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Oral Ecosystem and its Impact on Systemic Wellness - A Narrative Review

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Abstract

The oral micro biome is one of the important and considered to possess the second most complex micro-biota in human body, oral bacteria may be linked or serve as biomarkers for certain systemic diseases, such as pancreatic cancer, diabetes type, pediatric Crohn's disease, heart disease, and low weight, preterm birth. Every human possesses completely distinctive web of micro biota that is primarily determined by one's DNA. In case of any disruption in that balance along with infectious illnesses, certain diets, stress, environmental exposure as we age or extended use of antibiotics — DYSBIOSIS occurs, the body may become more susceptible to disease. A poly microbial communities embedded in an extracellular matrix and adhered on living and nonliving surfaces named biofilms can regulate numerous processes via quorum sensing which is a cell-to-cell communication mechanism that synchronizes gene expression in the biofilm. The EPS matrix of oral biofilm helps in biofilm growth and maturation. The bacteria residing inside the biofilm are protected from various environmental stresses, such as desiccation, attack from antimicrobial agents by the immune system, and ingestion of protozoa. Oral gut micro biome axis, bi-directional interaction is important to immune signaling however, the act of traveling bacteria can lead to dysbiosis where compounds like proteases and molecules like endotoxin and leukotoxins are produced potentially affecting the immune system and contributing to the onset of disease states. The purpose of this study examines the relation between oral microbiota on systemic wellness. The research

explores how dysbiosis in the oral ecosystem might trigger or exacerbate conditions affecting systemic conditions like – obesity, cardiovascular conditions, diabetes and insulin resistance.

Keywords: Consumption, Diabetes Type, Ecosystem, Harmonious, Holobiont

Introduction

Human body is considered a 'supra organism" or "holobiont", a communal group of human and microbial cells. This intricate ecosystem comprises bacteria, viruses, fungi, and other microbes that interact with each other and their host.

The oral micro biome is one of the important and considered to possess the second most complex micro-biota in human body, approximately 700 species are present in the oral cavity, and most of them are indigenous, exposed to both the inhaled and ingested microbes [1]. These microbial residents have co evolved with us over millions of years. Dysbiosis, or an imbalance in this microbial community, can lead to inflammation and may serve as a pathway for pathogens to enter the bloodstream, affecting organs far beyond the mouth.

Several distinct habitats within the oral cavity support heterogeneous microbial communities that constitute an important link between oral and general health. About 400–500 oral taxa have been detected in the subgingival crevice alone. The remaining taxa are distributed on the many oral habitats including different areas on the tongue, tooth surface, buccal mucosa, tonsils, soft and hard palate, and lip vestibule [2].

Understanding the interplay between the oral micro biome and systemic health is crucial for developing holistic approaches to disease prevention and health promotion.

These associational microorganisms contribute to host health by resisting pathogens, maintaining homeostasis ,modulating the immune system and development of many oral and systemic diseases.

The relationship between micro-biome and host is dynamically influenced by many aspects of modern lifestyle, such as diet, tobacco consumption and stress, which can alter our micro-biome and its properties, and induce a state in which this finely tuned ecosystem is no longer in balance. To address this divergence and maintain a harmonious state to protect health and prevent disease, we must not focus on the host and its residents as separate units, but instead consider the holobiont as one [3].

It is well known that specific bacterial taxa that colonize the oral cavity are associated with oral health and oral diseases or afflictions, such as dental caries, periodontal diseases, endodontic lesions, dry socket, halitosis, and odontogenic infections. Furthermore, oral bacteria may be linked or serve as biomarkers for certain systemic diseases, such as pancreatic cancer, diabetes type, pediatric Crohn's disease, heart disease, and low weight, preterm birth . However, it is yet to be established if there is a causal relationship between the oral microbiome and these systemic disorders [2].

