

Periodontitis Disease and its Drug Delivery System

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Abstract

A persistent inflammatory condition known as periodontitis affects the structures supporting and around the teeth. The treatment of Periodontitis typically involves the use of systemic antibiotics, local drug delivery, and mechanical debridement. In recent years, drug delivery systems have gained popularity as a means of delivering therapeutic substances directly to the location of infection, improving the effectiveness of treatment while minimizing systemic side effects. Some of the most commonly used drug delivery systems for periodontitis include gels, films, and nanoparticles. These systems can be loaded with antibiotics, anti-inflammatory agents, and growth factors, among other therapeutic agents, and can be designed to release the drug over a prolonged long enough to have ongoing therapeutic effects. Treatment of periodontitis by the use of drug delivery systems has shown promising results, with improved clinical outcomes and reduced systemic side effects. However, more study is required to assess these systems' long-term safety and effectiveness as well as to improve their design and delivery. Keywords associated with drug delivery systems for periodontitis include local drug delivery, sustained release, nanoparticles, antibiotics, anti-inflammatory agents, and growth factors.

Keywords

Periodontitis, drug delivery system, local drug delivery, sustained release, nanoparticles, antibiotics, anti-inflammatory agents, growth factors.

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To browse



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1. Introduction

Periodontitis is a chronic inflammatory disease that affects the issues surrounding and supporting the teeth. It is brought on by the buildup of plaque and germs on the teeth and gums, which can cause the alveolar bone and periodontal ligament that support the teeth to be destroyed. Periodontitis has been connected to a number of systemic health issues, including cardiovascular disease, diabetes, and respiratory disease, and if left untreated, can lead to tooth loss. The treatment of periodontitis typically involves a combination of mechanical debridement, systemic antibiotics, and local drug delivery. The first step in therapy is typically mechanical debridement, which is removing plaque and calculus from the tooth surfaces. Systemic antibiotics may be used in conjunction with mechanical debridement to target bacterial infections that cannot be reached with mechanical means alone. Local drug delivery is a newer treatment modality that involves the application of therapeutic agents directly to the site of infection or using a drug.

2. Periodontitis comes in a variety of common forms, including

2.1. Chronic Periodontitis

This is the most prevalent type of periodontitis, and it is distinguished by the elimination of periodontal problems and a slow growth of inflammation. It typically affects adults and may be linked to systemic conditions like diabetes.

2.2. Aggressive Gum Disease

This type of periodontitis frequently affects otherwise healthy people and is characterised by the rapid loss of the periodontal tissues. It can manifest in both localized and widespread forms.

2.3. Necrotizing Periodontitis

Periodontal tissues, such as the gingiva, periodontal ligament, and alveolar bone, exhibit necrosis (tissue death) in this severe form of periodontitis. It frequently coexists with underlying conditions such immunosuppression, malnutrition, and HIV.

2.4. Periodontitis as a symptom of underlying illnesses

Additionally, systemic conditions including diabetes, heart disease, and lung illness can present as periodontitis.

2.5. Refractory Periodontitis

This type of periodontitis may require more aggressive treatment methods since it does not respond to traditional periodontal therapies like scaling and root planning.



Figure 1. Initial Stage of Periodontitis Disease i.e. Starting Stage



Figure 2. A receding gum line and thin gum tissue i.e. II Stage of Periodontitis disease (Moderate)

3. Literature Review

3.1. Ramesh and Nagaraj, Year: 2018, Topic

Periodontal Drug Delivery Systems - An Overview, Journal Name: Journal of Clinical and Diagnostic Research, Remarks: Provides a comprehensive overview of different types of periodontal DDS and their advantages and limitations.

3.2. Teixeira et al., Year: 2019, Topic

Local Drug Delivery for Periodontitis Treatment, Name of the journal: Pharmaceutics Remarks: Reviews the state-of-the-art in periodontal medication delivery systems and focuses on more recent developments.

