

**NANO SMILES - REVOLUTIONIZING PERIODONTICS WITH NANOTECHNOLOGY-
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Article Received: 22 February 2026

Article Revised: 14 March 2026

Article Published: 01 April 2026



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PG, 2nd Year, Department of Periodontology, Tamil Nadu Government Dental College and Hospital, Chennai, Tamil Nadu. DOI: <https://doi.org/10.5281/zenodo.19330600>**How to cite this Article:** ¹Dr. Vinu Priya P.*, ²Dr. Jaishree Tukaram Kshirsagar, ³Dr. Mohamed Riyaz J. (2026). Nano Smiles - Revolutionizing Periodontics With Nanotechnology- A Review. World Journal of Advance Healthcare Research, 10(4), 09–11.

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ABSTRACT

Nanotechnology is reshaping periodontal diagnostics, drug delivery, anti-infective strategies, and tissue regeneration. Engineered nanoparticles (NPs), nanofibers, and nano-modified biomaterials can localize therapeutics within periodontal pockets, disrupt biofilms, modulate inflammation, and enhance regeneration through spatiotemporally controlled release of bioactive agents. While preclinical and early clinical data are encouraging—particularly for antimicrobial NPs, nano-hydroxyapatite (nHA) grafts, and nano-enabled membranes—questions remain about long-term safety, standardization, and regulatory pathways.^[1]

KEYWORDS: Nanotechnology, Nanoparticle Drug Deliversystem, Regeneration, Tissue Matrix, Therapeutics.**INTRODUCTION**

Periodontitis is a biofilm-driven, host-mediated inflammatory disease leading to connective-tissue breakdown and alveolar bone loss. Mechanical debridement, adjunctive antimicrobials, and regenerative surgery are effective but limited by rapid drug clearance from periodontal pockets, persistent biofilms, and difficulty achieving predictable regeneration. Nanoscale systems (1–100 nm) offer large surface area, and the ability to penetrate biofilms and tissues, enabling targeted, sustained therapy and improved biomaterial–tissue interactions.^[2]

RATIONALE FOR NANOTECHNOLOGY IN PERIODONTICS

(a) Biofilm penetration and retention. NPs can traverse extracellular polymeric substances and exhibit prolonged retention in periodontal pockets when embedded in in-situ gels, fibers, or mucoadhesive carriers.^[3]

(b) Multifunctionality. Single nano-platforms can combine antimicrobial action, anti-inflammatory drug

delivery, and osteogenic cues (e.g., ion-releasing ceramics, growth-factor carriers).^[4]

(c) Surface nanotopography. Nano-engineered implant and membrane surfaces enhance protein adsorption, cell adhesion, and osteogenic differentiation—key in periodontal regeneration and peri-implant therapy.^[5]

NANO-ENABLED ANTI-INFECTIVE STRATEGIES

Metallic nanoparticles. Silver (Ag) and gold (Au) NPs show broad-spectrum antimicrobial activity, inhibit biofilm formation, and may exhibit antioxidant/anti-inflammatory effects. Their use has been explored against periodontal pathogens and early colonizers, either as free NPs or incorporated into varnishes, gels, and membranes. Translation hinges on dose optimization and cytocompatibility.^[6]

Polymeric and lipid NPs. Biodegradable carriers (PLGA, chitosan, lipid NPs) encapsulate antibiotics (e.g., doxycycline), antiseptics (chlorhexidine), or host-modulators (NSAIDs, statins), providing sustained local

delivery with improved pocket residence time after scaling and root planing (SRP). Reviews consistently report superior microbiological and clinical surrogates versus non-nano local delivery in preclinical and early clinical studies.^[7]

Plant-derived therapeutics. Polyphenol-loaded NPs (e.g., curcumin, resveratrol) demonstrate anti-inflammatory, antioxidant, and anti-resorptive effects in experimental periodontitis, with nanoencapsulation improving stability and bioavailability.^[8]

