

## NANOTECHNOLOGY IN ENDODONTICS

Gangandeep,<sup>1</sup> Rajbinder,<sup>2</sup> Simar<sup>3</sup>

<sup>1</sup>Professor ,Desh Bhagat dental College and Hospital, Mandi Gobindgarh

<sup>2</sup>Lecturer ,Desh Bhagat dental College and Hospital, Mandi Gobindgarh

<sup>3</sup>PG Student, Department of Conservative Dentistry and Endodontics,  
Desh Bhagat dental College and Hospital, Mandi Gobindgarh

### ABSTRACT

Nanoparticle-based materials possess superior physical, chemical, and biological properties compared to conventional materials. This progress has led to the integration of nanoparticles into dental materials to enhance their performance and achieve more reliable clinical outcomes. Studies suggest that nanotechnology in endodontic applications benefits dental materials by improving the surface properties of Ni-Ti rotary instruments, enhancing root canal disinfection, enabling three-dimensional obturation, and supporting the repair and regeneration of dentinal and pulp tissues. The ultimate goal is to leverage nanoscale resources to achieve consistent outcomes that improve oral health and overall quality of life. However, the lack of long-term clinical evidence evaluating the effectiveness of these nanomodified biomaterials limits their widespread use. This review aims to summarize current research, address practitioners' concerns about the application of these materials in endodontics, and highlight their potential for clinical integration.

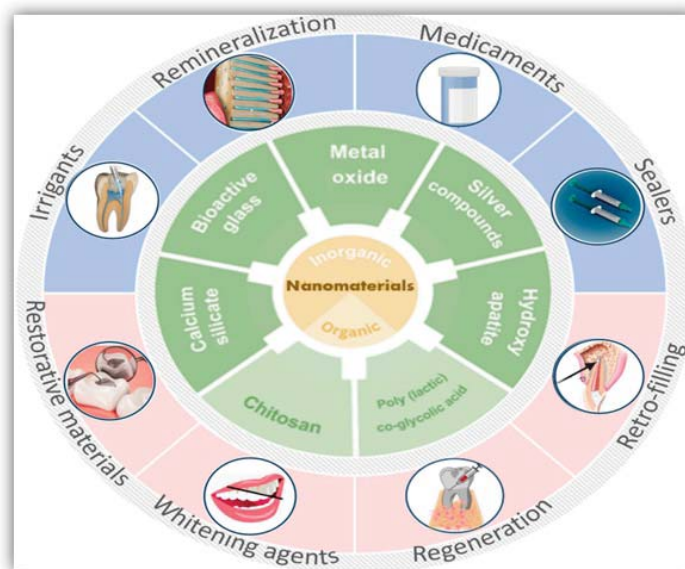
**Keywords:** Nanoparticles, Endodontics, Nanotechnology, Biomaterials.

### Introduction

In recent years, nanotechnology has experienced remarkable advancements, significantly influencing the field of oral health science. Its impact spans nearly all areas of dentistry, establishing itself as a highly effective tool due to its capacity to improve the physicochemical properties of dental materials at the nanoscale, thereby enhancing their biocompatibility and acceptance. The term 'Nano' originates from the Greek word 'vacos,' meaning dwarf. In endodontics, nanotechnology finds applications in various areas, including irrigants, medicaments, sealers, and whitening agents.<sup>1</sup>

In oral health science, nano biomaterials are utilized across a wide range of applications, including the development of dental materials with enhanced mechanical properties, the prevention of dental caries and periodontal diseases, and the treatment of conditions such as dentinal hypersensitivity, endodontic diseases, and oral cancer.<sup>2</sup> They also play a role in tissue engineering to restore lost tooth structure, serve as diagnostic tools for early detection of oral cancer, and, to a limited extent, facilitate localized drug delivery for managing periodontal issues.

