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**Review Article**

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# REVIEW ON PERIODONTAL DISEASES AND PHARMACEUTICAL NOVEL DEVICES FOR TREATMENT OF PERIODONTAL DISEASES

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**ABSTRACT**

Periodontal diseases are chronic inflammatory conditions affecting the supporting structures of the teeth, primarily caused by microbial plaque. Conventional treatment methods, including scaling, root planning, and systemic antibiotic therapy, often face limitations such as poor drug concentration at the target site, systemic side effects, and reduced patient compliance. In recent years, localized drug delivery systems have gained significant attention, among which periodontal films have emerged as a promising approach. Periodontal films are thin, flexible, and biodegradable drug delivery devices designed to be inserted directly into the periodontal pocket. These films enable site-specific, controlled, and sustained release of therapeutic agents, including antimicrobials, anti-inflammatory drugs, and growth factors, thereby enhancing treatment efficacy while minimizing systemic exposure. The review focuses on the various types of polymers used in formulating these films, such as natural (chitosan, gelatin) and synthetic (polyvinyl alcohol, Eudragit) polymers, their drug loading efficiency, mechanical properties, and biocompatibility. Additionally, the review discusses recent advancements in film design, including the incorporation of nano carriers, mucoadhesive agents, and stimuli-responsive materials to further improve therapeutic outcomes. In vitro and in vivo studies have demonstrated significant improvements in clinical parameters such as pocket depth reduction, attachment level gain, and microbial count reduction with the use of periodontal films. Overall, periodontal films represent a significant advancement in targeted periodontal therapy, offering benefits such as reduced dosing frequency, enhanced patient compliance, and effective disease management. Continued research and development are essential to optimize these systems for widespread clinical application and improved oral health outcomes.

***Keywords:*** Periodontal films, Local drug delivery, Controlled release, Sustained release, Site-specific delivery, Periodontal therapy, Periodontal pockets, Mucoadhesive polymers, Biodegradable films, Antimicrobial agents, Anti-inflammatory drugs, Dental drug delivery, Targeted therapy, Chitosan, Polymeric films, Bioadhesive systems, Gingival health, Oral drug delivery, Periodontitis treatment, Nanoparticle-loaded films.

## INTRODUCTION

Periodontal diseases represent a diverse group of inflammatory conditions affecting the supporting structures of the teeth, including the gingival, periodontal ligament, cementum, and alveolar bone. Once considered merely a consequence of poor oral hygiene, periodontal diseases are now recognized as complex, multifactorial disorders influenced by microbial, genetic, immunological, environmental, and systemic factors. Their high global prevalence and association with systemic diseases such as diabetes mellitus, cardiovascular disease, and adverse pregnancy outcomes have elevated periodontitis from a localized oral issue to a major public health concern.[1]

The pathogenesis of periodontal disease is initiated by the accumulation of microbial biofilm on tooth surfaces. However, it is the host's immune-inflammatory response to this microbial challenge that ultimately drives tissue destruction. Recent advances in microbiome research, host-pathogen interactions, and immunomodulation have reshaped our understanding of periodontal disease beyond the classical plaque hypothesis, pointing toward a dynamic interplay between dysbiosis and immune dysregulation. This has paved the way for new therapeutic strategies that go beyond mechanical debridement and antimicrobial control to include host modulation therapies, regenerative procedures, and precision medicine approaches.

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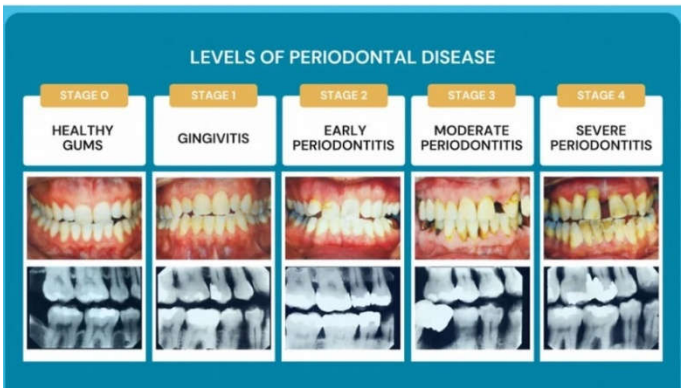
The global burden of periodontitis continues to rise, with severe periodontitis affecting nearly 10% of the world's population, making it one of the most prevalent chronic inflammatory conditions. Despite its high prevalence, diagnosis and management remain challenging, particularly due to the silent progression of the disease and individual variability in susceptibility and response to treatment. The 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions marked a significant step forward in addressing these challenges by introducing a multidimensional staging and grading system. This framework integrates disease severity, complexity, and risk factors, offering a more nuanced understanding of individual cases.[2]

In recent decades, advances in microbiology and immunology have expanded our understanding of periodontal pathogenesis. Keystone pathogens like *Porphyromonas gingivalis*, along with dysbiosis in the oral microbiome, are now recognized as key contributors to disease initiation and progression. Additionally, the concept of the "host-microbial interface" has highlighted the significance of host modulation in managing periodontal inflammation.

