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# The Role and Research Progress of Drug-Resistant Oral Microorganisms in the Pathogenesis of Periodontitis

Wenao Chen

E.V. Borovsky Institute of Dentistry, I.M. Sechenov First Moscow State University, Moscow, Russia

## ABSTRACT

This comprehensive paper takes a deep dive into the critical role played by drug-resistant oral microorganisms in the pathogenesis of periodontitis, along with the recent research advancements in this field. It begins by defining drug resistance and its underlying causes, delving into the various types of resistance encountered in oral microorganisms. The paper then shifts its focus to the complex pathogenesis of periodontitis, discussing how drug-resistant microorganisms contribute to the development and progression of this common oral disease. The intricate relationship between drug-resistant microorganisms and periodontitis is further explored, shedding light on how these microorganisms evade traditional antibiotic treatments and contribute to the persistence and recurrence of the disease. The paper also highlights the methodologies and cutting-edge techniques that researchers are utilizing to study this phenomenon, including advanced genomic sequencing, biofilm analysis, and animal models. The paper provides an overview of the latest research progress in this area, discussing promising new treatment strategies that are being developed to target drug-resistant microorganisms. These strategies include the use of novel antimicrobials, bacteriophage therapy, and immune-based approaches.

## KEYWORDS

Drug-resistant oral microorganisms; Periodontitis; Pathogenesis; Research progress; Therapeutic strategy

## 1. INTRODUCTION

The study of drug-resistant oral microorganisms in periodontitis pathogenesis is crucial. These microorganisms contribute significantly to the development and progression of the disease, posing challenges to conventional treatments. Understanding their role and research advancements can pave the way for more effective therapeutic strategies.

## 2. OVERVIEW OF DRUG-RESISTANT ORAL MICROORGANISMS

### 2.1. Definition and Classification of Drug Resistance

Drug resistance, also known as drug resistance, refers to the phenomenon that the viability or reproductive ability of microorganisms is not obviously inhibited after they are exposed to a certain drug [1]. This phenomenon is usually caused by the genetic variation of microorganisms under the pressure of drugs, so that their internal mechanisms can resist or escape the effects of drugs. Among oral microorganisms, drug resistance is particularly complicated, because the oral cavity is an environment where many microorganisms coexist, and there may be interactions among these microorganisms, which further increases the diversity of drug resistance. The classification of drug

resistance is diverse, mainly including inherent drug resistance and acquired drug resistance [2]. Inherent drug resistance refers to the natural insensitivity of microorganisms to certain drugs, which is related to their specific physiological structure and metabolic pathway. Acquired drug resistance is that microorganisms gradually gain resistance to drugs through gene mutation and horizontal gene transfer after they are exposed to drugs. Acquired drug resistance is particularly important in the pathogenesis of periodontitis, because it may lead to the resistance of oral microorganisms to commonly used antibiotics, and then aggravate the inflammatory process [3]. Understanding the definition and classification of drug resistance is of great significance for further study on the pathogenesis of periodontitis. With the increasing abuse of antibiotics worldwide, the study of oral microbial resistance is not only helpful to develop new antibacterial drugs, but also has a far-reaching impact on the prevention and treatment of oral infectious diseases [4].

### 2.2. Causes of Oral Microbial Resistance

The cause of oral microbial resistance is a complex process, involving many factors. First of all, the oral cavity is a diversified microbial ecological environment, which contains a large number of bacteria, fungi and other microorganisms. In daily oral activities, such as eating, gargling, etc., microorganisms will come into contact with various antibacterial substances, such as antibacterial toothpaste, mouthwash, etc., thus generating selection pressure and prompting some microorganisms to develop drug resistance. In the process of evolution, oral microorganisms obtain drug-resistant genes through gene mutation and horizontal gene transfer, so as to enhance their resistance to antibacterial substances [5]. These drug-resistant genes can spread among microorganisms, leading to the spread of drug resistance. In addition, the unreasonable use of antibacterial drugs is also an important reason for the drug resistance of oral microorganisms. Long-term or abuse of antibacterial drugs will destroy the balance of oral microorganisms, which will lead to the inhibition of sensitive bacteria and the proliferation of drug-resistant bacteria, further aggravating the development of drug resistance [6].

