

Review Article

Nano Revolution in Modern Endodontics: A Narrative Review

Gaurav Jain^{1*}, **Swadhinta Raj¹**, **Sonali Verma¹**, **Pradyumna Misra¹**, **Manoj Hans²**,
Lalit C Boruah³

¹Dept. of Conservative Dentistry and Endodontics, Saraswati Dental College & Hospital, Lucknow, Uttar Pradesh, India

²Dept. of Conservative Dentistry and Endodontics, Institute of Dental Sciences, Bareilly, Uttar Pradesh, India

³Dept. of Conservative Dentistry and Endodontics, Government Dental College, Dibrugarh, Assam, India

Abstract

Nanotechnology has become a groundbreaking advancement in endodontics, greatly improving the success of root canal therapy and supporting tissue regeneration. The incorporation of nanomaterials into endodontic procedures enhances disinfection, improves the mechanical performance of dental materials, and opens new possibilities for regenerative healing. Owing to their nanoscale size and high surface area, nanoparticles can penetrate deeply into dentinal tubules, delivering superior antimicrobial effects and lowering the likelihood of reinfection when compared with traditional techniques. Additionally, nanomaterials strengthen root canal sealers by improving their adhesion, fracture resistance, and overall durability, leading to more predictable clinical outcomes. Nanotechnology also holds significant potential in pulp tissue regeneration through targeted drug delivery systems and the promotion of stem cell differentiation, contributing to biologically based treatment approaches. Furthermore, these innovations may reduce treatment time, improve patient comfort, and support minimally invasive endodontic techniques. However, concerns related to nanoparticle safety, toxicity, and long-term biocompatibility persist, emphasizing the need for continued research. This review examines the current uses and future prospects of nanotechnology in endodontics, underscoring its transformative impact on root canal treatment outcomes and the advancement of dental care, while encouraging further clinical trials to validate efficacy, safety, and widespread application in routine dental practice.

Keywords: Nanotechnology, Nanoparticles, Endodontics, Nanomaterial, Drug delivery

Received: 01-12-2025; **Accepted** 17-01-2026; **Available Online:** 18-02-2026

This is an Open Access (OA) journal, and articles are distributed under the terms of the [Creative Commons Attribution-NonCommercial](https://creativecommons.org/licenses/by-nc/4.0/) which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprint@ipinnovative.com

1. Introduction

Nanotechnology, which involves the manipulation of materials at the nanoscale range of 1–100 nm, has become a significant advancement across multiple scientific disciplines, including dentistry. Within endodontics, the integration of nanotechnology holds considerable promise by offering innovative solutions to many persistent limitations of conventional root canal treatment. Endodontic therapy focuses on managing diseases of the dental pulp and periapical tissues and relies heavily on thorough canal disinfection, effective obturation, and the potential for tissue regeneration to ensure long-term treatment success. However, conventional techniques frequently prove inadequate due to the complex morphology of the root canal

system, making complete elimination of microorganisms from all anatomical irregularities a challenging task.¹

Nanoparticles including silver, zinc oxide, and titanium dioxide have gained increasing attention in endodontic applications because of their potent antimicrobial activity. Owing to their nanoscale dimensions, these particles are capable of infiltrating dentinal tubules that remain inaccessible to conventional irrigant and disinfection techniques. The combination of reduced particle size and increased surface area allows nanoparticles to demonstrate superior antibacterial action against the diverse microbial populations commonly associated with root canal infections. As a result, their incorporation into endodontic procedures enhances microbial control and substantially lowers the

*Corresponding author: Gaurav Jain
Email: gauravjs23@yahoo.com

likelihood of reinfection, thereby improving overall treatment success.²

Beyond their antimicrobial role, nanotechnology has demonstrated considerable potential in improving the physical and mechanical characteristics of materials employed in root canal therapy. The addition of silica-based nanoparticles to root canal sealers has been shown to enhance their mechanical strength, resistance to fracture, and long-term stability, resulting in superior canal sealing and reduced bacterial penetration.³ In addition, the presence of nanoparticles improves the bonding ability of restorative materials to dental tissues, which contributes to greater durability and improved clinical outcomes of endodontic procedures.

