

The Role Of Microbiome In The Development And Progression Of Periodontal Diseases

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Abstract

Periodontal disease (PD) is a multifaceted and contagious condition that originates from a disturbance in the balance of microorganisms. This condition triggers an immune reaction in the body, causing harm to the soft and connective tissues that support the teeth. Furthermore, in severe instances, it might lead to the loss of teeth. The causative causes of PDs have been extensively studied, however the underlying mechanisms of PD have not yet been fully elucidated. Several variables influence the cause and development of PD. The beginning and extent of the illness may be influenced by microbiological factors, genetic predisposition, and lifestyle choices. The immune system's defensive reaction to the buildup of plaque and associated enzymes is recognized as a significant contributor to PD. The oral cavity is inhabited by a distinct and intricate bacteria that forms various biofilms across all mucosal and tooth surfaces. The objective of this review was to provide the most recent advancements in the literature about ongoing issues with PD and to emphasize the significance of the oral microbiome in maintaining periodontal health and managing illness. Enhanced awareness and understanding of the variables that contribute to dysbiosis, environmental risk factors, and periodontal treatment help mitigate the increasing global occurrence of periodontal diseases. Implementing strategies to promote proper dental hygiene, restricting smoking and alcohol intake, managing stress levels, and providing complete treatment to lessen the harmful effects of oral biofilm may effectively lower the prevalence of periodontal disease (PD) and other associated conditions.

The growing body of evidence connecting oral microbiome disorders to systemic diseases has enhanced our comprehension of the crucial role played by the oral microbiome in regulating numerous physiological processes within the human body, thereby influencing the onset of various diseases.

Keywords: periodontal diseases, oral microbiome, oral health, oral diseases, systemic diseases

1. Introduction

Periodontitis is a prevalent infectious illness that affects a significant portion of the world population, ranging from 10% to 50%, depending on its severity. Gingivitis is a moderate and reversible kind of periodontal disease (PD). If not treated correctly, it may progress to periodontitis [3]. Parkinson's disease (PD) is a multifaceted and contagious sickness that starts with the disturbance of bacterial equilibrium. This condition triggers an inflammatory reaction in the body, which causes harm to the soft and connective tissues that support the teeth [4,5,6]. Furthermore, in severe instances, it might lead to the loss of teeth [7]. The causative causes of PDs have been extensively studied; however the underlying mechanisms of PD are still not fully understood. Several variables influence the cause and development of PD. Microbiological factors, genetic predisposition, and lifestyle are believed to have a role in determining the onset and severity of the illness [8,9].

The immune system's defensive reaction to the buildup of plaque and associated enzymes is recognized as a significant contributor to PD [10]. Microbial plaque is a kind of biofilm that develops on the teeth and gums and is a significant factor contributing to PD [11]. Additional individual risk factors associated with Parkinson's disease (PD) include obesity, inadequate dental hygiene, high levels of stress, a diet lacking in vitamins C and D, and tobacco use [6,10,12,13,14]. Multiple research have examined the relationship between cigarette smoking and PD, indicating that smoking is a substantial environmental risk factor for PD. Nicotine, a constituent of cigarette smoke, has been associated with altering clinical characteristics and progression [6,13]. Furthermore, several studies have shown that PD has a significant influence on the advancement of several systemic illnesses, including osteoporosis, atherosclerosis, diabetes, cardiovascular

diseases, and ischemic cardiomyopathy. These conditions have the potential to worsen the development of PD [15,16].

Furthermore, another research has shown a contrasting scenario, indicating that systemic illness might worsen the symptoms of PD. Furthermore, the use of pharmaceuticals such as corticosteroids, antiepileptic drugs, and chemotherapy treatments might further increase the risk of developing Parkinson's disease. The susceptibility to this illness is linked to the activation of the host's antibacterial defense systems [17]. Multiple studies have shown the correlation between hereditary variables and Parkinson's disease (PD). The presence of cytokines and their genetic variations have a role in determining the likelihood of developing this illness and the extent of its severity. However, Nibali et al. reported compelling findings from their study, showing that the heritability of periodontitis was estimated as an odds ratio (OR) of 0.38 (95% confidence interval [CI], 0.34–0.43) in twin studies and an OR of 0.15 (95% CI, 0.06–0.24) in other family research [18]. Research has shown that the makeup of the oral microbiome naturally undergoes changes as a person gets older [19]. This might be connected to the fact that older individuals are more prone to developing chronic periodontitis [20]. Periodontal abnormalities exacerbate difficulties with mastication, the ability to speak, and aesthetic appearance, ultimately leading to a decline in quality of life [19].