The drug resistance of oral microorganisms is the result of many factors, including the ecological environment of oral microorganisms, the genetic variation of microorganisms themselves and the unreasonable use of antibacterial drugs. In order to better control the drug resistance of oral microorganisms, we need to deeply understand its mechanism and take scientific and reasonable medication measures [7].

## 3. PATHOGENESIS OF PERIODONTITIS

### 3.1. The Basic Pathological Process of Periodontitis

Periodontitis is a common oral disease, and its basic pathological process involves many interrelated stages. First of all, plaque biofilm forms on the tooth surface, which is the initial factor of periodontitis. With the accumulation of biofilm, the pathogenic bacteria such as Porphyromonas gingivalis gradually increased, causing gingivitis. In the early stage of inflammation, the gums show symptoms such as redness and bleeding, which is the immune response of the body to infection. With the continuous development of inflammation, periodontal tissue is destroyed and periodontal pocket is formed, which is the key pathological sign of periodontitis [8]. The periodontal pocket provides an environment for anaerobic bacteria to grow, which further aggravates the inflammatory process. The release of inflammatory mediators such as interleukin and tumor necrosis factor leads to the further destruction of periodontal tissue and the absorption of alveolar bone. In the end, periodontitis may lead to the loss of supporting tissues of teeth, tooth loosening or even falling off. This process is the result of many factors, including microbial infection, host immune response and genetic factors. Understanding the basic pathological process of periodontitis is of great significance for the

prevention and treatment of this disease, and also provides a basis for the study of drug-resistant oral microorganisms [9].

### 3.2. The Role of Oral Microorganisms in Periodontitis

Oral microorganisms play a vital role in the pathogenesis of periodontitis. Periodontitis is a chronic infectious disease caused by many factors, among which the imbalance of oral microbial community is the key to the development of the disease. Under normal physiological conditions, there is a dynamic balance between microorganisms in the oral cavity and the host. However, when this balance is broken, some pathogenic microorganisms will over-multiply, causing inflammatory reaction of periodontal tissue [10]. Anaerobic bacteria in oral microbial community, such as Porphyromonas gingivalis and Fossettan bacteria, are the main pathogens of periodontitis. These anaerobic bacteria can produce a variety of virulence factors, such as protease, lipopolysaccharide and cell wall components, which can destroy the defense mechanism of periodontal tissue and lead to the formation of periodontal pocket and the absorption of alveolar bone. At the same time, these microorganisms can also trigger an overreaction of the host immune system, further aggravating the destruction of periodontal tissue. Therefore, in-depth study on the role of oral microorganisms in the pathogenesis of periodontitis will not only help us better understand the nature of the disease, but also provide an important theoretical basis for developing new treatment strategies. By regulating the balance of oral microbial community, inhibiting the growth of pathogenic bacteria and reducing the overreaction of host immune system, it is expected to bring more effective treatment methods to periodontitis patients in the future [11].

### 3.3. The Influence of Drug-Resistant Microorganisms on the Pathogenesis of Periodontitis

Drug-resistant microorganisms play an important role in the pathogenesis of periodontitis. These microorganisms can resist the treatment of conventional antibiotics, leading to the continuous development and deterioration of periodontitis. The existence of drug-resistant microorganisms makes the treatment of periodontitis more complicated and difficult. Drug-resistant microorganisms mainly affect the onset of periodontitis by destroying the ecological balance of periodontal tissue [12]. They can resist the removal of antibiotics, thus continuing to reproduce in the periodontal pocket, causing and aggravating inflammation. Toxins and enzymes produced by these microorganisms, such as collagenase and hyaluronidase, can destroy the structure of periodontal tissue, leading to the deepening of periodontal pocket and the absorption of alveolar bone. In addition, drug-resistant microorganisms can also cause abnormal reactions of the host immune system. They can escape the immune clearance mechanism of the host, persist in periodontal tissue, and activate immune cells to release a large number of inflammatory mediators. These inflammatory mediators further aggravate the destruction of periodontal tissue and form a vicious circle, which eventually leads to the sustainable development of periodontitis. Therefore, it is of great significance to study the role of drug-resistant microorganisms in the pathogenesis of periodontitis for developing new treatment strategies and improving the therapeutic effect of periodontitis [13].