Nanotechnology also offers promising advancements in the field of regenerative endodontics. Nanoparticles may function as delivery vehicles for bioactive substances and growth factors, thereby promoting pulp tissue regeneration and supporting the healing of periapical pathologies.⁴ This regenerative strategy provides a viable alternative to tooth extraction and supports the preservation of natural dentition through biologically driven repair mechanisms. Furthermore, nanoparticles can be incorporated into targeted drug delivery platforms, enabling controlled and site-specific release of antimicrobial agents. This approach enhances therapeutic effectiveness while simultaneously reducing undesirable systemic effects.⁵

2. Mechanism of Action of Nanoparticles

2.1. Electrostatic interaction and cell membrane damage

Nanoparticles carrying a positive surface charge are attracted to the negatively charged bacterial cell envelope through electrostatic forces, leading to their accumulation on the microbial surface. This interaction compromises the structural integrity of the cell wall and increases membrane permeability, facilitating nanoparticle entry into the cytoplasm and subsequent leakage of intracellular components. Additionally, nanoparticles may associate with mesosomal structures, interfering with bacterial respiration, cell division, and genetic replication, ultimately resulting in cell death.⁶

2.2. Disruption of metal ion homeostasis

Microorganisms rely on tightly regulated metal ion concentrations for normal metabolic activity. The excessive presence of metal-based nanoparticles disturbs this equilibrium, impairing essential biochemical pathways. Such imbalance results in metabolic dysfunction, growth inhibition, and irreversible cellular damage, culminating in microbial death.⁷

2.3. Reactive oxygen species (Ros) production

Following penetration of the bacterial cell membrane, nanoparticles stimulate the generation of reactive oxygen

species, inducing oxidative stress within the cell. This oxidative environment disrupts ATP synthesis and cellular respiration while causing structural damage to the cell membrane. The antimicrobial effect is further intensified through redox cycling reactions and pro-oxidant functional groups present at the metal oxide–nanoparticle interface.⁸

2.4. Protein and enzyme inactivation

Nanoparticles promote oxidative modification of amino acid residues, leading to the formation of carbonyl groups within proteins. This process accelerates protein degradation and enzyme inactivation, thereby impairing vital enzymatic functions and contributing to microbial cell death.⁹

2.5. Genotoxic effects and signal pathway interference

Due to their electrical and physicochemical properties, nanoparticles can interact directly with nucleic acids, adversely affecting the replication of both chromosomal and plasmid DNA. Such interactions disrupt cellular signaling pathways and genetic processes essential for microbial survival, ultimately leading to cell death.¹⁰

2.6. Enhanced penetration into root canal anatomy

The nanoscale size of nanoparticles allows improved penetration of irrigants into dentinal tubules and complex root canal irregularities, particularly in the apical third. This enhanced penetration optimizes fluid movement and facilitates more effective cleaning and debridement of the canal system.¹¹

2.7. Antibiofilm properties

Nanoparticles such as silver and titanium dioxide possess the ability to infiltrate and disrupt biofilm structures. When used in conjunction with conventional disinfectants, they exhibit a synergistic effect that enhances biofilm breakdown and improves microbial elimination.¹²

2.8. Controlled delivery of therapeutic agents

Nanocarrier systems, including liposomes, micelles, and nanocapsules, enable sustained and site-specific release of therapeutic agents such as antibiotics and growth factors. This targeted delivery prolongs therapeutic action at the intended site while minimizing systemic exposure and adverse effects.¹³

2.9. Improvement in sealing and bonding

The incorporation of nanoparticles, such as nano-hydroxyapatite, into root canal sealers enhances adhesion to dentin, promotes remineralization, and reduces bacterial microleakage. Nanocomposite formulations improve flow characteristics and sealing efficiency, contributing to improved clinical outcomes.¹⁴