3.3. Ma et al., Year: 2020, Topic

Nanoparticle-Based Drug Delivery Systems for Periodontitis Treatment: A Review of the Situation Now and Looking Forward, Journal Name: International Journal of Nanomedicine, Remarks: Focuses on the use of nanoparticles as periodontal drug delivery systems and discusses their potential benefits and challenges.

3.4. Matarazzo et al., Year: 2021, Topic

Topical delivery of bisphosphonates for the treatment of periodontitis, Journal Name: Drug Delivery and Translational Research, Remarks: Discusses the potential use of bisphosphonates as a topical treatment for periodontitis and highlights the advantages and limitations of this approach.

3.5. Anand et al., Year: 2022, Topic

For the treatment of periodontitis, a review of periodontal drug delivery systems is needed. International Journal of Pharmaceutical Sciences and Research is the name of the journal. Remarks: gives a thorough analysis of the various periodontal medication delivery methods available and how they might be used to treat periodontitis

3.6. The Contribution of Periodontitis disease that we studied is as follows

Studies on periodontitis have made significant contributions to our understanding of the disease, its risk factors, pathogenesis, diagnosis, and treatment.

3.6.1. Identification of Risk Factors

Numerous risk factors for periodontitis have been identified with the aid of research. Periodontitis can develop and worsen due to a number of factors, including poor dental hygiene, smoking, diabetes, genetic susceptibility, hormonal changes, and systemic disorders.

3.6.2. Understanding the Pathogenesis

Complex pathways involved in the aetiology of periodontitis have been clarified by studies. It involves the interaction between bacterial pathogens, host immune response, and inflammatory processes. Research has highlighted the role of specific bacterial species, such as *Porphyromonas gingivalis*, in triggering an immune response and the subsequent destruction of periodontal tissues.

3.6.3. Advancements in Diagnostic Techniques

Studies have contributed to the development of improved diagnostic techniques for periodontitis. These include periodontal probing, clinical measurements of periodontal parameters, radiographic evaluation, and more advanced methods such as microbial analysis, genetic testing, and biomarker identification. These techniques aid in early detection, accurate diagnosis, and monitoring of the disease.

3.6.4. Treatment Strategies

Studies have evaluated various treatment modalities for periodontitis, leading to the development of evidence-based therapeutic approaches. These include scaling and root planning, antimicrobial therapy, host modulation therapy, surgical interventions, and regenerative techniques. Research has helped refine these treatment strategies, optimize their efficacy, and develop personalized approaches for managing periodontitis.

3.6.5. Impact on Systemic Health

Studies have revealed the intricate link between periodontitis and systemic health. An increased risk of systemic problems like cardiovascular diseases, diabetes, respiratory illnesses, and unfavourable pregnancy outcomes has been linked to periodontal inflammation and the subsequent production of inflammatory mediators. Understanding these connections has emphasized the importance of periodontal health in overall well-being.

Overall, studies on periodontitis have significantly contributed to our knowledge of the disease, leading to improved diagnostic methods, treatment strategies, and a greater understanding of its impact on systemic health. Continued research in this field holds promise for further advancements in prevention, early detection, and personalized management of periodontitis.

3.7. From the remaining section we will learn that

Various sign and symptoms of periodontitis disease are arranged in chronological order and how periodontitis disease can arise and its factor and in next section Drug Delivery System is mentioned i.e. how drugs are administrated to cure the patient suffering from periodontitis and the advantages as well as disadvantages of Drug Delivery System and in next section we will learn which type of drugs are used in periodontitis disease i.e. Gels, Films, Nanoparticles.

3.8. Sign and symptoms

Depending on the kind and severity of the disease, periodontitis can have a variety of signs and symptoms.

However, some typical periodontitis symptoms and signs include

- Bleeding gums during brushing or flossing
- Swollen and tender gums
- The appearance of longer teeth or receding gums
- Loose or shifting teeth
- Changes in bite or jaw alignment



Figure 3. Stage III (severe with a potential for more tooth loss)



Figure 4. Last stage of Periodontitis Disease i.e. severe risk of teeth loss

3.9. Periodontitis can arise due to a number of factors, including

3.9.1. Bad Oral Health

Regular brushing and flossing helps prevent plaque and bacteria from building up on the teeth and gums, which can cause inflammation and eventually the degeneration of the periodontal tissues.

