Biomaterials Journal
http://www.biomatj.com
Online ISSN: 2812-5045

Type of the Paper (Mini-Review)

Antibacterial agents in dentistry: A Mini-Review

Tamer M. Hamdy [1,*]

Citation: Tamer M. Hamdy. Current Antibacterial agents in dentistry: A Mini-Review. *Biomat. J., 4 (3),1 – 4 (2025).*

https://doi.org/10.5281/znodo.5829408

Received: 30 September 2025
Accepted: 20 October 2025
Published: 31 October 2025

[1] Restorative and Dental Materials Department, Oral and Dental Research Institute, National Research Centre (NRC), Giza, Dokki, 12622, Egypt
* Corresponding author e-mail: dr_tamer_hamdy@yahoo.com

Abstract: Antibacterial agents are essential in today's dentistry, helping to prevent and manage oral infections that could jeopardize dental treatments and overall health. This review highlights the various mechanisms, applications, and the latest advancements in antibacterial agents used in dental practices, focusing on chemical, mechanical, and biological methods for managing biofilms.

Keywords: antibacterial agents; dental biofilm; oral microbiome; endodontic disinfection.

The oral cavity is like a bustling city of microbes, home to more than 700 different bacterial species. While many of these bacteria are harmless neighbors, some, like *Streptococcus mutans*, *Porphyromonas gingivalis*, and *Aggregatibacter actinomycetemcomitans*, can cause trouble, leading to dental caries, periodontitis, and endodontic infections. To keep these harmful pathogens in check, it's crucial to implement effective antibacterial strategies. This helps prevent biofilm formation and ensures that both restorative and surgical procedures go smoothly [1].

Common Antibacterial Agents in Dentistry

Chlorhexidine (CHX)

Chlorhexidine gluconate is a broad-spectrum bisbiguanide antiseptic widely used in mouth rinses and irrigants. It acts by disrupting bacterial cell membranes and precipitating cytoplasmic contents. Despite its efficacy, prolonged use may cause tooth staining, taste alteration, and mucosal irritation [2].

Sodium Hypochlorite (NaOCl)

Used mainly as an endodontic irrigant, sodium hypochlorite offers potent antibacterial and tissue-dissolving properties. It effectively eliminates Enterococcus faecalis from root canals but may cause tissue toxicity if extruded beyond the apex [3].

Hydrogen Peroxide (H_2O_2)

Hydrogen peroxide exhibits bactericidal activity through the release of reactive oxygen species (ROS). It is frequently used in periodontal therapy and teeth whitening procedures, though its oxidative potential can irritate oral tissues at high concentrations [4].

Fluoride Compounds

Fluoride not only strengthens enamel but also exhibits antibacterial properties by inhibiting bacterial enzymes such as enolase, thereby disrupting glycolysis in *S. mutans*. Topical fluoride varnishes and gels are standard preventive measures against caries [5].

Silver-Based Agents

Silver nanoparticles (AgNPs) have recently gained attention due to their strong antimicrobial activity and minimal resistance development. They are incorporated in dental composites, cements, and coatings for implant surfaces [6].

Natural and Novel Antibacterial Alternatives

The limitations of chemical agents have prompted interest in natural compounds such as essential oils (tea tree, clove, eucalyptus) and plant-derived polyphenols (green tea catechins, curcumin). Additionally, modern innovations include antimicrobial photodynamic therapy (aPDT), nanoparticle-based drug delivery, and bioactive glass materials that release antibacterial ions [7].

Recent Advances in Natural Antibacterial Agents

In recent years, there has been growing interest in the use of natural antibacterial agents as safer and biocompatible alternatives to conventional chemical antimicrobials in dentistry. Natural compounds derived from plants, herbs, and other biological sources have shown promising antimicrobial effects against key oral pathogens such as *Streptococcus mutans, Porphyromonas gingivalis, and Aggregatibacter actinomycetemcomitans*. These agents act through diverse mechanisms, including disruption of bacterial membranes, inhibition of adhesion and biofilm formation, and suppression of virulence factors [8].

Among the most studied natural agents are polyphenolic compounds such as curcumin, cinnamaldehyde, eugenol, thymol, carvacrol, and epigallocatechin gallate (EGCG). These molecules exhibit strong antibacterial activity against cariogenic species like S. mutans by inhibiting adhesion genes (e.g., gtfs, ftf, and gbpB), reducing acid production, and preventing biofilm maturation [9]. Curcumin, for instance, has been found to interfere with bacterial metabolism and energy production, while cinnamaldehyde and thymol act primarily by disrupting the bacterial cell membrane, leading to leakage of cytoplasmic contents and eventual cell death [10].

Another emerging compound, sulforaphane (SFN)—a naturally occurring isothiocyanate derived from cruciferous vegetables—has demonstrated notable antibacterial activity against S. mutans and other caries-associated bacteria. Recent studies suggest that SFN may serve as a natural substitute for traditional anti-caries agents, offering effective biofilm inhibition with minimal cytotoxic effects on oral tissues. Similarly, essential oils such as tea tree, clove, and eucalyptus oil have shown synergistic antimicrobial properties and are being evaluated for incorporation into mouth rinses and dental varnishes [11].

In the context of periodontal disease, natural agents such as resveratrol, EGCG, baicalin, berberine, and carvacrol exhibit dual antibacterial and anti-inflammatory effects. These bioactive compounds inhibit the growth of periodontal pathogens and modulate inflammatory signaling pathways such as NF-κB, MAPK, and JAK/STAT, thereby reducing tissue destruction and bone resorption. Their antioxidant properties further contribute to the maintenance of periodontal health by limiting oxidative stress and inflammatory cytokine release [11].