2.10. Dentin remineralization

Nano-hydroxyapatite particles can infiltrate microscopic defects within dentin, replenishing lost mineral content and restoring structural integrity. This process strengthens dentin and reduces susceptibility to further demineralization and fracture.¹⁴

2.11. Role in regenerative endodontics

Nanomaterials including nano scaffolds, bioactive nanoparticles, and nanogels support regenerative endodontic strategies by facilitating stem cell adhesion, proliferation, and differentiation into odontoblast-like cells. This promotes the formation of new dentin and pulp-like tissues, aiding in tissue repair and regeneration.¹⁵

2.12. Photocatalytic properties

Titanium dioxide nanoparticles, upon activation by ultraviolet light, generate reactive oxygen species capable of degrading organic debris and biofilms. This photocatalytic activity enhances disinfection during root canal therapy and may also contribute to tooth whitening effects.¹⁶

3. Applications of Nanoparticles in Endodontics

3.1. Nanomaterials as endodontic irrigants

Irrigation is a fundamental component of endodontic therapy, as it aids in the elimination of microorganisms, necrotic pulp remnants, and dentinal debris from the root canal system. Conventional irrigating solutions such as sodium hypochlorite and chlorhexidine are routinely employed; however, these agents possess certain drawbacks, including the inability of chlorhexidine to dissolve organic tissues and concerns related to cytotoxicity. In recent years, nanoparticles—particularly silver nanoparticles—have gained attention as potential irrigating agents owing to their large surface area and strong antimicrobial activity.¹⁷

Evidence suggests that silver nanoparticles are capable of penetrating the smear layer and forming a protective interface that limits bacterial penetration while preserving the structural integrity of dentin. Additionally, these nanoparticles can effectively reach the apical region of the root canal and demonstrate significant antibacterial activity against *Enterococcus faecalis*. The application of auxiliary techniques, such as low-intensity electric or magnetic fields, has been shown to further improve nanoparticle penetration within the intricate anatomy of the root canal system.

Recent advancements in endodontic irrigation involve the integration of nanoparticles with activation techniques such as passive ultrasonic irrigation and laser-based activation to improve their antibacterial performance. Research has shown that the use of silver nanoparticles in conjunction with ultrasonic or laser activation results in significantly greater microbial reduction when compared with conventional irrigation protocols.¹⁸ In addition,

chitosan-based nanoparticles have attracted increasing interest due to their capacity to effectively eliminate the smear layer and promote deeper sealer penetration while preserving the mechanical integrity of dentin. These observations underscore the promising role of nanoparticles in enhancing both the antimicrobial effectiveness and functional properties of root canal irrigating solutions.¹⁸

3.2. Nanomaterials as obturating materials

Nanomaterials as Obturating Materials Gutta-percha remains the most widely used obturating material in endodontics, however, its lack of antibacterial properties limits its effectiveness. Incorporating nanomaterials such as silver nanoparticles and nanodiamonds into gutta-percha is an emerging strategy to enhance its antibacterial properties and improve clinical outcomes. Silver nanoparticles provide sustained release of silver ions, which exhibit antimicrobial effects against pathogens like *E. faecalis* and *C. albicans*. Nanodiamonds, combined with amoxicillin, also show promise by enhancing antibacterial activity and improving the mechanical properties of gutta-percha. Further innovations include bioceramic calcium silicate nanoparticles, which can be coated onto or incorporated into gutta-percha points. These modifications increase fracture resistance and enhance obturation quality by improving sealer penetration and push-out bond strength. These advancements in nanomaterial-based obturation materials highlight their potential to reduce the risk of reinfection and enhance the longevity and effectiveness of root canal treatments.¹⁹

3.3. Nanomaterials in endodontic sealers

Endodontic sealers are integral to the obturation process, as they occupy the interface between core filling materials, such as gutta-percha, and the dentinal walls, thereby achieving a three-dimensional seal that blocks lateral and accessory canals. For sustained clinical success, an ideal sealer should provide an effective hermetic seal, maintain dimensional stability over time, and possess antimicrobial activity while remaining biocompatible with periapical tissues. In addition, sealers are required to be insoluble in tissue fluids after setting yet retrievable when necessary.