## 4. RELATIONSHIP BETWEEN DRUG-RESISTANT ORAL MICROORGANISMS AND PERIODONTITIS

### 4.1. Destruction of Periodontal Tissue By Drug-Resistant Microorganisms

Drug-resistant oral microorganisms play a key role in the pathogenesis of periodontitis. These microorganisms can survive and reproduce in anaerobic environment such as periodontal pocket by producing antibiotic resistance, thus causing continuous damage to periodontal tissue. Periodontal tissues include gingiva, periodontal ligament and alveolar bone, which together maintain the stability

and health of teeth. Drug-resistant microorganisms can produce a variety of enzymes and toxins, which can directly erode the cell wall and cell membrane of periodontal tissue, leading to necrosis and apoptosis of tissue cells. In addition, drug-resistant microorganisms can also trigger the host's immune response and produce a large number of inflammatory mediators, such as cytokines and chemokines, which further aggravate the inflammatory damage of periodontal tissue [14]. With the accumulation and reproduction of drug-resistant microorganisms in periodontal pocket, the destruction of periodontal tissue is gradually aggravated, which may lead to the deepening of periodontal pocket and the absorption of alveolar bone. This process not only affects the oral health of patients, but also may further lead to the loosening and loss of teeth. Therefore, it is of great significance to study the destructive effect of drug-resistant oral microorganisms on periodontal tissue for the prevention and treatment of periodontitis.

### 4.2. Drug-resistant Microorganisms Accelerate the Course of Periodontitis

The accelerating effect of drug-resistant oral microorganisms on the course of periodontitis can not be ignored. These microorganisms resist the treatment of antibiotics through various mechanisms, so that they persist in the oral cavity and reproduce, causing persistent damage to periodontal tissue. Drug-resistant microorganisms can produce a variety of biofilms, which can protect them from antibiotics and host immune system attacks. Microorganisms in these biofilms can secrete various virulence factors, such as protease and collagenase, which can degrade the structure of periodontal tissue and lead to the occurrence and development of periodontitis. In addition, drug-resistant microorganisms can also trigger an overreaction of the host immune system, leading to the aggravation of inflammation. In the process of periodontitis, drug-resistant microorganisms can stimulate the host to produce a large number of inflammatory mediators, such as prostaglandin and interleukin, which can trigger and aggravate the inflammatory reaction of periodontal tissue, leading to the destruction and loss of periodontal tissue. Therefore, drug-resistant oral microorganisms can accelerate the course of periodontitis in many ways. They can promote the occurrence and development of periodontitis by producing biofilm, secreting virulence factors and triggering immune overreaction. In-depth study on the characteristics and mechanism of drug-resistant microorganisms is of great guiding significance for the treatment and prevention of periodontitis [15].

### 4.3. The difficulty of Treatment Caused by Drug-Resistant Microorganisms Increases

Drug-resistant oral microorganisms play a key role in the pathogenesis of periodontitis, which not only aggravate the pathological process of periodontitis, but also lead to a significant increase in the difficulty of treatment. These drug-resistant microorganisms escape the attack of conventional antibiotics by producing various drug-resistant mechanisms, such as drug pumping, drug modification and drug target change, which makes the treatment of periodontitis more complicated and difficult. In the course of treatment, the existence of drug-resistant microorganisms means that conventional antibiotic therapy may not effectively remove pathogens, thus prolonging the treatment cycle. This not only increases the pain of patients, but also may lead to the recurrence and deterioration of the disease. In addition, drug-resistant microorganisms may also lead to the imbalance of oral ecological balance, which further aggravates the progress of periodontitis [16]. In order to meet this challenge, researchers are actively exploring new treatment strategies, such as the use of new antibacterial drugs, combination drugs, and targeted therapy for specific drug resistance mechanisms [17]. However, the development and application of these new strategies still face many challenges, and more basic research and clinical trials are needed to verify their effectiveness and safety. Therefore, the increase of treatment difficulty caused by drug-resistant microorganisms is still an important problem in the field of periodontitis treatment, which needs the joint efforts of researchers and clinicians [18].