A novel conceptual framework for the development of periodontal diseases posits that the illness is characterized by a wider range of microorganisms linked to periodontitis than previously believed. The illness is a consequence of the combined action of many bacteria and dysbiosis, which disturb the ecologically balanced biofilm associated with periodontal homeostasis. It is important to note that this disruption is not caused by individual pathogens [21]. When in a state of good health, the oral microbiome demonstrates a harmonious and ever-changing ecology [22]. Dysbiosis of the oral microbiome refers to an imbalance in the relative abundance or an influence on microbial species, which leads to the development of illness in vulnerable people [23].

2. The Role of Microbiome in Oral Health

The term "microbiome" was coined by Joshua Lederberg and encompasses the collective population of symbiotic, commensal, and pathogenic microorganisms [24]. The

structure and interplay of a microbiome have a significant impact on one's general well-being, particularly in relation to dental health [25]. The oral cavity is inhabited by a distinct and intricate microbiota that forms various biofilms on all mucosal and dental surfaces [26]. The mouth cavity contains around 700 species of bacteria, fungus, viruses, archaeobacteria, and protozoa [20]. Bacteria are the most extensively studied microorganisms in the oral cavity [27], yet, only 57% of bacterial species in the oral cavity have been formally identified [28]. The oral microflora in the field of health mostly comprises of facultative anaerobic Gram-positive bacteria [29]. The oral mycobiome, which refers to the fungal microbiome in the mouth, is an important part of the overall oral microbiome. The *Candida* genus is found in around 25-75% of healthy humans as a commensal organism [30]. *Candida albicans* is a very significant and widespread fungus species.

Certain favorable circumstances might lead to *Candida* species, which are opportunistic pathogens, causing infections in the oral mucosa [31]. The oral microbiota often coexists harmoniously with the host and provides significant advantages that contribute to general well-being. The bacteria in oral biofilms do not exist as individual cells but instead reside in close proximity to one other [27]. Microbial interactions might exhibit either synergistic or antagonistic effects [32,33]. Furthermore, the oral environment exerts influence on the makeup of the microbiome. Alterations in local circumstances might potentially impact the interactions among bacteria in the oral cavity, hence raising the likelihood of developing periodontal disease (PD). The structure of the oral microbiome has been extensively investigated via the use of metagenomics and metatranscriptomics [2].

Belstrøm et al. used these techniques to examine the transcriptional activity of common *Streptococcus* species in both healthy individuals and those with periodontitis. The researchers found that the level of transcriptional activity in *Streptococcus* species was greater in healthy conditions and decreased in individuals with PD [34]. *Streptococcus* species are noteworthy Gram-positive bacteria that can survive with or without oxygen and are often found in the regular bacteria population of the mouth. Two newly discovered species of bacteria, *Streptococcus dentisani* and *Streptococcus salivarius*, have potential probiotic properties and are being studied for their ability to cure various oral ailments, including periodontal disorders [35,36,37].

Lately, there has been an increasing fascination in utilizing probiotics as a means to address PDs. Probiotics are live bacteria that, when consumed in enough amounts, may have a positive impact on the host. Their primary role is to control and manage the immunological function of the host, ensuring a state of equilibrium and stability in the oral cavity [3]. Probiotics have shown positive outcomes in enhancing oral health, not only in periodontal problems [39], but also in dental caries [40], *Candida* infection [41], and halitosis [42]. The *Lactobacillus* genus is well recognized for its beneficial effects on oral health in periodontal treatment. *Bifidobacterium*, *Streptococcus*, and *Weissella* are recognized as probiotics that have a beneficial impact on dental hygiene.