This review aims to enhance and investigate the relationship between the oral microbiome and systemic health, with a focus on understanding how changes in the composition and dysbiosis in diversity of oral microbial communities may influence the development or progression of systemic conditions such as cardiovascular disease, diabetes, and autoimmune disorders.

Material Methodology

To review the literature, the studies were selected from google scholar, pub med and other websites without any restrictions on publication year, to provide a

comprehensive overview of current knowledge on Effect of oral micro-biome on systemic health. The review focused on describing the microbial diversity of the oral cavity and the relationship between oral bacterial community shifts and systemic diseases. Moreover, their role in human body, various good and commensal micro biome colonization of oral micro-biota modulation.

Let's understand micro biome

The diverse group of microbial habitants such as bacteria, fungi, viruses, and their genes that harbor our body space inside and out is called the micro biome (or micro biota). Each body site – for example, the gut, skin, and oral and nasal cavities – has a different community of microbes. These are even tagged as supporting organ as it engages in contributing to smooth daily functioning of the human body.

Every human possesses completely distinctive web of micro biota that is primarily determined by one's DNA. A person's core micro biome is formed or is first exposed to microorganisms as an infant, during delivery in the birth canal and through the mother's breast milk. Exactly which microorganisms the infant is exposed to depends solely on the species found in the mother. Later, environmental exposures and diet can change one's micro biome to be either beneficial to health or place one at greater risk for disease [4].

Are Microbes Supposed To Be Dangerous?

The micro biota is composed of microbes which are both useful (commensal microbes) and potentially harmful. Some are symbiotic (where both the human body and micro biota benefit) and some are pathogenic (causing disease). In a sound body, symbiotic and pathogenic microbes coexist without problems. However, in case of any disruption in that balance along with infectious illnesses, certain diets, stress, environmental exposure as we age or extended use of antibiotics —DYSBIOSIS occurs, terminating these normal interactions. Consequently, the body may become more susceptible to disease [5].

Since the micro biome is a key interface between the body and the environment, these microbes can affect health in different ways. Some microbes alter environmental substances in ways that make them more toxic, while others make environmental substances less harmful, these are good microbes or commensal microbe.

In humans, bacteria that live in your gut aids in the digestion, bacteria that live on your skin help to break down the lipids to produce natural moisturizing factor for your skin [6]. They also are wonderful in providing colonization resistance by basically taking up all the space so that the pathogens that might want to try to invade humans don't have the opportunity to colonize us, providing nutrients for our cells and aids in breaking down the array of sugars found in human breast milk. "These sugars are not broken down by the infant. Instead, microbes in the baby's gut do the job [7].

Ubiquity of microbes

A study from 2016 suggests that in fact microbial cells and human cells coexist in somewhere around a 1.3 to one ratio – suggesting they only slightly outnumber our own cells, although that doesn't count viruses and viral particles [8]. A human should be seen as a holobiont , a term that reflects the intimate, co-dependent relationship humans have with microbes [9]. Human cells don't just contain chromosomes, but also carry DNA within our cellular powerhouses, mitochondria, which are evolutionary descendants of bacteria.

Oral micro biome and their role

Genome of Bacteria that dwells in the mouth is termed as oral micro biome. It is the second largest microbial

community in the humans after gut and considered to be the most essential microbes in the human body.

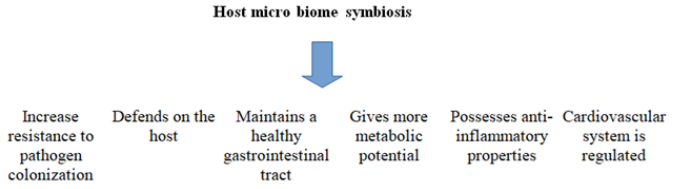

Figure 1: Host–micro biome interactions in oral cavity of Human. [10]

These oral micro biome are diverse and abundant. The most abundant bacterial genera in healthy adults include Actinomyces, Bacteroides, Prevotella, Streptoco ccus, Fusobacterium, Leptotrichia, Corynbacterium, Veil lonella, Rothia, Capnocytophaga, Selenomonas, and Tre ponema, as well as the TM7 lineage (Saccharibacteria). 1 cc (ml) of human saliva in a healthy adult contains approximately 100 million cells, which is discrete from the community of the surrounding oral micro biome [11] with only 50 species a given set of the 1000 species are capable of colonizing the mouth at any given moment.