# 5. RESEARCH METHODS AND TECHNIQUES OF DRUG-RESISTANT ORAL MICROORGANISMS

## 5.1. Traditional Culture Methods and Drug Sensitivity Test

Traditional culture methods and drug sensitivity tests play an important role in the study of drug-resistant oral microorganisms. Through traditional culture methods, researchers can directly separate and identify the microbial species in the oral cavity, which is the basis for understanding the composition and drug resistance of oral microbial communities. These methods include anaerobic culture and aerobic culture, which are set according to the growth needs of different microorganisms to ensure that the oral environment can be accurately simulated and reliable microbial culture results can be obtained. Drug sensitivity test is an important means to test the drug sensitivity of isolated microorganisms. Through drug sensitivity test, we can know which antibiotics are effective for specific microorganisms and which may not be effective, that is, microbial resistance. This is of great significance for the selection of antibiotics in clinical treatment, which can avoid the blind use of antibiotics and reduce the generation and spread of drug-resistant strains [19].

Traditional culture methods and drug sensitivity tests are indispensable in the study of drug-resistant oral microorganisms. They provide researchers with tools to deeply understand the community structure and drug resistance mechanism of oral microorganisms, and provide scientific basis for the prevention and treatment of oral diseases such as periodontitis.

## 5.2. Application of Molecular Biology Technology in Drug Resistance Research

Molecular biology plays an important role in the study of drug-resistant oral microorganisms. These technologies not only help us deeply understand the molecular mechanism of drug resistance, but also provide strong support for the development of new antibacterial drugs. Polymerase chain reaction (PCR) is one of the most commonly used molecular biology techniques in drug resistance research. Through PCR technology, researchers can specifically amplify drug resistance genes, so as to quickly detect and analyze drug resistance of microorganisms. Real-time fluorescence quantitative PCR technology can evaluate the expression level of drug-resistant genes more accurately and provide a powerful tool for the analysis of drug-resistant mechanism [20]. In addition, gene sequencing technology also played a key role in drug resistance research. Through high-throughput sequencing technology, we can comprehensively analyze the genome information of microorganisms, including the existence and variation of drug-resistant genes. This information is very important for understanding the origin and evolution of drug resistance, and also provides important clues for the development of new drugs. In a word, molecular biology technology plays an important role in the study of drug-resistant oral microorganisms. The application of these technologies not only promotes the research progress of drug resistance mechanism, but also provides new ideas and methods for the development of new antibacterial drugs [21].

## 5.3. The Application of Metagenomics in the Study of Oral Drug-Resistant Microorganisms

Metagenomics, as a Qualcomm-quantity genomics research method, has played an important role in the study of oral drug-resistant microorganisms in recent years. It can reveal the distribution and spread of drug-resistant genes in the oral ecosystem and their interaction with the host by comprehensively analyzing the genetic material of all microorganisms in the oral microbial community. Metagenomics technology can not only detect known drug-resistant genes, but also find new drug-resistant genes and their variants, which provides a powerful tool for further understanding the drug-resistant mechanism. In the study of oral drug-resistant microorganisms, metagenomics technology is widely used in the analysis of drug resistance spectrum of oral microbial communities,

the analysis of drug resistance gene transmission network and the study of drug resistance mechanism. Through the method of metagenomics, researchers can obtain the overall information of drug resistance genes in oral microbial communities, and further explore the relationship between drug resistance and oral diseases such as periodontitis. These studies not only help to understand the emergence and spread of drug resistance, but also provide an important scientific basis for developing new treatment strategies. With the continuous development of metagenomics technology, its application prospect in the study of oral drug-resistant microorganisms will be broader [22].