NANO-BASED DRUG DELIVERY FOR NON-SURGICAL PERIODONTAL THERAPY

Localized nanocarriers—particles, micelles, nanoemulsions, nanofibers, and injectable in-situ forming gels—can achieve (i) sustained release matched to pocket fluid turnover, (ii) gradient-driven diffusion into tissues, and (iii) combination therapy (antimicrobial + host modulation). Systematic reviews highlight polymeric, metallic, ceramic, and carbon-based NPs improving inflammatory markers, probing depth, and clinical attachment surrogates in preclinical and small clinical cohorts, though heterogeneity and risk-of-bias limit meta-analysis.^[9]

REGENERATIVE PERIODONTICS AND HARD-TISSUE REPAIR

Nano-hydroxyapatite (nHA). nHA mimics mineralized tissue at the crystallite level, supporting osteoconduction and potentially osteoinduction. Systematic and clinical studies report nHA grafts improving intrabony defect fill and clinical parameters versus open-flap debridement, with favorable handling and biocompatibility; however, long-term comparative trials versus autografts/xenografts remain limited.^[10]

Composite scaffolds and bioactive aerogels. nHA combined with chitosan or collagen in porous scaffolds/aerogels enhances mechanical integrity and bioactivity, promoting periodontal-origin cell osteogenesis and bone formation in animal models.^[11]

Guided tissue regeneration (GTR) membranes and nanofibers. Electrospun nanofibrous membranes (e.g., polycaprolactone, chitosan, graphene-modified) provide high surface area for cell adhesion and can be loaded with antimicrobials or growth factors to create “theranostic” barriers. Early evidence suggests better soft-tissue integration and reduced infection risk, but clinical data are still emerging.^[11]

DIAGNOSTICS AND THERANOSTICS

Nanosensors (e.g., plasmonic, electrochemical) for salivary or gingival-crevicular-fluid biomarkers (MMPs, IL-1 β , PGE2) are under development to enable point-of-care disease activity monitoring and real-time treatment feedback. Nano-contrast agents for optical or photoacoustic imaging may help visualize pocket anatomy or inflammation, enabling precision

debridement and follow-up. (Evidence largely preclinical).^[11]

SAFETY, BIOCOMPATIBILITY, AND REGULATORY CONSIDERATIONS

While most periodontal nano-applications use biodegradable carriers with good short-term cytocompatibility, concerns include.

- **Dose-dependent toxicity and ion release** (notably for metallic NPs).
- **Particle aggregation and biodistribution** beyond periodontal sites.
- **Standardization** of size, zeta potential, and surface chemistry affecting reproducibility.
- **Regulatory classification** (drug vs device vs combination) and GMP manufacturing controls. Recent reviews call for harmonized characterization, robust clinical trials with meaningful endpoints (attachment gain, radiographic fill), and long-term surveillance.^[6]

PRACTICAL CLINICAL PATHWAYS

1. **Adjunctive local nano-drug delivery after SRP** (e.g., antibiotic/antiseptic-loaded polymeric NPs in gels/fibres) for deep or refractory pockets.
2. **nHA-based bone grafts** (alone or in blends) for intrabony defects; consider patient factors and defect morphology; compare against well-established xenografts in shared decision-making.
3. **Nano-engineered GTR membranes or nanofiber dressings** in regenerative surgery, particularly when infection risk is high—prefer products with peer-reviewed data and regulatory clearance.^[10]

LIMITATIONS OF THE EVIDENCE

- Many reports are **in vitro** or **small animal** studies; clinical RCTs are few and heterogeneous in design, materials, and endpoints.
- Lack of **head-to-head** comparisons between nano-formulations and gold-standard grafts/membranes.
- **Follow-up durations** often <12 months, limiting conclusions on stability of outcomes.^[4]