Recent years have also witnessed growing interest in the bidirectional relationship between periodontal health and systemic diseases, supported by emerging evidence of shared inflammatory pathways and microbiological links. These connections highlight the importance of interdisciplinary collaboration in managing periodontal disease and suggest that effective periodontal care may have broader health implications.[3]

This review aims to provide a comprehensive and updated synthesis of current knowledge on periodontal diseases, focusing on their etiology, pathogenesis, diagnostic criteria, classification, and treatment modalities. Special emphasis will be placed on recent scientific advancements, including the role of the oral microbiome, immune response, systemic interrelationships, and novel therapeutic approaches. By highlighting contemporary perspectives and identifying gaps in current understanding, this review seeks to inform both clinical practice and future research directions in the field of periodontology.




## Types of Periodontal Disease:-

Periodontal diseases are a group of inflammatory conditions affecting the supporting structures of the teeth, including the gingiva, periodontal ligament, cementum, and alveolar bone. These diseases are primarily caused by microbial plaque and are influenced by various systemic and environmental factors. Based on clinical presentation and progression, periodontal diseases are broadly classified into the following types:

1. Gingivitis

Gingivitis is the mildest and most common form of periodontal disease. It is characterized by inflammation of the gingiva without loss of connective tissue or bone. Common signs include redness, swelling, bleeding on probing, and tenderness. Gingivitis is reversible with proper oral hygiene and professional care.[4]

2. Chronic Periodontitis

Chronic periodontitis is a slow-progressing form of periodontal disease that typically affects adults. It involves inflammation of the supporting tissues with clinical attachment loss and alveolar bone destruction. Pocket formation and gingival recession are common features. It is often associated with poor oral hygiene and plaque accumulation.[5]

3. Aggressive Periodontitis

Aggressive periodontitis occurs in otherwise healthy individuals and is characterized by rapid attachment loss and bone destruction. It often has a familial tendency and is further divided into localized and generalized forms. The localized type commonly affects the first molars and incisors in adolescents.[6]

4. Necrotizing Periodontal Diseases (NPD)

This group includes necrotizing ulcerative gingivitis (NUG) and necrotizing ulcerative periodontitis (NUP). These are acute infections characterized by necrosis of gingival tissues, pain, bleeding, and foul odor. They are commonly associated with immunocompromised states, poor nutrition, and stress.[7]

5. Periodontitis as a Manifestation of Systemic Diseases

Certain systemic conditions, such as diabetes, leukemia, and genetic disorders like Down syndrome and Papillon-Lefèvre syndrome, can present with periodontal destruction. These cases are categorized separately due to their systemic origin and require comprehensive management.[8]

6. Peri-implant Diseases

With the rise in dental implant use, peri-implant diseases have gained attention. These include peri-implant mucositis (inflammation limited to soft tissue) and peri-implantitis (involving bone loss around implants).[9]

## Approaches for treating periodontal disease:-

### 1. Mechanical Therapy

- **Scaling and Root Planing (SRP):** Removal of plaque, calculus, and bacterial toxins from tooth surfaces and root surfaces.
- **Surgical Debridement:** Flap surgery (open debridement) for better access to deep periodontal pockets.
- **Gingivectomy:** Removal of diseased gum tissue to eliminate pockets.

### 2. Pharmacological Therapy

- **Systemic Antibiotics:** e.g., doxycycline, amoxicillin, metronidazole – used in severe or generalized infections.
- **Local Drug Delivery Systems:**
  - Gels, chips, microspheres, and **periodontal films** that deliver drugs directly into periodontal pockets.
- **Antiseptics:** e.g., chlorhexidine mouthwashes or rinses to reduce bacterial load.

### 3. Surgical Therapy

- **Flap Surgery (Periodontal Flap Surgery):** To access and clean root surfaces.
- **Bone Grafting:** For bone regeneration in areas with bone loss.
- **Guided Tissue Regeneration (GTR):** Use of membranes to encourage growth of new bone and tissue.
- **Soft Tissue Grafts:** To treat gum recession.

### 4. Regenerative Therapy

- **Use of Growth Factors:** Platelet-rich plasma (PRP), platelet-rich fibrin (PRF).
- **Stem Cell Therapy:** Experimental approach to regenerate periodontal structures.

### 5. Laser Therapy

- **LANAP (Laser-Assisted New Attachment Procedure):** Minimally invasive alternative to traditional surgery, using laser to disinfect pockets and promote healing.

### 6. Host Modulation Therapy

- Use of agents that modify the body's response to bacterial challenge, e.g., sub-antimicrobial dose doxycycline to inhibit collagenase activity.