# 6. RESEARCH PROGRESS AND TREATMENT STRATEGIES OF DRUG-RESISTANT ORAL MICROORGANISMS

## 6.1. Research Status of Drug-Resistant Oral Microorganisms at Home And Abroad

In recent years, remarkable progress has been made in the study of drug-resistant oral microorganisms at home and abroad. With the widespread use of antibiotics, the drug resistance of oral microorganisms has gradually become an important challenge in the treatment of oral diseases such as periodontitis. Through high-throughput sequencing and other advanced technologies, foreign research teams have deeply explored the composition and dynamic changes of oral microbial communities, and found the existence and transmission mechanism of multiple drug-resistant genes. At the same time, they also studied the interaction between drug-resistant microorganisms and their hosts, revealing the key role of drug-resistant microorganisms in the pathogenesis of periodontitis. In contrast, domestic research pays more attention to the clinical application and prevention strategies of drug-resistant microorganisms. Through the collection and analysis of clinical samples, domestic scholars deeply understand the species and distribution of drug-resistant oral microorganisms and their association with periodontitis and other diseases. In addition, domestic research also pays attention to the monitoring and early warning of drug-resistant microorganisms, as well as the research and development of new antibacterial drugs and alternative therapies, so as to provide more effective treatment strategies for clinic. In a word, the research status of drug-resistant oral microorganisms at home and abroad shows a diversified and in-depth trend, which provides strong support for the treatment and prevention of oral diseases. However, the evolution and complexity of drug-resistant microorganisms still need more research and exploration [23].

## 6.2. The Latest Discovery of Drug Resistance Mechanism

In recent years, the role of drug-resistant oral microorganisms in the pathogenesis of periodontitis has been widely concerned. With the deepening of research, the latest discovery of drug resistance mechanism provides a new perspective for understanding the complexity of periodontitis and formulating effective treatment strategies. It is found that drug-resistant oral microorganisms mainly escape or weaken the effects of antibacterial drugs through horizontal gene transfer, efflux pump mechanism and biofilm formation. Horizontal gene transfer makes drug-resistant genes spread rapidly among microorganisms and enhances the drug resistance of the whole microbial community. The efflux pump mechanism reduces the drug concentration in cells by actively pumping drugs out of cells, thus avoiding drug killing. In addition, the formation of biofilm also provides protection for drug-resistant microorganisms from drug attacks. It is worth mentioning that some drug-resistant microorganisms further weaken the role of antibacterial drugs by regulating metabolic pathways and changing cell membrane permeability. The complexity and diversity of these drug resistance mechanisms have brought challenges to the treatment of periodontitis. Therefore, it is of great significance to study the latest discovery of drug resistance mechanism for developing new antibacterial drugs and formulating personalized treatment strategies. In the future, with the continuous progress of science and technology, we are expected to find more effective ways to deal with the challenges brought by drug-resistant oral microorganisms [24].

## 6.3. Interaction between New Antibacterials and Drug-resistant Microorganisms

With the continuous development and application of antibacterial drugs, new antibacterial drugs have shown unique advantages in the treatment of periodontitis caused by drug-resistant oral microorganisms. These new drugs usually have broader antibacterial spectrum and stronger antibacterial activity, which can effectively inhibit the growth and reproduction of drug-resistant microorganisms. In the interaction with drug-resistant microorganisms, new antibacterial drugs often achieve the purpose of sterilization or bacteriostasis by interfering with the metabolic process of microorganisms, destroying their cell walls or inhibiting their DNA synthesis. However, drug-resistant microorganisms are constantly evolving, and escape the attack of antibacterial drugs by changing their genetic structure or producing drug-resistant enzymes. In order to meet the challenge of drug-resistant microorganisms, researchers are constantly exploring new treatment strategies. On the one hand, they are committed to developing new antibacterial drugs with brand-new mechanism of action to overcome the drug resistance of existing drugs; On the other hand, they are also trying to use a variety of antibacterial drugs in combination to enhance the bactericidal effect through synergy. In addition, with the development of biotechnology, new treatments such as gene editing and immunotherapy also show potential application value in the treatment of drug-resistant oral microorganisms. These emerging technologies are expected to bring new breakthroughs in the treatment of periodontitis [25].

