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Chlorhexidine-hexametaphosphate nanoparticles for antimicrobial dental implants

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Abstract:

Titanium is the major component of many dental implant systems due to its biocompatibility and high rate of osseointegration. While micro-roughened surfaces have been shown to increase the adhesion of osteoblasts, they have also been shown to promote that of bacteria; increasing the likelihood of implant failure. Antimicrobial nanoparticles are advantageous due to the possibility of tuneable coverage, leaving most of the titanium available for osseointegration, while retaining an antimicrobial efficacy.

Objectives:

The aim of this investigation was to apply novel antimicrobial nanoparticles formulated from chlorhexidine and hexametaphosphate (CHX-HMP) as a coating for dental implants.

Methods:

CHX-HMP nanoparticles were precipitated upon the addition of aqueous chlorhexidine digluconate solution (10 mM) to an aqueous solution of sodium hexametaphosphate (10 mM), under constant stirring. Commercially pure grade II titanium substrates were immersed in the rapidly stirred colloidal nanoparticle suspension for 30s and then rinsed by immersion in deionised water for 10s and dried.

The release of chlorhexidine from the surfaces, into water, was monitored over time for over 50 days using UV-Visible spectroscopy (UV-Vis). The surfaces before and after being soaked in water were observed using Atomic Force microscopy (AFM) and Scanning Electron Microscopy (SEM). The size and charge was also probed through Dynamic Light Scattering (DLS).

Results:

The CHX-HMP nanoparticles, with an average size of ~150 nm and charge of ~50 mV (DLS), adhered readily to titanium, forming surface aggregates in discrete regions surrounded by bare titanium (SEM, AFM). CHX was shown to elute from the surfaces into water for over 50 days (UV-Vis). Nanoparticulate regions were still present on the surface even after CHX had been released from the surface (SEM).

Conclusions:

CHX-HMP nanoparticles adhered to clinically relevant titanium substrates. The nanofunctionalised surfaces exhibited a long-term steady elution of CHX, while still retaining nanoparticles on the surface.