Recent developments also focus on enhancing the delivery and bioavailability of these natural agents. Many plant-derived compounds face challenges such as low solubility, instability, and rapid degradation in the oral environment. To overcome these limitations, researchers are developing advanced drug delivery systems (DDSs) such as nanoparticle carriers, hydrogels, and bioadhesive films to provide controlled release and improved antimicrobial efficacy. Silver- and chitosan-based nanocarriers, in particular, have been shown to enhance the stability and sustained antibacterial activity of plant extracts and essential oils [12].

While the results so far are encouraging, the real-world application of natural antibacterial agents in clinical settings is still quite limited. Most of the evidence we have comes from lab studies and tests done outside the body, with only a handful of large-scale clinical trials that actually confirm their safety and effectiveness in humans. There are several hurdles to overcome, such as figuring out the right concentrations, ensuring they taste

good, how they interact with dental materials, and making sure they remain stable over time before we can start using these agents regularly in dental care. Additionally, future studies should focus on finding the best formulations and looking into how these natural agents can work together with traditional treatments like chlorhexidine or fluoride [12].

Overall, natural antibacterial agents represent a rapidly advancing and scientifically grounded field in dental research. Their potential to serve as adjuncts or even alternatives to conventional chemical antimicrobials holds great promise for promoting oral health with fewer side effects. The integration of nanotechnology and bioactive material science is expected to further enhance the clinical applicability and therapeutic outcomes of these natural compounds in preventive and restorative dentistry.

Clinical Relevance and Future Perspectives

In restorative, periodontal, and endodontic treatments, the choice of antibacterial agent depends on infection severity, tissue type, and patient tolerance. The future lies in smart biomaterials capable of controlled antibacterial release and personalized antimicrobial therapy guided by microbiome profiling.

Conclusion

Antibacterial agents are crucial for preventing and managing oral infections. Ongoing research into biocompatible, resistance-proof, and targeted antimicrobial strategies is set to improve the safety and effectiveness of dental care.

Refernces

[1] P. J. Alves *et al.*, "Role of antiseptics in the prevention and treatment of infections in nursing homes," *Journal of Hospital Infection*, vol. 131. pp. 58–69, 2023. doi: 10.1016/j.jhin.2022.09.021.

[2] C. C. R. Ferraz, B. P. F. A. Gomes, A. A. Zaia, F. B. Teixeira, and F. J. Souza-Filho, "Comparative study of the antimicrobial efficacy of chlorhexidine gel, chlorhexidine solution and sodium hypochlorite as endodontic irrigants," *Braz. Dent. J.*, vol. 18, no. 4, pp. 294–298, 2007, doi: 10.1590/s0103-64402007000400004.

[3] K. G. Malavika, R. Sekar, and K. Ramar, "Antimicrobial efficacy of Andrographis paniculata, sodium hypochlorite, and their combination with diode laser on endodontic pathogen - Enterococcus faecalis - An in vitro study," *J. Int. Oral Heal.*, vol. 14, no. 3, pp. 260–265, 2022, doi: 10.4103/jioh.jioh_39_22.

[4] E. Patel, P. Pradeep, P. Kumar, Y. E. Choonara, and V. Pillay, "Oroactive dental biomaterials and their use in endodontic therapy," *Journal of Biomedical Materials Research - Part B Applied Biomaterials*, vol. 108, no. 1. pp. 201–212, 2020. doi: 10.1002/jbm.b.34379.

[5] A. Haider, P. Khadatkar, S. Suresh, S. Arisutha, and S. Verma, "Fluorides-foundation for healthy teeth: a dental perspectives," *Journal of Sol-Gel Science and Technology*, vol. 100, no. 3. pp. 375–387, 2021. doi: 10.1007/s10971-021-05668-x.

[6] M. Z. I. Nizami, V. W. Xu, I. X. Yin, O. Y. Yu, and C. H. Chu, "Metal and metal oxide nanoparticles in caries prevention: A review," *Nanomaterials*, vol. 11, no. 12. 2021. doi: 10.3390/nano11123446.

[7] L. Cheng, J. Li, L. He, and X. Zhou, "Natural products and caries prevention," in *Caries Research*, 2015, vol. 49, pp. 38–45. doi: 10.1159/000377734.

[8] A. Minkiewicz-Zochniak *et al.*, "Biofilm formation on dental implant biomaterials by staphylococcus aureus strains isolated from patients with cystic fibrosis," *Materials (Basel).*, vol. 14, no. 8, 2021, doi: 10.3390/ma14082030.

[9] L. Bartosikova and J. Necas, "Epigallocatechin gallate: A review," *Veterinarni Medicina*, vol. 63, no. 10. pp. 443–467, 2018. doi: 10.17221/31/2018-VETMED.

[10] S. J. Hewlings and D. S. Kalman, "Curcumin: A review of its effects on human health," *Foods*, vol. 6, no. 10. 2017. doi: 10.3390/foods6100092.

[11] X. Cao, X. W. Cheng, Y. Y. Liu, H. W. Dai, and R. Y. Gan, "Inhibition of pathogenic microbes in oral infectious diseases by natural products: Sources, mechanisms, and challenges," *Microbiological Research*, vol. 279. 2024. doi: 10.1016/j.micres.2023.127548.

[12] A. Prince, S. Roy, and D. McDonald, "Exploration of the Antimicrobial Synergy between Selected Natural Substances on Streptococcus mutans to Identify Candidates for the Control of Dental Caries," *Microbiol. Spectr.*, vol. 10, no. 3, 2022, doi: 10.1128/spectrum.02357-21.