### APPLICATIONS OF NANOTECHNOLOGY IN ENDODONTICS

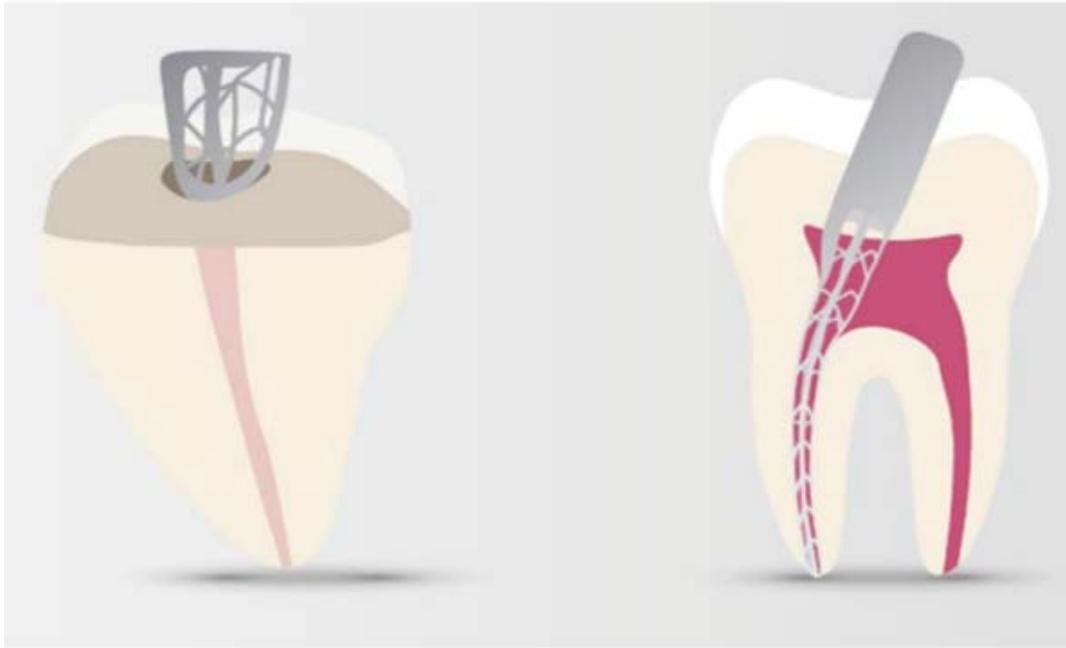


Farzaneh Afkhami, Yuan Chen, Laurence J. Walsh, Ove A. Peters, Chun Xu. Application of Nanomaterials in Endodontics. BME Front. 2024;5:0043

## MODIFICATION IN THE SURFACE QUALITY OF ENDODONTIC INSTRUMENTS

Previously, stainless-steel blanks were used for the fabrication of endodontic instruments. However, these materials exhibited inherent stiffness that increased with the size of the instruments.<sup>3</sup> After extensive research, the Ni-Ti alloy system was introduced, offering improved flexibility and performance.

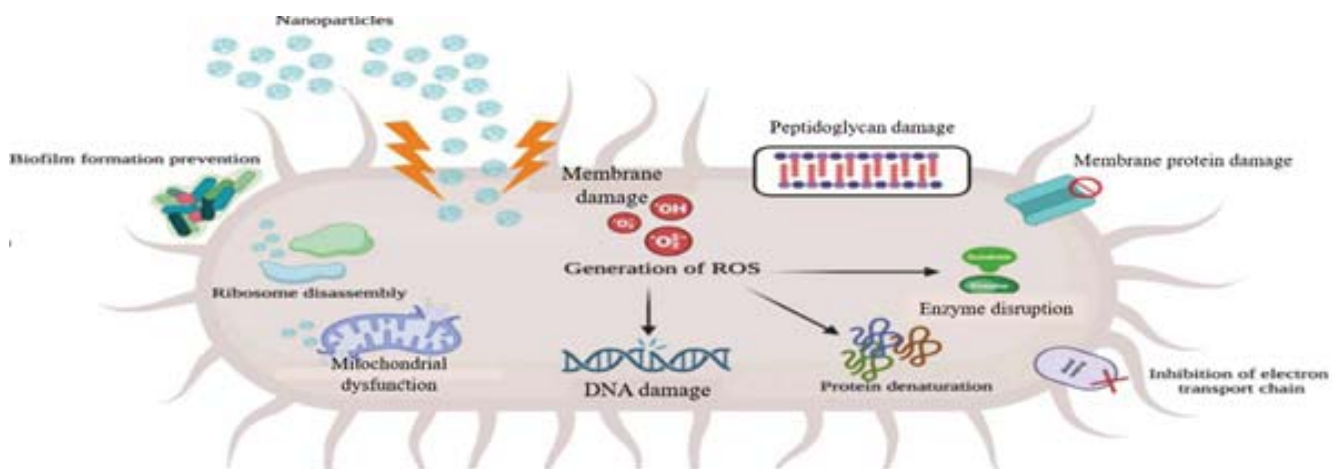
### Self-adjusting file (SAF) technology visualization.



