient, as well as the number of visits to the dentist [1–4]. Both the restorative material used and oral bacteria are believed to be responsible for restoration failure [4]. Secondary caries is the main cause of restoration failure of dental restoratives, including resin composites and glass ionomer cements [1–4]. Secondary caries often occurs at the interface between the restoration and the cavity, primarily caused by demineralization of the tooth structure due to invasion by plaque bacteria (acid-producing bacteria) such as Streptococcus mutans and Lactobacillus sp. in the presence of fermentable carbohydrates [1]. To produce long-lasting restorations the materials should be antibacterial. Although numerous efforts have been made at improving the antibacterial activity of dental restoratives, most have focused on the release, especially slow release, of various incorporated low molecular weight antibacterial agents, such as antibiotics, zinc ions, silver ions, iodine, and chlorhexidine [5–9]. However, release can lead and has led to a reduction in the mechanical properties of the restorative over time and the short-term effectiveness, and a possible increase in toxicity to the surrounding tissues if the dose or release is not properly controlled [5–9]. Materials containing quaternary ammonium salt (QAS) or phosphonium salt groups have been extensively studied as an important antimicrobial material and used in a variety of applications due to their potent antimicrobial activities [10–14]. These materials were found to be capable of killing bacteria that are resistant to other types of cationic antibacterials [15]. Examples of QAS-containing materials as antibacterials for dental restoratives include incorporation of methacryloyloxydodecyl pyridinium bromide as an antibacterial monomer into resin composites [14], use of methacryloxyethyl cetyl ammonium chloride as a component for antibacterial bonding agents [16,17], addition of quaternary ammonium polyethyleneimine nanoparticles into composite resins [18,19], and incorporation of poly-quaternary ammonium salt (PQAS) into glass ionomer cements [20]. All these studies found that the QAS-containing materials exhibited significant antibacterial activity. However, it has been reported that human saliva can significantly decrease the antibacterial activity of QAS-containing restoratives, probably due to electrostatic interactions between the QAS and proteins in the saliva [21,22]. Recently furanone derivatives have been found to have strong antitumor [23,24] and antibacterial functions [25]. Therefore, we sought to explore their use in dental applications.

The objective of this study was to use a newly synthesized furanone-containing polyacid to formulate light-curable glass ionomer cements and study the effect of this derivative on the compressive strength and antibacterial activity of the formed cements.