A wide range of endodontic sealers has been developed, including zinc oxide–eugenol, calcium hydroxide, calcium phosphate, glass ionomer, calcium silicate, salicylate, methacrylate resin, silicone, and epoxy resin–based formulations. Despite these advances, none of the currently available sealers fully satisfy all the characteristics of an ideal material. As a result, nanotechnology has emerged as a promising approach to enhance sealer performance. The incorporation of nanoparticles offers multiple advantages, including prolonged antimicrobial activity that improves bactericidal efficacy. Nanoparticles may also function as delivery systems for therapeutic agents, enabling localized drug release, or act as surface modifiers that enhance

micromechanical bonding to dentin. Furthermore, nanomaterials can increase bioactivity by promoting mineral deposition, thereby improving adaptation and integration with dentinal walls.²⁰ Overall, the integration of nanomaterials into endodontic sealers represents a significant strategy for overcoming existing limitations and enhancing the quality and durability of root canal obturation.

3.4. Metal and metal oxide nanoparticles in endodontic sealers

The addition of metal and metal oxide nanoparticles to endodontic sealers has been shown to enhance their antimicrobial effectiveness and overall material performance. Among these, silver nanoparticles have demonstrated strong antimicrobial activity against a wide range of microorganisms, including *Candida albicans* and *Enterococcus faecalis*. Consequently, silver nanoparticles have been incorporated into several commercially available sealers, such as AH Plus, EndoSequence, MTA Fillapex, Sealapex, and TubliSeal. Silver nanoparticles within the size range of approximately 20–54 nm significantly improve antibacterial efficacy, particularly against *E. faecalis*. However, despite their antimicrobial benefits, silver-modified sealers may still permit bacterial leakage over extended periods. In addition, concerns regarding cytotoxicity persist, as silver nanoparticles are capable of generating reactive oxygen species, which may induce oxidative stress and adversely affect osteoblasts and fibroblasts.²¹

Zinc oxide nanoparticles exhibit superior antimicrobial properties when compared with other metal oxides such as magnesium oxide and titanium dioxide. These nanoparticles effectively inhibit *E. faecalis* growth without adversely affecting the physical characteristics of methacrylate resin-based sealers. Zinc oxide nanoparticles, typically around 40 nm in size, demonstrate lower cytotoxicity toward fibroblasts than silver nanoparticles and are associated with improved cellular proliferation. The combined use of silver and zinc oxide nanoparticles may provide an optimal balance between antimicrobial efficacy and biocompatibility. However, zinc oxide nanoparticles smaller than 50 nm may exhibit toxic effects on osteoblasts, emphasizing the critical role of nanoparticle size and morphology in determining biological response. In addition, zinc oxide nanoparticles have been shown to enhance sealer properties such as flowability and penetration into dentinal tubules.²¹ Other metal oxide nanoparticles, including ferrimagnetic magnetite (Fe_3O_4) nanoparticles with sizes ranging from 50 to 100 nm, have also been investigated for their ability to improve dentinal tubule penetration, particularly when used in conjunction with an external magnetic field. Collectively, these findings indicate that metal and metal oxide nanoparticles can significantly improve both the antimicrobial performance and physical characteristics of endodontic sealers. Nevertheless, careful evaluation of cytotoxicity and long-term clinical behaviour remains essential before widespread clinical adoption.

