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Nanoparticles In Endodontics: A Review

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Abstract
Nanotechnology has revolutionized the field of endodontics by enhancing antimicrobial activity, improving mechanical properties of materials, and providing innovative solutions for drug delivery. Various nanoparticles, including silver, gold, chitosan, and zinc oxide, have shown promise in improving root canal disinfection, enhancing sealer properties, and promoting periapical healing. This review explores the applications, advantages, and limitations of nanoparticles in endodontics, providing insights into their current status and future prospects.

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I. Introduction

Endodontic infections are polymicrobial in nature and often persist despite conventional treatment approaches. The emergence of antibiotic resistance has necessitated the development of alternative antimicrobial strategies. Nanoparticles (NPs) offer unique physicochemical properties, including a high surface-area-to-volume ratio and enhanced bioactivity, making them suitable candidates for endodontic applications.

II. Types Of Nanoparticles In Endodontics

1. Silver Nanoparticles (AgNPs)

Silver nanoparticles exhibit strong antibacterial effects against endodontic pathogens due to their ability to disrupt bacterial cell membranes and interfere with intracellular processes [1]. They have been incorporated into irrigants, intracanal medicaments, and sealers to enhance antimicrobial efficacy [2].

2. Chitosan Nanoparticles (CNPs)

Chitosan, a natural polysaccharide, has antimicrobial and biocompatible properties. Chitosan nanoparticles have been used to improve the effectiveness of root canal disinfection and enhance the mechanical properties of endodontic sealers [3].

3. Zinc Oxide Nanoparticles (ZnONPs)

Zinc oxide nanoparticles possess antibacterial, antifungal, and anti-inflammatory properties. Studies have shown their potential in improving the sealing ability and antimicrobial function of endodontic materials [4].

4. Gold Nanoparticles (AuNPs)

Gold nanoparticles have demonstrated biocompatibility and anti-inflammatory effects. Their role in endodontics includes drug delivery systems and tissue regeneration applications [5].

5. Titanium Dioxide Nanoparticles (TiO_2NPs)

Titanium dioxide nanoparticles have been explored for their photocatalytic antimicrobial activity, which can help in reducing bacterial load in infected root canals [6].

III. Applications Of Nanoparticles In Endodontics

1. Root Canal Irrigation and Disinfection

Nanoparticles can enhance the antimicrobial activity of irrigants such as sodium hypochlorite and chlorhexidine.

AgNPs and ZnONPs have been incorporated into irrigants to improve their penetration and biofilm disruption capabilities [7].

2. Intracanal Medicaments

Nanoparticles have been used in intracanal medicaments to achieve prolonged antimicrobial effects. Chitosan-based nanoparticle formulations have demonstrated sustained antimicrobial activity against *Enterococcus faecalis* and *Candida albicans* [8].

3. Endodontic Sealers and Obturation Materials

Nanoparticles can improve the physical and biological properties of endodontic sealers. Silver and zinc oxide nanoparticles have been added to sealers to enhance their antimicrobial activity and sealing ability [9].

4. Regenerative Endodontics

Nanoparticles play a role in regenerative endodontics by promoting cell proliferation and differentiation. Hydroxyapatite and bioactive glass nanoparticles have been used to enhance tissue regeneration and mineralization in pulp capping and apexogenesis procedures [10].

IV. Advantages Of Nanoparticles In Endodontics

- Enhanced antimicrobial activity against resistant endodontic pathogens
- Improved penetration into dentinal tubules
- Strengthened mechanical properties of endodontic materials
- Potential for controlled drug delivery and regenerative applications

V. Challenges And Limitations

- Cytotoxicity concerns with some nanoparticles, particularly at high concentrations
- Possible development of bacterial resistance
- Lack of standardization in nanoparticle synthesis and application
- Need for long-term clinical studies to establish safety and efficacy

VI. Future Perspectives

Future research should focus on optimizing nanoparticle formulations for clinical use, minimizing cytotoxicity, and developing bioactive nanoparticles that can promote healing while preventing reinfection. Advances in nanotechnology, such as smart nanoparticles with targeted drug delivery capabilities, may revolutionize endodontic treatment approaches.

VII. Conclusion

Nanoparticles have demonstrated promising applications in endodontics, from root canal disinfection to regenerative procedures. While challenges remain, continued research and technological advancements will further enhance their clinical potential.

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