3.9.2. Use of Tobacco

Periodontitis risk has been linked to tobacco use and other tobacco products.

3.9.3. Genetic Predisposition

Some individuals may be genetically predisposed to periodontitis, making them more susceptible to the disease.

3.9.4. Systemic Diseases

Periodontitis risk can be increased by certain systemic conditions such as diabetes, heart disease, and respiratory illness.

3.9.5. Hormonal Changes

Women may be more susceptible to developing periodontitis as a result of hormonal changes related to puberty, pregnancy, and menopause.

3.9.6. Medications

Some medications, such as antidepressants and heart medications can cause dry mouth, which can increase the risk of periodontitis.

4. Periodontal Drug Delivery Systems

Using periodontal drug delivery systems (DDS) to treat periodontal disease is a promising strategy. Local delivery of therapeutic agents to the site of infection can improve the effectiveness of treatment while minimizing the risk of systemic side effects.

Several types of DDS have been developed for periodontal therapy, including gels, films, fibers and nanoparticles. These systems can be loaded with a variety of therapeutic agents, including antibiotics, anti-inflammatory agents, and growth factors. DDS can be applied directly to the periodontal pockets or surgical sites using syringes or applicators. DDS has several advantages over traditional drug delivery methods, such as systemic administration or oral medications. Local drug delivery ensures a high concentration of therapeutic agents at the site of infection resulting in better efficacy faster healing delivery system such as gels, films, or nanoparticles.

The utilization of medication delivery devices for the treatment of periodontitis has gained more attention in recent years. These systems have the potential to deliver therapeutic substances directly to the location of infection, improving the effectiveness of treatment while minimizing systemic side effects. The utilization of drug delivery systems for the treatment of periodontitis will be reviewed in this paper, with an emphasis on local drug administration and sustained-release methods. We will also discuss the advantages and limitations of these systems and highlight areas for future research.

This is crucial for the treatment of chronic periodontitis, which calls for ongoing care to stave against disease recurrence.

4.1. Advantages of Periodontal Drug Delivery Systems

- Increases the efficacy of treatment while minimizing the risk of systemic side effects
- Reduces the frequency of dosing
- Prolongs the therapeutic effect of the delivered agents
- Offers sustained-release capabilities

- Improves patient compliance
- Can be altered to satisfy each patient's unique demand

4.2. Disadvantages of Periodontal Drug Delivery Systems

- Limited penetration into deep periodontal pockets
- Potential for DDS degradation or clearance from the site of application
- Requires specialized expertise and technology, making them potentially more expensive than traditional drug delivery methods
- May cause local irritation or allergic reactions in some patients
- May require multiple applications over an extended period, which can be time-consuming for patients
- Not suitable for all types of periodontal disease or all patients

4.3. Gels

One of the most popular periodontal drug delivery systems (DDS) is gel. These semi-solid formulations can be applied to the periodontal pockets using syringes or applicators. Gels are designed to adhere to the periodontal tissues, providing sustained release of therapeutic agents over an extended period. Several types of gels have been developed for periodontal therapy, including hydrogels, mucoadhesive gels, and thermo sensitive gels. These gels can be loaded with a variety of therapeutic agents, such as antibiotics, anti-inflammatory agents, and growth factors. The choice of gel type and therapeutic agent depends on the severity and type of periodontal disease.

Hydrogels are water-based gels that have high water content and are designed to mimic the natural hydrophilic environment of the periodontal tissues. These gels can provide sustained release of therapeutic agents and can also absorb excess fluid in the periodontal pockets, reducing inflammation and swelling. Mucoadhesive gels are made to stick to periodontal tissues and slowly release the medicinal ingredient. These gels can improve the bioavailability of the therapeutic agent and reduce the frequency of dosing required.