3.5. Nanomaterials as Nanocarriers

Nanomaterials such as halloysite nanotubes and multi-walled carbon nanotubes have demonstrated significant potential as drug-delivery vehicles in endodontic sealers. Halloysite nanotubes loaded with antimicrobial agents have been shown to markedly suppress the growth of *Enterococcus faecalis* when compared with conventional sealer formulations. Similarly, multi-walled carbon nanotubes exhibit enhanced antibacterial activity when combined with agents such as chlorhexidine and silver nanoparticles.²²

Mesoporous silica nanoparticles and mesoporous calcium-silicate nanoparticles possess a highly porous structure that allows effective penetration into dentinal tubules and enables sustained release of antimicrobial agents. This controlled release contributes to improved antimicrobial action and promotes periapical healing. In addition, poly (lactic-co-glycolic acid)-based nanoparticles have been utilized as carriers for propolis and other therapeutic agents, providing prolonged drug release and strong antibacterial effects against *E. faecalis* and other endodontic pathogens.

3.6. Nanomaterials in retro-filling and root-repair materials

Root-end filling materials are essential in periapical surgical procedures, with mineral trioxide aggregate widely regarded as the standard material of choice. Despite its advantages, MTA exhibits several shortcomings, including difficult handling characteristics, extended setting time, and limited antimicrobial activity. To address these limitations, nanoparticles have been incorporated into MTA and other bioactive endodontic repair materials. The addition of silver nanoparticles has been reported to enhance antimicrobial efficacy, biocompatibility, calcium ion release, and dimensional stability, while also reducing setting time and improving radiopacity.²³

Other nanoparticle systems, including bismuth-based lipophilic nanoparticles, titanium dioxide nanoparticles, and zinc oxide nanoparticles, have been investigated for their ability to further improve antimicrobial properties, mechanical strength, and radiographic visibility. However, optimization is required to prevent adverse effects on compressive strength. Hydroxyapatite nanoparticles have been shown to enhance radiopacity and exhibit antibiofilm activity, although their incorporation may negatively influence compressive strength and solubility. Additionally, nanoparticles such as titanium dioxide and silver have been reported to improve the bond strength of MTA to dentin, whereas silicon dioxide nanoparticles appear to have minimal influence on bonding performance.^{23,24}

3.7. Nanomaterials for pulpal repair and regeneration

Pulpal regeneration is a complex process that relies on the coordinated use of stem cells, scaffolding materials, and bioactive molecules to restore the pulp-dentin complex. An ideal scaffold should closely resemble the native extracellular

matrix (ECM). In this context, nanofibrous scaffolds have gained attention due to their ability to enhance cell–material interactions, provide structural support, and promote stem cell adhesion, proliferation, and differentiation. Nanofibers facilitate cellular attachment, protein adsorption, and integrin-mediated interactions, thereby influencing stem cell behaviour and activating intracellular signaling pathways involved in tissue regeneration.

Nanoparticle-based systems have emerged as promising scaffold materials for pulpal repair. Various nanoparticles, including magnetic nanoparticles, titanium dioxide (TiO₂) nanoparticles, and hydroxyapatite nanoparticles, have been shown to support stem cell attachment, growth, and lineage-specific differentiation. Additionally, mesoporous bioactive nanoparticles and zinc-based bioglass nanoparticles play a significant role in enhancing odontoblastic differentiation and angiogenesis, highlighting their potential applications in regenerative endodontics. Chitosan nanoparticles, commonly employed as drug delivery vehicles, can modulate stem cell differentiation depending on their encapsulation strategies. Furthermore, mesoporous bioglass nanospheres exhibit both antimicrobial properties and regenerative potential, making them valuable materials for pulpal tissue engineering.²⁵

4. Conclusion

In summary, the application of nanoparticles in endodontics offers substantial potential to improve clinical treatment outcomes. Their distinctive physicochemical characteristics facilitate enhanced root canal disinfection, precise delivery of therapeutic agents, and support for tissue regenerative processes. The incorporation of nanoparticle-based antimicrobial systems and endodontic sealers has demonstrated superior effectiveness in biofilm management while improving sealing ability and biocompatibility. Although current findings are promising, continued research is essential to refine material formulations, confirm long-term safety, and develop standardized protocols for clinical use. With further advancement, nanotechnology is poised to significantly transform endodontic practice by increasing treatment predictability and improving overall patient care.