Micro biome: Ecology and Colonization

Ecology is the natural science that studies the interrelationships between living organisms (biotic) and their physical environment (abiotic) and ecosystem is a place where their interaction takes place. The oral ecosystem is thus composed of the oral microorganisms and their surroundings, the oral cavity. The ecology of the oral cavity is complicated with different niches, that provide a distinctive environment for the colonization of the microbes.

Some of These distinctive niches in the oral cavity include tongue, cheek, saliva, gingival sulcus, hard and soft palates, throat, the floor of the mouth and the teeth. The action starts with the colonization of the habitat by pioneer microbial populations. There are some commensal microbes (resident) which are present in harmony with the host. Some of which belong to Streptococcus, Eubacteria, Fusobacterium, Staphylococcus, Porphyromona, Prevotella, Peptostreptococcus, Treponema, Actinomyces genera.

Besides the commensal flora there are other microbes such as coliforms which survive in the mouth only for short period (hours to weeks) and do not establish themselves permanently are called transient flora. [12] In the oral cavity of newborns, streptococci (S. mitis biovar 1, S. oralis, and S. salivarius) are the pioneer organisms. Pioneer microorganisms fill the niche of this new environment and modify the habitat that results in new populations. As this process continues, the diversity and the complexity of the microbial community increase. Succession ends when no additional niche is available for new populations. At this stage, a relatively stable assemblage of bacterial populations is achieved. It is called a climax community. The stability is based upon homeostasis, which implies compensating mechanisms that act to maintain steady-state conditions. The concepts of homeostasis and bacterial succession are important in oral microbiology. Some factors, such as a high-sucrose diet, may cause an irreversible breakdown in the homeostasis of the oral ecosystem, resulting in the initiation of caries [13].

Biofilms: role in the Oral Environment

A poly microbial communities which is embedded in an extracellular matrix and adhered on living and nonliving surfaces are named biofilms. This micro colonies development on surfaces is an important strategy for bacterial survival. We usually have more than 700 different species of bacteria that reside in the mouth, some being innocuous and some being pathogen. Dental plaque is a tenacious microbial community which develops on soft and hard tissue of the mouth as a biofilm, embedded in a matrix of polymers of host and bacterial origin, comprising living, dead and dying

bacteria and their extracellular products, together with host compounds derived from saliva. Plaque is natural and contributes to the normal development of the physiology and defenses of the host [14]. Our oral cavity provides ideal conditions for microbial growth and proliferation by providing a moist, warm, and nutritious environment. Due to the complex interactions among the host, microorganisms, and diet, microbial colonization of pathogenic biofilm takes place.

The biofilm produces acid at the tooth restoration margin, leading to predisposing factors like dental caries, gingivitis, secondary caries, most restoration failures, Pulp infections, apical periodontitis and re-infection, peri-implantitis and periodontitis. [15]

The oral biofilm bacteria can regulate numerous processes via quorum sensing, which is a cell-to-cell communication mechanism that synchronizes gene expression in the biofilm in reaction to the density of the cell population. As the biofilm matures, the microbial composition changes from one that is primarily gram-positive and streptococcus-rich to a structure filled with gram-negative anaerobes. These anaerobic bacteria are able live deeper within the biofilm, further protecting them from the oxygen-rich environment within the oral cavity. [16]

Deleterious strains of bacteria in the oral biofilm can make their way to bloodstream during any inflammatory response and can is carried to other parts of the body, wielding a systemic effect linked to numerous diseases like cardiovascular disease, diseases related to oral gut relation, diabetes, pre term pregnancy, pulmonary disease, chronic kidney disease, various types of cancer and so on. Bacteria present in the biofilm are less susceptible to antimicrobial agents, locally applied or systemically administered as structure of the biofilm might restrict penetration of antimicrobial agents.

