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Novel nanofunctionalised glass ionomer cements containing chlorhexidine-hexametaphosphate nanoparticles: chlorhexidine release and mechanical properties

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INTRODUCTION

Glass ionomer cements (GIC) are biomaterials used extensively in dentistry. Their applications include restorations, orthodontic adhesives and for use in atraumatic restorative treatment (ART). They have clinically beneficial properties such as good biocompatibility, minimal cavity preparation prior to application, and good adhesion to the tooth structure.[1] The main reason dental restoratives are replaced are due to bacterial decay around the material. A dental material with a sustained antimicrobial effect would have great clinical significance. Chlorhexidine (CHX) is a cationic antiseptic which has a broad spectrum antibacterial activity[2] and is widely used in mouthwashes and gels in order to help prevent plaque and gingivitis. CHX-containing nanoparticles have recently been reported by our group.[3] The aim of this project is to incorporate CHX nanoparticles into a commercial GIC using two different methods, to investigate how this affects mechanical properties and to assess CHX release from the experimental cements.

EXPERIMENTAL METHODS

Nanoparticle synthesis-100mL each of 10mM CHX digluconate (sigma) and sodium hexametaphosphate (HMP; sigma) were combined under ambient laboratory conditions with vigorous stirring. 30mL of 1M potassium chloride was added after 1 min and stored for 24h without stirring. The supernatant was discarded and the remaining aqueous sediment centrifuged for 30 min at 5000 rpm. The supernatant was again discarded leaving a viscous white paste.

Preparation of nanoparticles for GICs-Nanoparticles were added to GICs as either the viscous white paste yielded by the process above, or as dry particles. To create the dry particles, the paste was removed from the centrifuge tubes and dried under ambient laboratory conditions under a fume hood and then milled in a ball mill for 4 h on a rotating platform. These were then substituted at 1, 2, 5 or 10% for the glass component in the ball milled GIC specimens.

GIC specimens using nanoparticle paste-Powder and liquid were mixed in a 4:1 according to the manufacturers' instructions. The nanoparticle paste was first added to the GIC liquid and then this combined liquid was mixed with the powder. The nanoparticle paste was substituted by weight and 1% of paste added was 0.005g therefore the powder to liquid ratio was decreased to 0.396:0.099g. The substitutions of 2, 5 and 10% were substituted in the same manner.

Specimen preparation-For diametral tensile strength (DTS) testing and elution experiments, GIC specimens were created in cylindrical PTFE moulds 4mm in height and 6mm in diameter. For compressive strength (CS) testing a steel mould measuring 6mm in height and 4mm in diameter was used. After 5 min, specimens were removed from the moulds and stored in sealed tubes in 100% humidity for 7 days.

CHX elution-GIC specimens were placed in UV-transparent cuvettes, 1.5ml deionised water added and the cuvettes were tightly sealed. The specimens were agitated on an orbital shaker at 150rpm and the CHX concentration was sampled periodically using absorbance at 255nm using a UV-vis spectrophotometer (Hitachi U1900, Tokyo, Japan). The GIC control absorbance reading was subtracted from the results to account for low levels of absorbance from free PAA.

Strength testing-DTS and CS were measured using an Instron universal testing machine. Strength data were analysed using a Kruskal-Wallis test.

RESULTS AND DISCUSSION

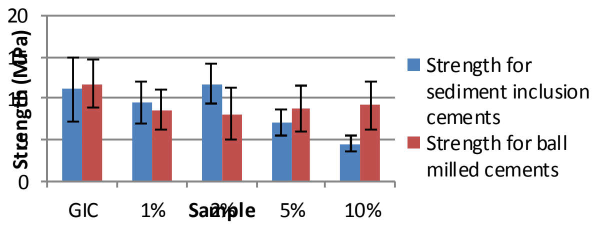

Figure 1. DTS of experimental GIC specimens as a function of nanoparticle substitution and method of incorporation.

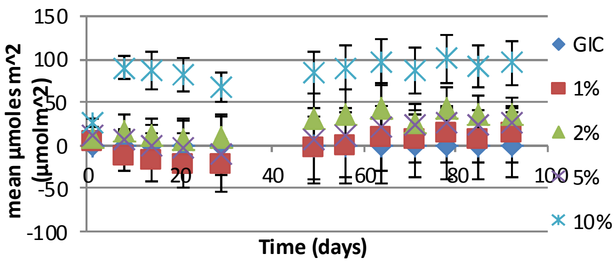

Figure 2. CHX release from experimental GIC specimens created using nanoparticle paste as a function of substitution and time

DTS decreased as a function of nanoparticle substitution. The effect was less pronounced for the ball milled method of substitution. Statistically significant differences compared to unmodified cement were observed with the 5 and 10% paste method and 2% with the ball-milled method.

CHX elution was very small compared to previous methods of incorporating these CHX-HMP nanoparticles into a GIC[5], which may indicate that the CHX is less mobile in these versions of the GIC.

CONCLUSION

Experimental GICs containing CHX-HMP nanoparticles at a range of dopings were created. Some reduction in DTS was observed; the effect was less for the ball milled specimens. Little CHX elution was observed.

REFERENCES

1. Sidku SK, Glass ionomer cement restorative materials: a sticky subject? Aust Dent J 2011, 56(1):23-30

2. Varoni et al, Chlorhexidine in dentistry: state of the art, Minerva Stomatol, 2012, 61:399-419

3. Barbour et al, Synthesis, characterisation and efficacy of antimicrobial chlorhexidine-hexametaphosphate nanoparticles for applications in biomedical science and consumer products, Int J Nanomedicine, 2013, 8: 3507-19

4. Darvell BW, Materials science for dentistry, 9th edition, 2009, 20-21

5. Hook et al, Development of a novel antimicrobial-releasing glass ionomer cement functionalised with chlorhexidine-hexametaphosphate nanoparticles, J Nanobiotechnology, 2014, 12(1):3

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