## 6.4. Limitations of Traditional Treatment Methods

In traditional treatment methods, there are some limitations in periodontitis caused by drug-resistant oral microorganisms. First of all, the use of traditional antibiotics is limited by drug-resistant strains, because long-term use or abuse can easily lead to drug resistance of microorganisms, making antibiotics lose their original therapeutic effect. The particularity of oral environment makes it difficult for drugs to reach effective concentration locally, which affects the therapeutic effect to some extent. In addition, traditional treatment methods usually focus on eliminating inflammation and infection, but ignore the balance of oral microbial community, which is easy to cause flora imbalance and further aggravate oral health problems. In recent years, with the in-depth study of oral microbial community, people gradually realize the importance of maintaining oral ecological balance. Therefore, the traditional treatment methods seem to be stretched when dealing with periodontitis caused by drug-resistant oral microorganisms. In order to solve these problems, researchers are exploring new treatment strategies, such as precise treatment based on microbiology, application of probiotics and local drug delivery system, in order to achieve better results in the future treatment of periodontitis. These new strategies aim to comprehensively consider the overall balance of oral microbial community, so as to fundamentally solve the oral health problems caused by drug-resistant micro

## 6.5. Exploration and Application of Emerging Treatment Strategies

In view of the role of drug-resistant oral microorganisms in the pathogenesis of periodontitis, the exploration and application of emerging treatment strategies are attracting increasing attention. These strategies aim to overcome the limitations of traditional treatment methods and fight drug-resistant microorganisms more effectively. Gene editing techniques such as CRISPR-Cas9 provide new possibilities for precise treatment. By editing specific genes, the survival mechanism of drug-resistant microorganisms can be destroyed, thus achieving the purpose of treatment. In addition, the development of new antibacterial drugs is also making continuous progress. These drugs are aimed at specific targets of drug-resistant microorganisms and are expected to become powerful weapons for treating periodontitis in the future. In addition to medication, immunotherapy is also being explored. It is a potential treatment method to enhance the ability of removing drug-resistant microorganisms by activating or regulating the patient's own immune system. In addition, non-

antibiotic therapies such as photodynamic therapy and biofilm breaker are also under study, which attack drug-resistant microorganisms from different angles and provide more choices for the treatment of periodontitis. The exploration and application of these new treatment strategies not only bring hope for the treatment of periodontitis caused by drug-resistant oral microorganisms, but also provide new ideas and methods for the research in the whole field of oral microorganisms.

### 6.6. The Necessity of Individualized Treatment Plan

Individualized treatment scheme is of great necessity in the treatment of periodontitis. Periodontitis is a complex oral disease, and its pathogenesis involves the interaction of many drug-resistant oral microorganisms. The resistance of these microorganisms to conventional antibiotics is increasing, which makes the traditional treatment methods face challenges. Therefore, it is particularly critical to formulate an individualized treatment plan according to the specific situation of each patient. Individualized treatment plan can fully consider the individual differences of patients, including oral microbial species, drug resistance level, host immune status and living habits. Through accurate diagnosis and evaluation, doctors can choose the most suitable antibacterial drugs for patients and avoid ineffective treatment and drug abuse. In addition, the individualized treatment plan can be adjusted in time according to the patient's condition changes to ensure the maximum treatment effect. In short, in the treatment of periodontitis, individualized treatment is an important way to improve the treatment effect, reduce the risk of drug resistance and improve the quality of life of patients. With the deepening of the research on oral microbial resistance, individualized treatment will become the mainstream trend of periodontitis treatment in the future.

## 7. FUTURE PROSPECTS AND CHALLENGES

### 7.1. The Seriousness of Drug Resistance and its Countermeasures

The seriousness of drug resistance cannot be ignored. With the extensive use of antibiotics, the resistance of oral microorganisms to drugs is increasing. This not only challenges the treatment of traditional diseases such as periodontitis, but also may lead to new and more serious infections. Drug-resistant strains spread rapidly, and once formed, they will pose a serious threat to public health. In view of this problem, the formulation of countermeasures needs to start from many aspects. First of all, researchers should devote themselves to developing new antibacterial drugs, especially drugs for drug-resistant strains, to break the existing treatment deadlock. Clinicians and patients should use antibiotics rationally to avoid unnecessary drug use and abuse, so as to delay the development of drug resistance. In addition, strengthening oral health education and improving the public's awareness and attention to oral health are also effective means to prevent drug resistance. At the policy level, we should strengthen the supervision of antibiotic use and formulate stricter norms to reduce the generation and spread of drug-resistant strains.

Drug resistance is a complex public health challenge, which needs the joint efforts of the whole society.

