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Pachymic Acid In Dentistry: Bioactivity And Regeneration

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Abstract
Pachymic acid (PA) is a lanostane-type triterpenoid isolated from Poria cocos, a traditional medicinal fungus. It exhibits potent antioxidant, anti-inflammatory, antitumor, antimicrobial, and osteogenic properties. Recent studies have explored its use in dentistry for reducing inflammation, enhancing bone and dentin regeneration, improving material biocompatibility, and inhibiting oral pathogens. This review summarizes the current evidence on the biological properties, mechanisms of action, and potential dental applications of PA, highlighting its promise as a multifunctional biomolecule in bioactive and regenerative dentistry.

Keywords: *Pachymic acid, Poria cocos, antioxidant, anti-inflammatory, bioactive materials, endodontics, regenerative dentistry.*

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I. Introduction

Bioactive dental materials seek to combine mechanical performance with favorable biological interactions. Many conventional dental sealers and restorative materials can trigger oxidative stress and inflammation in pulpal or periapical tissues. Natural compounds, particularly triterpenoids, are being investigated as biocompatible additives to mitigate these effects [1,2].

Pachymic acid (PA)—a triterpenoid from *Poria cocos*—has attracted attention due to its anti-inflammatory, antioxidant, and osteogenic potential [3,4]. Studies have shown that PA can reduce cytotoxicity of dental materials, stimulate odontoblastic differentiation, and suppress microbial growth in the oral environment [5,6].

II. Chemical Nature And Pharmacology

PA ($C_{30}H_{48}O_4$) belongs to the lanostane-type triterpenoid class [7]. The compound's hydroxyl and carbonyl groups enable multiple bioactivities:

- **Anti-inflammatory:** Inhibits NF-κB and MAPK signaling pathways [8].
- **Antioxidant:** Activates the Nrf2/HO-1 pathway [9].
- **Antimicrobial:** Disrupts bacterial and fungal membranes [5,10].
- **Cytoprotective:** Reduces oxidative injury induced by resin-based sealers [11].
- **Osteogenic:** Upregulates BMP-2 and Runx2 expression [12].

III. Mechanisms Relevant To Oral Tissues

Mechanism	Molecular Target	Dental Relevance
Inhibition of NF-κB	↓ TNF-α, IL-1β	Controls pulpal and gingival inflammation
Activation of Nrf2/HO-1	↑ Antioxidant enzymes	Protects pulp and bone cells from oxidative stress
Stimulation of BMP-2/Runx2	Osteogenic genes	Enhances bone and dentin regeneration
Membrane disruption	Microbial cell wall	Inhibits oral pathogens
Mitochondrial stabilization	↓ Apoptosis	Improves material biocompatibility

IV. Applications Of Pachymic Acid In Dentistry

Endodontics and Pulpal Biology

Senthamilselvan Arun et al. demonstrated that adding PA to root canal sealers significantly reduced cytotoxicity compared with unmodified sealers [4]. Chakravarthy et al. found that incorporation of PA into resin-based sealer (AH Plus) enhanced antimicrobial efficacy against *Enterococcus faecalis* and *Candida albicans*. The inhibition zones increased with PA concentration, demonstrating a dose-dependent effect [5].

Lee et al. further reported that PA upregulated heme oxygenase-1 (HO-1) in human dental pulp cells, promoting odontoblastic differentiation—indicating potential use in vital pulp therapy and regenerative endodontics [6].

Periodontology

PA reduces inflammatory cytokines such as IL-6 and TNF-α and downregulates RANKL expression, decreasing osteoclastic bone resorption [10]. Its antioxidant capacity supports periodontal tissue healing, suggesting possible use in locally delivered gels or membranes for regeneration.

Oral Oncology

PA demonstrates anticancer effects by inducing mitochondrial apoptosis and cell-cycle arrest in oral squamous carcinoma cells [11]. Such properties propose its use as an adjunctive chemopreventive agent in oral oncology.

Oral Microbiology and Biofilm Control

PA effectively inhibits oral microorganisms including *Streptococcus mutans*, *E. faecalis*, and *C. albicans* [5,9]. When integrated into dental materials, it prevents biofilm formation and secondary infection—useful for coatings, varnishes, and mouthrinses.

Bone and Implant Regeneration

PA promotes osteoblast differentiation through BMP-2 and Runx2 signaling [12,13], while suppressing osteoclastogenesis. This dual action supports its application in implant osseointegration and guided bone regeneration.

Oral Soft-Tissue Healing

Due to its antioxidant and anti-inflammatory properties, PA accelerates mucosal wound healing and reduces postoperative inflammation [14]. It may be valuable in oral gels or ulcer management formulations.

V. Advantages And Limitations

Advantages:

- Natural, biocompatible compound
- Multifunctional (antioxidant, antimicrobial, osteogenic)
- Potential additive in bioactive dental materials

Limitations

- Scarcity of in vivo and clinical data
- Low aqueous solubility
- Need for optimized delivery systems

VI. Future Perspectives

Further research should address:

- Nanocarrier or hydrogel-based formulations for sustained PA release.
- Clinical trials assessing pulp, bone, and periodontal responses.
- Synergistic combinations of PA with calcium-silicate or bio-ceramic materials.

VII. Conclusion

Pachymic acid exhibits significant therapeutic potential across multiple dental disciplines. By modulating oxidative stress, inflammation, and microbial growth while promoting regenerative signaling, it serves as a promising natural agent for next-generation bioactive materials and therapies in dentistry.

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