In addition, *Bacillus subtilis* and *Saccharomyces cerevisiae* have a positive influence on the oral cavity [3]. Furthermore, several types of bacteria that have been obtained from the mouth have been manufactured and sold as probiotics. These include *Lactobacillus reuteri*, *Lactobacillus brevis*, and *Streptococcus salivarius* [25,43]. Kawai et al. [44] proposed that *Limosilactobacillus* (*Lactobacillus*) *fermentum* ALAL020 has the potential to be a probiotic candidate in the future. This bacterium synthesizes a cyclic dipeptide that has antibacterial properties against *Porphyromonas gingivalis* and *Prevotella intermedia* [44]. Presently, scientific study is highly focused on investigating the advantageous impacts of synbiotics on health. Synbiotics are a combination of living microorganisms and specific substances that are used by the microorganisms in the host's body, resulting in a positive effect on the host's health. Studies have shown that the administration of a synbiotic, together with probiotics, may effectively prevent and cure certain metabolic problems. Nevertheless, there is little evidence to support this claim [45]. Duraisamy et al. observed that synbiotics have the ability to reduce the levels of *Streptococcus mutans* in the saliva of children; however they are not as effective as probiotics [46].

3. The Role of Oral Microbiome in Periodontal Diseases

The group of oral bacteria that thrive without oxygen, known as the "red complex" (*Porphyromonas gingivalis*, *Treponema denticola*, and *Tannerella forsythia*), have long been recognized as the primary infectious agents linked to periodontitis [27]. Nevertheless, this phenomenon has been detected in research that relies on culture-based methods, resulting in the omission of several diverse bacteria found in

the samples [47]. However, only a few number of bacteria, including *P. gingivalis*, *Aggregatibacter actinomycetemcomitans*, *Tannerella forsythia*, *Prevotella intermedia*, and *Fusobacterium nucleatum*, have been shown to be responsible for starting and advancing periodontal diseases [48]. Furthermore, *Candida albicans* is a very significant fungus inhabitant of the oral microbiota. This symbiotic inhabitant shields *P. gingivalis* from detection by the host's immune cells and might potentially facilitate bacterial infections of the gums [29].

The field of contemporary periodontology focuses on the interaction between oral bacteria and the host, in addition to studying the pathogenicity of dental plaque [3]. Disruptions in the microflora subsequently result in the development of gingivitis and, ultimately, periodontitis. Disruptions in homeostasis in the oral cavity and systemic illnesses may be caused by factors such as the presence of oxygen, nutrients, and changes in pH [47,49]. Alterations in the oral microbiome may result in the proliferation of bacteria and provide favorable environments for the development of opportunistic microbes [10]. Furthermore, disruptions in the periodontal microbiota are linked to a shift from a mutually beneficial to an imbalanced microbial population. The symbiotic structure consists of facultative bacteria, such as *Actinomyces* and *Streptococcus*, which later transition to mostly anaerobic species, including the phyla Firmicutes, Proteobacteria, Spirochaetes, Bacteroidetes, and Synergistetes [48]. The shift in microbial makeup occurs before the onset of clinical symptoms in Parkinson's disease [50]. Residing bacteria, age, general health, lifestyle, and nutritional status are well-established variables that influence dental health [50].

4. Summary

Prior research emphasizes the significance of the oral microbiota in maintaining periodontal health and the development of periodontal disease. Enhanced awareness and understanding of the underlying causes of dysbiosis, environmental risk factors, and periodontal treatment have the potential to mitigate the growing occurrence of periodontal disease on a global scale. To decrease the occurrence of PD, it is important to promote good dental hygiene, decrease smoking, alcohol intake, and exposure to stress, and provide complete therapy to diminish the harmful effects of the oral biofilm. Recent scientific studies on the

human microbiome have sparked more curiosity in the oral microbiome and its influence on the regular functioning of oral processes and the emergence of disorders, including various systemic diseases. The mounting evidence connecting problems of the oral microbiome to many systemic illnesses has raised awareness about the crucial role of the oral microbiome in controlling multiple processes in the human body and, therefore, its influence on the onset of several diseases. A comprehensive understanding of the function of the oral microbiome in maintaining health and its involvement in the progression of diseases may aid in the prevention and treatment of many illnesses.

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