### 7.2. Research and Development Direction of New Antibacterial Drugs and Technologies

In view of the role of drug-resistant oral microorganisms in the pathogenesis of periodontitis, the research and development direction of new antibacterial drugs and technologies should focus on the following aspects. First of all, develop antibacterial drugs with new mechanism of action to deal with the problem of drug resistance of existing drugs. This includes finding new drugs that can interfere with microbial metabolic pathways, destroy their cell walls or inhibit their DNA replication. Research on precise therapy for specific drug-resistant microorganisms, such as structure-based drug design,

to improve drug targeting and therapeutic effect. At the same time, the research of nano-drug delivery systems is also a major focus. These systems can directly deliver drugs to the diseased site, reduce side effects and enhance the curative effect. In addition, the combination of new antibacterial drugs and oral care products is also an important direction of research and development, such as developing toothpaste and mouthwash containing antibacterial ingredients to prevent and control periodontitis. Using synthetic biology and gene editing technology, we can develop therapeutic methods that can regulate the balance of oral microbial community and fundamentally solve the problems caused by drug-resistant microorganisms. These research directions will provide new strategies and means for the treatment of periodontitis in the future and bring new dawn to the development of oral health.

### 7.3. Drug-resistant Microorganisms Monitoring and Prevention and Control Strategies

Monitoring and control strategies of drug-resistant microorganisms will be an important research direction in the field of periodontitis prevention and treatment in the future. With the increasing drug resistance, the therapeutic effect of traditional antibiotics is gradually weakened, which brings great challenges to the treatment of periodontitis. Therefore, developing new monitoring technology of drug-resistant microorganisms and realizing rapid and accurate identification of drug-resistant bacteria has become the focus of current research. In the future, Qualcomm quantitative drug-resistant gene detection method based on gene sequencing technology will become the mainstream, which can fully understand the genetic background and drug-resistant mechanism of drug-resistant microorganisms. At the same time, the research and development of new antibacterial drugs is also the key, especially targeted drugs targeting specific drug-resistant genes, which is expected to provide new weapons for the treatment of periodontitis. In addition to drug research and development, prevention and control strategies for drug-resistant microorganisms are equally important. The breeding and spread of drug-resistant microorganisms can be reduced by strengthening oral hygiene education, popularizing correct brushing methods and regular oral examination. In addition, the balanced regulation of oral microbial flora is also a research direction. By regulating oral microecology and inhibiting the growth of drug-resistant microorganisms, the purpose of preventing and controlling periodontitis can be achieved.

## REFERENCES


[1] Zouali, Moncef. The emerging roles of B cells as partners and targets in periodontitis [J]. [2024-04-12].

[2] Kornman K, Le H. The role of local factors in the etiology of periodontal diseases [J]. Periodontology 2000, 1993, 2:, 83-97. DOI:10.1111/J.1600-0757.1993.TB00222.X.

[3] Aw, Vincent. Discuss the role of microorganisms in the aetiology and pathogenesis of periapical disease [J]. Australian Endodontic Journal, 2016, 42(2):53-59.DOI:10.1111/aej.12159.

[4] Wang W, Liu Y. Research Progress on the Immunomodulatory Effect of Mesenchymal Stem Cells on Chronic Periodontitis [J]. Open Journal of Stomatology, 2024, 14(2):8.DOI:10.4236/ojst.2024.142006.

[5] Sanz M, Beighton D, Curtis M A, et al. Role of microbial biofilms in the maintenance of oral health and in the development of dental caries and periodontal diseases. Consensus report of group 1 of the Joint EFP/ORCA workshop on the boundaries between caries and periodontal disease [C] // European Workshop on Periodontology. 2017.

[6] Cai R, Wang L, Zhang W, et al.The role of extracellular vesicles in periodontitis: pathogenesis, diagnosis, and therapy [J]. Frontiers in Immunology, 2023, 14.DOI:10.3389/fimmu.2023.1151322.

[7] Hostetter M K, Devore-Carter D. Antibodies to the propeptide of candida albicans and methods of use [J]. 2003.

[8] Pishan Y, Aimei S, Periodontology D O, et al. The role of TNF-α/NF-κB signaling pathway and its antagonism in periodontitis pathogenesis and periodontal tissue regeneration [J]. Stomatology, 2019.