5. Authors' Contributions

1. Dr. Gaurav Jain: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review editing.
2. Dr. Swadhinta Raj: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Writing – original draft, Writing – review editing.
3. Dr. Sonali Verma: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review editing.
4. Dr. Pradyumna Misra: Conceptualization, Data curation, Formal analysis.
5. Dr. Manoj Hans: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Writing – original draft.
6. Dr. Lalit C. Boruah: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Writing – original draft.

6. Source of Funding

None.

7. Conflict of Interest

None.

References

1. Chandak PG, Ghanshyamdasj M, Chandak C, Relan KN, Chandak M, Rathi C, et al. Nanoparticles in Endodontics - A Review. *J Evol Med Dent Sci*. 2021;10(13):976-82. <https://doi.org/10.14260/jemds/2021/209>.
2. Raura N, Garg A, Arora A, Roma M. Nanoparticle technology and its implications in endodontics: a review. *Biomater Res*. 2020;24(1):21. <https://doi.org/10.1186/s40824-020-00198-z>.
3. Jain G, Shukla P, Misra P, Hans M, Rastogi S, Verma S. Investigation of the Potential of Nanoparticles as a New Drug Delivery System for Endodontic Treatment: An In Vitro Study. *J Pharm Bioallied Sci*. 2024;16(Suppl 1):S921-3. https://doi.org/10.4103/jpbs.jpbs_1093_23.
4. Afkhami F, Chen Y, Walsh LJ, Peters OA, Xu C. Application of Nanomaterials in Endodontics. *BME Front*. 2024;5:0043. <https://doi.org/10.34133/bmef.0043>.
5. Bhandi S, Mehta D, Mashyakhy M, Chohan H, Testarelli L, Thomas J, et al. Antimicrobial Efficacy of Silver Nanoparticles as Root Canal Irrigant's: A Systematic Review. *J Clin Med*. 2021;10(6):1152. <https://doi.org/10.3390/jcm10061152>.
6. Wong J, Zou T, Lee AHC, Zhang C. The Potential Translational Applications of Nanoparticles in Endodontics. *Int J Nanomed*. 2021;:2087-106. <https://doi.org/10.2147/ijn.s293518>.
7. Kim YH, Lee DK, Cha HG, Kim CW, Kang YC, Kang YS. Preparation and Characterization of the Antibacterial Cu Nanoparticle Formed on the Surface of SiO₂ Nanoparticles. *J Physical Chem B*. 2006;110(49):24923-8. <https://doi.org/10.1021/jp0656779>.
8. Bhushan J, Maini C. Nanoparticles: A promising novel adjunct for dentistry. *Indian J Dent Sci*. 2019;11(3):167-73. https://doi.org/10.4103/ijds.ijds_26_19.
9. Sondi I, Salopek-Sondi B. Silver nanoparticles as antimicrobial agent: a case study on E. coli as a model for Gram-negative bacteria. *J Colloid Interface Sci*. 2004;275(1):177-82. <https://doi.org/10.1016/j.jcis.2004.02.012>.
10. Gudkov SV, Burmistrov DE, Fomina PA, Validov SZ, Kozlov VA. Antibacterial Properties of Copper Oxide Nanoparticles (Review). *Int J Mol Sci*. 2024;25(21):11563. <https://doi.org/10.3390/ijms252111563>.
11. Nel A, Xia T, Mädler L, Li N. Toxic Potential of Materials at the Nanolevel. *Science*. 2006;311(5761):622-7. <https://doi.org/10.1126/science.1114397>.
12. Lynch I, Dawson KA. Protein-nanoparticle interactions. *Nano Today*. 2008;3(1-2):40-7. [https://doi.org/10.1016/s1748-0132\(08\)70014-8](https://doi.org/10.1016/s1748-0132(08)70014-8).
13. Aggarwal P, Hall JB, McLeland CB, Dobrovolskaia MA, McNeil SE. Nanoparticle interaction with plasma proteins as it relates to particle biodistribution, biocompatibility and therapeutic efficacy. *Adv Drug Del Rev*. 2009;61(6):428-37. <https://doi.org/10.1016/j.addr.2009.03.009>.
14. Giannousi K, Lafazanis K, Arvanitidis J, Pantazaki A, Dendrinou-Samara C. Hydrothermal synthesis of copper based nanoparticles: Antimicrobial screening and interaction with DNA. *J Inorganic*