Rybak, Z. (2021, November 17). Nanomaterials Application in Endodontics. In Encyclopedia.

The Self-Adjusting File (SAF) technology is a compressible and resilient Ni-Ti mesh structure without a central core. This design enables efficient irrigant flow, effective disinfection, and adaptability to various root canal shapes. SAF technology removes only the necessary layer of dentin, preserving healthy dentin and minimizing the risk of creating microcracks in the root dentin.<sup>4</sup>

### Nanoparticle-based endodontic disinfection



Capuano N, Amato A, Dell'Annunziata F, Giordano F, Folliero V, Di Spirito F, More PR, De Filippis A, Martina S, Amato M, Galdiero M, Iandolo A, Franci G. Nanoparticles and Their Antibacterial Application in Endodontics. *Antibiotics* (Basel). 2023 Dec 1;12(12):1690.

The intricate structure of the root canal system, including accessory canals, isthmuses, and dentinal tubules, presents significant challenges for achieving effective disinfection. These areas often serve as reservoirs for bacteria and biofilms. Nanoparticles offer unique antimicrobial mechanisms that differ from traditional treatments.<sup>5</sup> They disrupt microbial metal ion homeostasis, causing irreversible damage that inhibits growth, and the excess metal content in nanoparticles can ultimately lead to microbial death.

Nanoparticles exert their antimicrobial effects through four primary mechanisms: (1) attaching to the cell wall and membrane surface, (2) penetrating cells and damaging intracellular structures and biomolecules, (3) generating oxidative stress by producing reactive oxygen species (ROS) and free radicals, and (4) disrupting signal transduction pathways.<sup>6</sup>

Nanoparticle combined root canal sealers and obturating material

Nano-diamond impregnated gutta-percha (GP) demonstrates improved chemical and mechanical properties, along with enhanced biocompatibility when used in conventional obturation techniques. Additionally, it conforms more effectively to the canal walls with minimal void formation, making nano-GP a highly promising material for root canal obturation.<sup>7</sup>

Lee et al.<sup>8</sup> developed a gutta-percha formulation infused with nanodiamond-amoxicillin conjugates, where the nanodiamond particles (4 to 6 nm) possess natural antibacterial properties and can adsorb antibiotics, aiding in the eradication of persistent bacteria. This nanodiamond-gutta-percha combination not only reduces the risk of re-infection but also strengthens the mechanical properties of the gutta-percha points, enhancing their clinical usability.

## NANOMATERIALS IN DENTAL TISSUE

### REGENERATION

#### Nanoscaffolds

Nanotechnology can alter the properties of scaffolds by enhancing their mechanical strength and controlling the

release of bioactive agents. Through nanotechnology-driven tissue regeneration, it is possible to create a framework that closely resembles native tissue, ultimately forming a structure similar to dental tissues.<sup>9</sup> Nanoscaffolds should be porous, biocompatible with the host tissues, biodegradable, and designed to mimic the extracellular matrix in order to effectively replace lost tissue.

