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Review Article

Nanoparticles in endodontics – A review

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ABSTRACT

Nanodentistry implies the application of nanomaterial and dental nanorobots toward diagnosis and treatment, with the goal of improving comprehensive oral health. In the field of endodontics, the development of nanomaterials is focused on steps that would improve antimicrobial efficacy. The current study undertakes review to assess the effectiveness of different nanoparticles irrigation systems is to improve the antibiofilm efficacy in root canal. Application of nanoparticles in the form of solution for irrigation, medication, and as an additive for sealer/restorative material has been evaluated to primarily improve the antibiofilm efficacy in root canal; in addition, the functionalized nanoparticles can provide better antibacterial effect. Nanoparticles-based treatment strategies have the potential to improve antibacterial/antibiofilm efficacy in endodontics. Thus, the increasing interest in this field warrants sound research based on scientific and clinical collaborations to emphasize the future potential of nanoparticles in clinical endodontics.

Keywords: Chitosan nanoparticles, bio active nanoparticles, silver nanoparticles

Introduction

Nanomaterial denotes an incidental, natural, or manufactured materials containing particles in an unbound state.[1] Nanomaterials as unique physicochemical properties, such as large surface, ultra small size, and increased chemical reactivity, compared with their bulk counterparts.[2,3] The surface increased to volume ratio and number are increased of atoms that are present near the surface compared with micro-/macrostructures are suggested to contribute to the distinctly different properties of nanomaterials.

Nanotechnology has formed rapidly as science and technology creating a myriad of biomedical applications such as tissue regeneration, drug delivery system, antimicrobial application, gene transformation, and imaging.[2-5] The term nanodentistry implies the application of nanomaterials and dental nanorobots toward diagnosis and treatment, with the goal of improving comprehensive oral health. The scope of such strategies includes a wide variety of oral health-related issues such as treatment of biofilm elimination, diagnosis dentin hypersensitivity, and oral cancer.

In the field of endodontics, the nanomaterials are focused on steps that would improve mechanical integrity, antimicrobial of previously diseased tissue regeneration, and dentin matrix. Currently, it is a new technology tested in endodontics to have challenges over microorganism.[6,7]

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Chitosan Nanoparticles (CS-NPs)

Chitosan (poly [1, 4-b-D-glucopyranosamine]), a DE acetylated derivative of chitin, is the second most abundant natural biopolymer. Nanoparticles of chitosan could be synthesized or assembled using various methods depending on the physical characteristics or end of application required on the nanoparticles.[7] Chitosan has many interest in biomedicine[8] because of its versatility in various forms such as capsule (micro-and nanoparticles), powder, scaffolds, films, beads, hydrogels, and bandages.

Chitosan has a similar structure to extracellular matrix components and is therefore used to reinforce the construction of collagen.[9] This hydrophilic polymer with a large number of hydroxyl and free amino groups can be subjected to numerous grafting and chemical modifications, resulting in functionalization.[10,11] CS-NPs have been developed mainly for drug/gene delivery applications and antibacterial.

Chitosan has excellent antiviral, antibacterial, and antifungal properties.[12] In case of bacteria, Gram-positive bacteria which are more susceptible than Gram-negative ones. The minimum inhibitory concentrations which are ranged from 18 to 5000 ppm depending on the organism, pH, degree of deacetylation (DD), molecular weight, chemical modifications, and presence of lipids and proteins.[12,13] DD is known to influence the antibacterial activity. With higher DD, the number of amine groups increases per glucosamine unit, and thus, chitosan which showed higher antibacterial efficacy.[12] CS-NPs by

virtue of their size and charge are expected to possess enhanced antibacterial activity.

Bioactive Glass (BAG)

BAG received most considerable interest mainly due to its antibacterial properties and osteoinductive effect toward various orthopedic and dental applications. The antibacterial activity of BAGs has been investigated has three different approaches.[14] BAG consists of CaO2, SiO2, Na2O, and P2O5 at different and depends on the local physiological changes for its antibacterial effects (45).

BAGs in micro-and nanoforms have been tested to improve root canal disinfection. The nanometric BAG used by Zehnder *et al*.[15] were amorphous in nature, ranging from 20 to 60 nm in size. *In vitro* root canal disinfection studies showed a significantly less antibacterial effect of BAG compared with calcium hydroxide in preventing residual bacterial growth. Waltimo *et al*. suggested that an ideal preparation of 45S5 BAG suspensions/slurries for root canal disinfection should combine a high pH induction with a capacity for continuing release of alkaline species. Despite the higher specific surface area of nanometric BAG, the micrometric counterpart had a considerably higher alkaline capacity and eliminated biofilms significantly better.[16]

They were killed planktonic bacteria significantly better compared with biofilm bacteria.[17] The reduced antibacterial efficacy of nano-BAG compared with micro-BAG has been mainly contributed to the 10-fold increase in silica release and solution pH elevation by more than 3 units by the latter.

Silver Nanoparticles (Ag-NPs)

Silver compounds and nanoparticles which are used in biomedicine, mainly because of their antibacterial property.[18] In case of dental application, silver and its nanoparticles have been tested for application as endodontic retrograde filling material, dental restorative material, dental implants, and caries inhibitory solution.[19]

Silver is known to produce an antibacterial effect by acting on multiple targets starting from interaction with the sulfhydryl groups of proteins and DNA, alter the hydrogen bonding/respiratory chain, unwind DNA, and interfere with cell wall synthesis/cell division.[20] Ag-NPs are known to further destabilize the bacterial membrane and increase permeability, leading to leakage of cell constituents.[21]

Ag-NPs with significant antibacterial activity could be used for root canal disinfection. However, the prolonged interaction time required by Ag-NPs for effective bacterial killing needs to be considered, and its use ideally should be limited to medicament rather than as an irrigant.

Most of the nanoparticles were tested for root canal disinfection depends on time-dependent and contact-mediated antibacterial activity. Adding of various nanoparticles into root filling materials sealers or significantly improved the antibacterial efficacy by inhibition of biofilm formation on the surface as well as the resin-dentin interface.

Conclusion

Nanoparticles-based treatment strategies have the potential to improve antibacterial/antibiofilm efficacy in endodontics. Thus, the increasing interest in this field warrants sound research based on scientific and clinical collaborations to emphasize the future potential of nanoparticles in clinical endodontics.

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