Synergistically antibacterial effect of chlorhexidine-loaded, silver-decorated mesoporous silica nanoparticles against peri-implantitis pathogens

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Background: As the global number of individuals that undergo restorative therapy through dental implants increases, peri-implantitis is considered as a major and growing problem in dentistry. Significantly higher ORs for moderate severe peri-implantitis were found for patients presenting with periodontitis. Up to date, combination of CHX and silver ions could engender an obviously synergistic bactericidal effect and improve the bactericidal efficacy in oral infections.

Aim/Hypothesis: We aimed to develop multifunctional mesoporous silica nanoparticles that were capable of loading both CHX and silver with a pH triggered drug release for antibacterial applications.

Material and Methods: Monodisperse MSNs nanospheres were developed as an ideal carrier for CHX and nanosilver co-delivery through a facile and environmentally friendly method and well characterized. The resulting Ag-MSNs@CHX were employed here to determine the loading content and the pH-responsive releasing profiles of CHX and silver ions. Of note, the synergistic bactericidal effect of Ag-MSNs@CHX was comprehensively investigated on both Gram-positive Streptococcus mutans and Gram-negative Porphyromonas gingivalis. The bactericidal activities of Ag-MSNs@CHX were also determined against oral bacterial biofilms. Additionally, biocompatibility of Ag-MSNs@CHX was evaluated with normal cells and mice. Statistical analyses were performed by ANOVA and paired t-test with significance at $P < 0.05$.

Results: Ag-MSNs@CHX with high density and well-distributed silver nanodots exhibited a pH-responsive release manner of both CHX and silver ions simultaneously. Thus, Ag-MSNs@CHX possessed synergistic bactericidal activity on Streptococcus mutans and Porphyromonas gingivalis at a low concentration. Importantly, Ag-MSNs@CHX exhibited an enhanced effect against the multi-species oral biofilms at 24 hours. Furthermore, the effective antibacterial concentration of Ag-MSNs@CHX showed less cytotoxicity on normal cells and have good biocompatibility on mice.

Conclusions and Clinical Implications: Given their synergistically bactericidal ability and good biocompatibility, Ag-MSNs@CHX might have effective and broad clinical applications for oral pathogenic bacterial infections. We expect this co-delivery strategy to be a general approach for antibacterial agent release in dental materials and other biomaterials where antibacterial function is required.