When antimicrobial agents are used, only some cells are exposed, while some of the drug entrance is reduced by the EPS (extracellular polymeric substance) matrix of the biofilm, hence diffusion of drugs into the deeper layer of oral biofilm is prohibited. The EPS matrix of oral biofilm helps in biofilm growth and maturation. The bacteria residing inside the biofilm are protected from various environmental stresses, such as desiccation, attack from antimicrobial agents by the immune system, and ingestion of protozoa; therefore, the oral biofilm structure makes for more complex bacterial communities. Restorations, non-surgical or surgical periodontal therapies, root canal treatments, and dental implants are well established curative regimens that remove oral biofilm; however, these treatments are not always entirely successful at removing secondary biofilm infections. [15]. Some techniques for effective management and removal of oral biofilms also includes Contact-killing, Nanoparticles, Photodynamic Therapy, Cold Atmospheric Plasma

Oral and Gut – Micro Biome Axis; Mode of Travel

Our oral cavity and gut are linked through the Gastrointestinal tract, a continuous duct that runs from the mouth to the anus and includes organs such as the mouth, stomach, small and large intestines as well as through the enzymes present in saliva that helps in digest food. Translocation of oral micro-organisms from the mouth to the gut is a bi-directional movement of microorganisms, which can also see microbes translocate upwards from the gut to the mouth. This is known as the oral-gut micro biome axis. [17]. This bi-directional interaction is important to immune signaling however, the act of traveling bacteria can lead to dysbiosis where compounds like proteases and molecules like endotoxin and leukotoxins are produced

potentially affecting the immune system and contributing to the onset of disease states.

Oral dysbiosis may mostly come from associated microbial cells (biofilm) on the dorsum of the tongue. This structure has a unique physical-chemical conditions that modulate the bacterial composition, this area shows the lowest amount of oxygen, which is like the colorectal tract. Saliva carries food nutrients to nourish these bacteria and helps maintain stable levels of bacteria involved in health.

Where the number of potential pathogens often exceeds the physiological limit because of the host's bad eating habits.

Clinical observational studies have also shown that the coating on the tongue is related to dysbiosis status which changes the structure and composition of the bacterial biofilm. This coating can vary in appearance and thickness and serves as a good indicator of oral and overall health.

Another mode is the transient presence of bacteria in your blood (bacteremia), which is a silent process where oral bacteria temporarily enter the bloodstream. This can occur after certain dental hygiene activities or medical procedures that disturb the oral mucosa, allowing bacteria and their toxins to enter the bloodstream. Therefore, these bacteria can migrate from the tongue to the saliva and bloodstream through inflamed oral tissues, thereby exacerbating the onset of various degenerative conditions. [18] [19]

Conclusion

This review explores on how oral micro biota and its ecosystem affects human health, influencing various bodily functions beyond the mouth. We have focused to identify of numerous bacteria as predominantly oral species that colonize the body of host. Dysbiosis, or imbalance within this microbial community, is linked to increased inflammation and has been implicated in a range of systemic conditions, including cardiovascular disease, diabetes, and respiratory infections. This review also underscores the importance of understanding biofilms, a unique strategy of cell survival and the oral cavity which serves as a reservoir for microbes that can translocate to the gut, affecting its microbial composition and systemic health.

Given the bidirectional interactional nature of the relationship between oral health and systemic health, it is evident that maintaining oral microbiome balance could be a crucial factor in preventing or managing systemic diseases. Therefore, understanding the impact of the oral microbiome on systemic health brings new possibilities for preventive healthcare that will emphasizing the need for an integrated approach to oral and systemic disease management.

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