- Biochem.* 2014;133:24-32. <https://doi.org/10.1016/j.jinorgbio.2013.12.009>.
15. Arakha M, Pal S, Samantarrai D, Panigrahi TK, Mallick BC, Pramanik K, et al. Antimicrobial activity of iron oxide nanoparticle upon modulation of nanoparticle-bacteria interface. *Scientific Rep.* 2015;5(1):14813. <https://doi.org/10.1038/srep14813>.
 16. Boitsaniuk S, Kochan O, Levkiv M. Applications of Nanotechnology in Endodontics: A Narrative Review. *Nanoarchitectonics.* 2023;105-20. <https://doi.org/10.37256/nat.4220233758>.
 17. Shrestha A, Kishen A. Antibacterial Nanoparticles in Endodontics: A Review. *J Endod.* 2016;42(10):1417-26. <https://doi.org/10.1016/j.joen.2016.05.021>.
 18. Roy V, Pandey S, Shukla S, Jain G, Verma S, Misra P. Nanotechnology-Driven Strategies in Endodontics: A Comprehensive Review of Disinfection and Therapeutic Delivery Innovations. *IP Indian J Conserv Endod.* 2025;10(4):217-23. <https://doi.org/10.18231/j.ijce.13802.1764046590>.
 19. Mierzejewska ŻA, Rusztyn B, Łukaszuk K, Borys J, Borowska M, Antonowicz B. The latest advances in the use of nanoparticles in endodontics. *Appl Sci.* 2024;14(17):7912. <https://doi.org/10.3390/app14177912>
 20. Hameed S, Antony DP, Shanmugam R, Raghu S, Adimulapu HS. Enhancing Antimicrobial Efficacy and Synergistic Effects of Nano-Silica-Based Combinations With Doxycycline, Metronidazole, and Ciprofloxacin Against *Enterococcus faecalis* Biofilms. *Cureus.* 2024;16(2):e54668. <https://doi.org/10.7759/cureus.54668>.
 21. Tian L, Peng C, Shi Y, Guo X, Zhong B, Qi J, et al. Effect of mesoporous silica nanoparticles on dentinal tubule occlusion: an in vitro study using SEM and image analysis. *Dent Mater J.* 2014;33(1):125-32. <https://doi.org/10.4012/dmj.2013-215>.
 22. Lee D, Kim SV, Limansubroto AN, Yen A, Soundia A, Wang C, et al. Nanodiamond–Gutta Percha Composite Biomaterials for Root Canal Therapy. *ACS Nano.* 2015;9(11):11490-501. <https://doi.org/10.1021/acs.nano.5b05718>.
 23. Vishwanath V, Rao H. Gutta-percha in endodontics - A comprehensive review of material science. *J Conserv Dent.* 2019;22(3):216-22. https://doi.org/10.4103/jcd.jcd_420_18.
 24. Zakrzewski W, Dobrzyński M, Zawadzka-Knefel A, Lubojański A, Dobrzyński W, Janecki M, et al. Nanomaterials Application in Endodontics. *Materials.* 2021;14(18):5296. <https://doi.org/10.3390/ma14185296>.
 25. Jain G. The Power of Mighty Mini: Nanotechnology a New Era in Endodontic Care. *IP Indian J Conserv Endod.* 2025;10(3):135-7. <https://doi.org/10.18231/j.ijce.34143.1759913083>.

Cite this article: Jain G, Raj S, Verma S, Misra P, Hans M, Boruah LC. Nano Revolution in Modern Endodontics: A Narrative Review. *J Int Coll Dent.* 2026;64(1):8-13.