#### Antibiotic-eluting scaffolds:

Triple Antibiotic Paste (TAP) is commonly recommended as an intracanal medicament in regenerative endodontic procedures for treating immature permanent teeth, containing equal amounts of ciprofloxacin, metronidazole, and minocycline. While TAP demonstrates excellent antimicrobial activity against a wide range of bacteria, it has been found to be cytotoxic to dental pulp stem cells (DPSCs) and stem cells of the apical papilla (SCAPs) in a time- and concentration-dependent manner.<sup>10</sup> To address this cytotoxicity and ensure a controlled, slow release of antibiotics, drug-releasing scaffolds have been proposed as a solution.

### CHALLENGES FACED BY NANO-DENTISTRY

Nanoparticles have the potential to accumulate in target organs and trigger harmful responses. Materials like titanium dioxide, zinc oxide, manganese oxide, aluminum oxide, and silver can accumulate in organs such as the heart, lungs, liver, kidneys, spleen, and regional lymph nodes, potentially causing negative effects on human health.<sup>11</sup> While the blood-brain barrier typically serves as a protective mechanism, blocking substances from entering the brain, nanomaterials can bypass this barrier due to their small size and high surface reactivity.

### CONCLUSION

Nanotechnology is poised to shape the future of dentistry, particularly in restorative and conservative procedures. As new technologies are adopted, the use of nanotechnology in dental materials will expand, improving their properties. However, it is essential to assess the cost-effectiveness of nanotechnology to ensure it is accessible to a broader population. Additionally, the safety and potential cytotoxic effects of these materials must be thoroughly evaluated to ensure they are safe for use in clinical settings.

### References

1. K. R. Saravana, R. Vijayalakshmi, Nanotechnology in dentistry

- Indian J Dent Res.,17,62-65 (2006).
2. P. N. Ramachandran Nair, Light and electron microscopic studies of root canal flora and periapical lesions, J Endod., 13(1),29-39 (1987).
3. G. N. Tzanetakis, M. A. Azcarate-Peril, S. Zachaki, P. Panopoulos, E. G. Kontakiotis, P. N. Madianos, K. Divaris, Comparison of Bacterial Community Composition of Primary and Persistent Endodontic Infections Using Pyrosequencing, J Endod., 41(8),1226-1233 (2015).
4. Metzger Z. The self-adjusting file (SAF) system: An evidence-based update. J Conserv Dent. 2014 Sep;17(5):401-19.
5. D. Ricucci, J. F. Siqueira, Biofilms and apical periodontitis: study of prevalence and association with clinical and histopathologic findings, J Endod., 36(8),1277-1288 (2010).
6. Capuano N, Amato A, Dell'Annunziata F, Giordano F, Folliero V, Di Spirito F, More PR, De Filippis A, Martina S, Amato M, Galdiero M, Iandolo A, Franci G. Nanoparticles and Their Antibacterial Application in Endodontics. Antibiotics (Basel). 2023 Dec 1;12(12):1690.
7. Liao SC, Wang HH, Hsu YH, Huang HM, Gutmann JL, Hsieh SC. The investigation of thermal behaviour and physical properties of several types of contemporary gutta-percha points. Int. Endod. J. 2021;54(11):2125–2132.
8. Lee D-K, Kim SV, Limansubroto AN, Yen A, Soundia A, Wang C-Y, Shi W, Hong C, Tetradis S, Kim Y, et al. Nanodiamond-gutta percha composite biomaterials for root canal therapy. ACS Nano. 2015;9(11):11490–11501.
9. Rodríguez CG, Cepeda MAAN, Arana HLM, Lopez JFG, del Perpetuo Socorro Mendiburu Zavala CE, Cuevas RP, Molina BC, Soto DJMS. Current and future options for dental pulp regeneration. Int J Appl Dental Sci. 2023;9(1):178–182
10. Malu K, Khubchandani M. Triple Antibiotic Paste: A Suitable Medicament for Intracanal Disinfection. Cureus. 2022 Sep 15;14(9):e29186.
11. Bonilla-Represa V, Abalos-Labruzzi C, Herrera-Martinez M, Guerrero-Pérez MO. Nanomaterials in Dentistry: State of the Art and Future Challenges. Nanomaterials (Basel). 2020 Sep 7;10(9):1770.