Thermo sensitive gels are designed to change from a liquid to a gel state in response to temperature changes. These gels can be applied as a liquid and then solidify at body temperature, providing sustained release of the therapeutic agent. Gels have several advantages over other periodontal DDS, such as ease of application and high patient compliance. Gels are also highly versatile and can be customized to meet the specific needs of each patient. However, gels also have some limitations, such as limited penetration into deep periodontal pockets and the potential for degradation or clearance from the site of application.

All things considered, gels are a potential method for treating periodontal disease and have produced encouraging outcomes in clinical trials. To improve the design of gels and increase their therapeutic effectiveness for the treatment of periodontitis, more study is required. Films are another type of periodontal drug delivery system (DDS). These thin, flexible sheets can be applied to the periodontal pockets or surgical sites to provide sustained release of therapeutic agents.

4.4. Films

Films are typically composed of polymers, such as polyethylene glycol, polylactic acid, or chitosan. The film matrix contains the therapeutic substance, allowing for regulated release of the substance over an extended period of time.

4.4.1. Several advantages of films as periodontal DDS include



- Easy to apply and remove
- Can deliver a continuous delivery of medicinal substances
- Can be altered to satisfy each patient's unique demands provides strong patient adherence

However, there are also some limitations to the use of films as periodontal DDS, including

- Limited penetration into deep periodontal pockets.
- Potential for degradation or clearance from the site of application.
- May cause local irritation or allergic reactions in some patients.
- Requires specialized expertise and technology for preparation.
- Limited availability of suitable polymers and therapeutic agents

Despite these limitations, films are a promising approach for the treatment of periodontal disease. Further research is needed to optimize film design and enhance their therapeutic efficacy, while minimizing their potential drawbacks.

4.5. Fibres

For the treatment of periodontal disease, fibres are a form of periodontal drug delivery system (DDS). These thin, flexible strands can be inserted into the periodontal pockets to provide sustained release of therapeutic agents.

Fibers are typically composed of biocompatible materials, such as collagen, synthetic polymers, or a combination of both. The fibre matrix contains the medicinal substance, allowing for a prolonged duration of regulated release of the substance.

Several advantages of fibers as periodontal DDS include

- Easy to insert and remove
- can deliver a continuous delivery of medicinal substances
- Can be altered to accommodate each patient's unique requirements.
- Provides strong patient adherence

4.6. Nanoparticles

Nanoparticles are a type of periodontal drug delivery system (DDS) that have gained increasing attention in recent years.

These are small particles, typically less than 100 nanometers in diameter that can be loaded with therapeutic agents and delivered to the periodontal tissues. Lipids, polymers, and metals are some examples of the materials that can be used to create nanoparticles. These particles can be designed to have certain qualities like controlled release, targeting, or imaging capabilities.

Several advantages of nanoparticles as periodontal DDS include

- Can penetrate deep into periodontal pockets
- Offers controlled release of therapeutic agents
- Can be customized to target specific bacteria or cells
- Reducing dose frequency can increase patient compliance.
- Offers potential for combination therapy with multiple therapeutic agents

However, there are also some limitations to the use of nanoparticles as periodontal DDS, including

- Requires specialized expertise and technology for preparation

- Potential for toxicity or accumulation in the body
- May cause local irritation or allergic reactions in some patients
- Limited availability of suitable materials and manufacturing techniques

Despite these drawbacks, using nanoparticles to treat periodontal disease is a promising strategy. Additional study is required to optimize nanoparticle design and enhance their therapeutic efficacy, while minimizing their potential drawbacks.

5. Conclusions and Future Scope

In conclusion; the gums, periodontal ligament, and alveolar bone that support the teeth are all affected by periodontitis, a common inflammatory condition. Bacterial infections cause it, and if addressed, it can lead to tooth loss and other systemic health problems. The different kinds of drug delivery methods created, such as gels, films, fibres, and nanoparticles, which offer significant potential for enhancing the effectiveness of periodontal therapy. To improve the clinical outcomes and optimize the delivery methods, additional research is necessary. Periodontal drug delivery systems will become more advanced as drug delivery technologies continue to progress.

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