[9] Slots J, Gunnar Dahlén.Subgingival microorganisms and bacterial virulence factors in periodontitis [J]. European Journal of Oral Sciences, 2010, 93(2):119-127.DOI:10.1111/j.1600-0722.1985.tb01319.x.

[10] Csaba Szabó. Role of Poly (ADP-Ribose) Polymerase Activation in the Pathogenesis of Inflammation and Circulatory Shock [J]. 2006.DOI:10.1007/0-387-36005-0_16.

[11] Williams D W, Lewis M A O, Percival S L, et al. Role of Biofilms in the Oral Health of Animals [J]. 2011.DOI:10.1007/978-3-642-21289-5_5.

[12] C A, Squier. The permeability of oral mucosa [J]. Critical reviews in oral biology and medicine: an official publication of the American Association of Oral Biologists, 1991.

[13] Muzio L. A possible role for the WNT-1 pathway in oral carcinogenesis [J]. Critical reviews in oral biology and medicine: an official publication of the American Association of Oral Biologists, 2001.

[14] Kurago Z B, Lam-Ubol A, Flaitz C M. Role of Microorganisms in Oral and Oropharyngeal Squamous Cell Carcinoma [J]. 2015.DOI:10.1007/978-1-4899-7475-4_61.

[15] Ramya R, Appukuttan D, Subramanian S, et al. Role of High Mobility Group Box 1 and Receptor for Advanced Glycation End Products in the Periodontal Disease Pathogenesis-A Review [J]. JOURNAL OF CLINICAL AND DIAGNOSTIC RESEARCH, 2022.DOI:10.7860/jcdr/2022/57020.16826.

[16] Ohira T, Kim M J, Pamulapati M, et al. The Role of NK Cells in Inflammatory Resolution in Periodontitis [C] // IADR General Session 2010.2010.

[17] Xiao-Long W, Shun-Shun C, Peng Z, et al. The Role of TLR4/MyD88 Signaling Pathway in the Pathogenesis of Type 2 Diabetes Mellitus with Chronic Periodontitis [J]. Journal of Oral and Maxillofacial Surgery, 2019.

[18] Chen L, Liang-Jia B I, Stomatology D O. Research progress of tumor necrosis factor-α in chronic periodontitis [J]. Chinese Journal of Geriatric Dentistry, 2019.

[19] Bian-Hong W, Li-Hua G E. The pathogenic potential of oral anaerobic microorganisms in rat periapical lesions [J]. Beijing Journal of Stomatology, 2011.

[20] Syniachenko O, Ermolaieva M V, Gaviley D, et al. Clinical and pathogenetic significance of the gingival microbiota in rheumatoid arthritis [J]. ACTUAL INFECTOLOGY[2024-04-14]. DOI:10.22141/2312-413x.9.1.2021.228826.

[21] Allenspach-Petrzilka G E, Guggenheim B. Bacterial invasion of the periodontium; an important factor in the pathogenesis of periodontitis? [J]. Journal of Clinical Periodontology, 2010, 10(6):609-617. DOI:10.1111/j.1600-051X.1983.tb01299.x.

[22] Listgarten M A. The role of dental plaque in gingivitis and periodontitis [J]. Journal of Clinical Periodontology, 2010, 15(8):485-487. DOI:10.1111/j.1600-051X.1988.tb01019.x.

[23] Chen Y, Li Y, Zou J. Intrageneric and Intergeneric Interactions Developed by Oral Streptococci: Pivotal Role in the Pathogenesis of Oral Diseases [J]. Current issues in molecular biology, 2019. DOI:10.21775/9781912530229.09.

[24] Beck J D, Offenbacher S. The association between periodontal disease and cardiovascular disease: A state-of-the-science review [J]. Annals of Periodontology, 2002, 6(1):9-15.DOI:10.1902/annals.2001.6.1.9.

[25] Kamierczyk-Winciorek M, Magorzata Ndzi-Góra, Sylwia Magorzata Sotwińska. The immunomodulating role of probiotics in the prevention and treatment of oral diseases [J]. Central-European Journal of Immunology, 2021(1). DOI:10.5114/CEJI.2021.104412.