**7. Preventive and Maintenance Therapy**

- **Oral Hygiene Instruction:** Brushing, flossing, and use of interdental brushes.
- **Regular Professional Cleaning:** Periodontal maintenance every 3–6 months.
- **Smoking Cessation and Risk Factor Control:** Managing diabetes, stress, and other systemic conditions.[10]

**Pharmaceutical novel devices for treatment of Periodontal diseases:-**

These novel pharmaceutical devices aim to overcome the limitations of conventional drug delivery by enabling site-specific, controlled, and sustained release of therapeutic agents directly into periodontal pockets. This approach not only enhances local drug bioavailability but also minimizes systemic side effects, offering a more efficient alternative to systemic antibiotic therapy. Devices such as bioresorbable films, gels, microspheres, nanofibers, and hydrogels have been engineered to deliver antimicrobial, anti-inflammatory, or regenerative agents with high specificity and extended action.[11]

One of the most promising developments is the use of **local drug delivery (LDD) systems**, which include devices like chlorhexidine chips, doxycycline gels, and minocycline microspheres. These products have demonstrated favorable outcomes in reducing pocket depth, improving attachment levels, and controlling microbial load. Beyond these first-generation devices, newer innovations focus on **smart biomaterials** and **nanotechnology-based platforms** that respond to environmental cues such as pH, temperature, or enzymatic activity within the periodontal pocket to modulate drug release dynamically.

In addition to antimicrobial delivery, pharmaceutical devices are also being designed to promote **tissue regeneration**. Devices incorporating growth factors, stem cells, or biomimetic scaffolds are being investigated to encourage the regrowth of periodontal ligament, cementum, and alveolar bone. These regenerative approaches represent a paradigm shift in periodontal therapy—moving from infection control alone to functional tissue reconstruction.[12]

Moreover, advancements in **3D printing** and **customized intraoral drug carriers** have enabled the fabrication of patient-specific delivery systems tailored to the anatomy of individual periodontal lesions. These personalized devices improve drug retention and targeting, thus enhancing therapeutic outcomes. Emerging trends also include **electrospun nanofiber mats**, **mucoadhesive films**, and **injectable nanoformulations**, each offering unique advantages in terms of handling, release kinetics, and ease of application.

Despite promising results in preclinical and early clinical studies, the widespread adoption of these devices in routine dental practice still faces challenges, including regulatory approval, cost-effectiveness, and long-term safety validation. Nonetheless, the continuous evolution of pharmaceutical device technology holds great potential to transform the management of periodontal diseases into a more efficient, minimally invasive, and patient-centered approach.

This review aims to explore and critically evaluate the latest pharmaceutical devices developed for periodontal therapy, focusing on their design, mechanisms of action, therapeutic outcomes, and future prospects. By highlighting innovations at the intersection of periodontology and pharmaceutical sciences, this article seeks to inform researchers and clinicians about emerging tools that may soon become essential components of advanced periodontal care.

## RECOMMENDATIONS

This study summarize traditional treatment options such as scaling and root planning, surgical interventions, and systemic/local antimicrobial therapies. Highlight limitations of conventional treatments, including antibiotic resistance, patient compliance, and recurrence. Offer guidance on integrating novel pharmaceutical devices into clinical practice. Personalized treatment approaches considering patient-specific factors. Recommend ongoing monitoring and evaluation of emerging therapies.

## CONCLUSIONS

The review of periodontal diseases and the emerging pharmaceutical novel devices highlights significant advancements in the management and treatment options available today. Periodontal diseases, being multifactorial and chronic, require innovative approaches beyond traditional mechanical debridement. Recent developments in pharmaceutical technologies and novel device-based interventions offer promising adjuncts to conventional therapy, aiming to improve clinical outcomes, reduce treatment time, and enhance patient compliance.

1. Emergence of Novel Pharmaceutical Agents: The development of targeted antimicrobial agents, host-modulating drugs, and sustained-release systems has improved control over periodontal infections and inflammation. These pharmaceutical innovations facilitate localized therapy, minimizing systemic side effects and enhancing efficacy.
2. Advancements in Device Technology: The integration of laser therapy, ultrasonic devices, and nanotechnology-based tools has revolutionized periodontal treatment. These devices enable minimally invasive procedures, precise plaque removal, and enhanced tissue regeneration.
3. Synergistic Approach: Combining pharmaceutical novel devices with traditional mechanical therapy offers a synergistic effect, leading to improved periodontal healing and stability. Personalized treatment protocols incorporating these new technologies can cater to individual patient needs.
4. Future Perspectives: Ongoing research into bioactive materials, regenerative devices, and smart drug delivery systems holds promise for further breakthroughs. The future of periodontal therapy lies in multidisciplinary approaches that integrate pharmaceutical innovations with advanced device technologies.

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