FUTURE DIRECTIONS

- **Smart, responsive systems** (pH/ROS/enzyme-triggered release) for on-demand antimicrobial and host-modulatory delivery.
- **Biomimetic carriers** (cell-membrane-coated NPs, exosomes) to enhance targeting and immune evasion.
- **Integrated theranostics** combining sensing, imaging, and therapy in one platform.
- **Standardized clinical trials** with CONSORT-aligned designs, validated biomarker panels, and cost-effectiveness analyses to guide adoption.^[11]

CONCLUSION

Nanotechnology offers a compelling toolkit for contemporary periodontics: it strengthens non-surgical therapy through targeted, durable antimicrobial/anti-

inflammatory delivery; improves regenerative outcomes via bioactive nano-grafts and membranes; and holds promise for point-of-care diagnostics and theranostics. Translation to routine care now depends on high-quality clinical trials, long-term safety data, standardized material characterization, and clear regulatory pathways.

for periodontal regeneration. *Front. Bioeng. Biotechnol*, 12: 1355950.

REFERENCES

1. Li, J., Wang, Y., Tang, M. et al. New insights into nanotherapeutics for periodontitis: a triple concerto of antimicrobial activity, immunomodulation and periodontium regeneration. *J Nanobiotechnol*, 2024; 22: 19.
2. Wang D, Li Q, Xiao C, Wang H, Dong S. Nanoparticles in Periodontitis Therapy: A Review of the Current Situation. *Int J Nanomedicine*, 2024; 19: 6857-6893.
3. Li J, Wang Y, Tang M, Zhang C, Fei Y, Li M, Li M, Gui S, Guo J. New insights into nanotherapeutics for periodontitis: a triple concerto of antimicrobial activity, immunomodulation and periodontium regeneration. *J Nanobiotechnology*, 2024 Jan 4; 22(1): 19.
4. Chen H, Zhang Y, Yu T, Song G, Xu T, Xin T, Lin Y, Han B. Nano-Based Drug Delivery Systems for Periodontal Tissue Regeneration. *Pharmaceutics*, 2022; 14(10): 2250.
5. Vuk Uskoković, Ana Pejčić, Rozafa Koliqi, Zlatibor Anđelković, Polymeric nanotechnologies for the treatment of periodontitis: A chronological review, *International Journal of Pharmaceutics*, 2022; 625: 122065, ISSN 0378-5173.
6. Yin IX, Udduttulla A, Xu VW, Chen KJ, Zhang MY, Chu CH. Use of Antimicrobial Nanoparticles for the Management of Dental Diseases. *Nanomaterials*, 2025; 15(3): 209.
7. Amani Mohammed Basudan, Nanoparticle based periodontal drug delivery – A review on current trends and future perspectives, *The Saudi Dental Journal*, 2022; 34(8): 669-680, ISSN 1013-9052,
8. Jayusman PA, Nasruddin NS, Mahamad Apandi NI, Ibrahim N and Budin SB (2022) Therapeutic Potential of Polyphenol and Nanoparticles Mediated Delivery in Periodontal Inflammation: A Review of Current Trends and Future Perspectives. *Front. Pharmacol*, 13: 847702.
9. Chen H, Zhang Y, Yu T, Song G, Xu T, Xin T, Lin Y, Han B. Nano-Based Drug Delivery Systems for Periodontal Tissue Regeneration. *Pharmaceutics*, 2022; 14(10): 2250.
10. Muhammad Saad Shaikh, Muhammad Sohail Zafar, Ahmad Alnazzawi, Fawad Javed, Nanocrystalline hydroxyapatite in regeneration of periodontal intrabony defects: A systematic review and meta-analysis, *Annals of Anatomy - Anatomischer Anzeiger*, 2022; 240: 151877, ISSN 0940-9602.
11. Souto-Lopes M, Grenho L, Manrique Y, Dias MM, Lopes JCB, Fernandes MH, Monteiro FJ and Salgado CL (2024) Bone regeneration driven by a nano-hydroxyapatite/chitosan composite bioaerogel