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ORAL MICROBIOME AND SYSTEMIC DISEASES PATHOGENETIC LINKS AND MODERN CLINICAL APPROACHES

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Abstract: This article analyzes the oral microbiome not merely as a factor in local pathologies (caries, periodontitis), but as a complex ecosystem that determines the systemic homeostasis of the organism. Drawing on metagenomic research from the last decade, the authors reveal the molecular links between oral dysbiosis and cardiovascular diseases, diabetes mellitus, and neurodegenerative processes.

The mechanisms by which pathogenic microorganisms, particularly Porphyromonas gingivalis and Fusobacterium nucleatum, cross the blood-brain barrier and the endothelial layer are discussed based on clinical cases and biological models. The uniqueness of this study lies in viewing oral health as a strategic factor in reducing the overall systemic inflammatory load of the body. The conclusion substantiates the promising directions of dental prevention in reducing the risk of systemic diseases and emphasizes the importance of a multidisciplinary approach among physicians. The systemic spread of periodontal pathogens through the bloodstream, the stimulation of the cytokine cascade, and their role in the development of cardiometabolic and neurodegenerative diseases are analyzed.

Keywords: oral microbiome, dysbiosis, systemic inflammation, Porphyromonas gingivalis, cardiometabolic risk, microbiota-host interaction, atherosclerosis.

Introduction

The human body is a complex ecosystem living in symbiosis with trillions of microorganisms. Research conducted within the "Human Microbiome Project" (HMP) over the last decade has shown that the oral microbiota is second only to the gut microbiota in terms of complexity. In a healthy organism, more than 700 species of microorganisms exist in a state of homeostasis, modulating the local immune system.

However, a significant challenge in modern dentistry is that dental pathologies are often viewed as localized processes. In reality, chronic inflammatory foci in the oral cavity are primary factors determining the systemic inflammatory load of the body. Dysbiosis, triggered by poor hygiene, smoking, malnutrition, or genetic predisposition, serves as a biological catalyst for the development of systemic diseases [2].

Foci of infection in the oral cavity, specifically periodontitis, serve as a constant source of endotoxemia for the organism. The destruction of the periodontal pocket epithelial layer results in an open "ulcerated epithelium," which acts as a gateway for microorganisms. Clinical estimates suggest that in moderate to severe periodontitis, this ulcerated surface area can range from 15 to 72 cm2 [3].

Through this open surface, microorganisms and their metabolites, particularly the lipopolysaccharides (LPS) of Gram-negative bacteria, enter the systemic circulation. Once in the bloodstream, pathogens like Porphyromonas gingivalisstimulate the liver to synthesize acute-

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phase proteins—C-reactive protein (CRP), fibrinogen, and serum amyloid A. This process negatively affects the vascular endothelium, creating a subclinical inflammatory background and maintaining constant irritability of the immune system.

Cardiovascular Diseases and the Oral Microbiome

Epidemiological studies confirm a strong correlation between periodontitis and cardiovascular diseases (CVD). P. gingivalis possesses specific fimbriae that allow it to adhere to and invade vascular endothelial cells [4].

Two primary mechanisms are at play:

Direct Effect: Histological analysis of atherosclerotic plaques has revealed the presence of oral pathogen DNA and even live bacterial cells within them.

Molecular Mimicry: Bacterial Heat Shock Proteins (HSP) are remarkably similar to human vascular wall proteins (HSP60).

Consequently, antibodies produced by the immune system to fight the bacteria mistakenly attack the host's own vascular endothelium, accelerating the progression of atherosclerosis [5].

Diabetes Mellitus and Periodontitis: A "Two-Way Street"

The interaction between periodontitis and diabetes is one of the most extensively studied topics at the intersection of dentistry and endocrinology.

Effect of Diabetes on the Periodontium: Chronic hyperglycemia leads to the accumulation of "Advanced Glycation End-products" (AGE) in tissues. These substances bind to RAGE receptors on macrophages, drastically accelerating periodontal tissue destruction (bone resorption).

Effect of Periodontitis on Diabetes: Chronic inflammatory mediators (TNF-α, IL-6) from the mouth enter the blood and cause the blocking of insulin receptors, leading to insulin resistance.

Clinical trials show that professional oral cleaning and sanitation can reduce glycated hemoglobin (HbA1c) levels by 0.3-0.4% in diabetic patients, which is as effective as some pharmacological interventions.

The Oral-Brain Axis

In recent years, the concept of the "Oral-Brain Axis" has entered scientific discourse. Gingipain enzymes secreted by P. gingivalis have been identified in the brain tissue of patients with Alzheimer's disease [6]. These enzymes degrade "tau-proteins" in neurons, leading to the formation of neurofibrillary tangles, which accelerates memory loss and cognitive decline [7]. Thus, maintaining oral hygiene in elderly patients is not just about tooth retention but is a method of protecting mental health.

Clinical Approaches

Based on these analyses, it is vital to emphasize that the role of the modern dentist should not be limited to "treating teeth." Every patient must be viewed through the prism of general somatic health. For instance, a simple case of periodontitis or a cyst in a patient preparing for cardiac surgery can increase the risk of post-operative infectious endocarditis by 5 to 10 times.

As dental professionals, our responsibilities include:

Conducting a deep study of the patient’s general medical history.

Implementing aggressive preventive measures for patients with systemic diseases.

Promoting oral sanitation as a strategic treatment to reduce the body's overall inflammatory load.

The oral microbiome is increasingly viewed as a critical biomarker of human health, as dysbiosis can trigger systemic inflammatory processes. Recent studies suggest that shifts in the oral microbiota are significant factors in cardiovascular, endocrine, and autoimmune diseases. This necessitates evaluating oral hygiene as an integral part of general health. The impact of

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periodontal pathogens on other organ systems via the bloodstream confirms that the microbiome serves a systemic biological role rather than a purely local one. Preventive dentistry and microbiome-oriented approaches (probiotics, prebiotics, individual hygiene strategies) represent promising directions in future medicine.

Conclusion

In conclusion, the oral microbiome is a biological indicator reflecting the overall condition of the human organism. Although dysbiosis processes may appear local, they disrupt the immune-biological stability of the entire body. The integration of dentistry and fundamental medicine serves as the cornerstone for early disease detection and improving the quality of human life. The disruption of microbial balance—dysbiosis—is widely documented in scientific research to be linked not only to periodontal diseases and caries but also to cardiovascular diseases, diabetes, respiratory infections, autoimmune disorders, and even certain neurodegenerative conditions.

Studying the link between the oral microbiome and systemic diseases opens new opportunities in the pathogenesis, early diagnosis, and prevention of illnesses. Specifically, using shifts in microbiome composition as biomarkers is a promising direction for the development of personalized medicine.

Simultaneously, adherence to oral hygiene, prevention of periodontal diseases, healthy nutrition, and preventive approaches that support microbiome balance play a crucial role in reducing the risk of many systemic diseases. Therefore, maintaining the health of the oral microbiome must be considered a vital component of strengthening general health.

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