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THE ROLE OF ORAL MICROBIOME DYSBIOSIS IN THE DEVELOPMENT OF DENTAL CARIES

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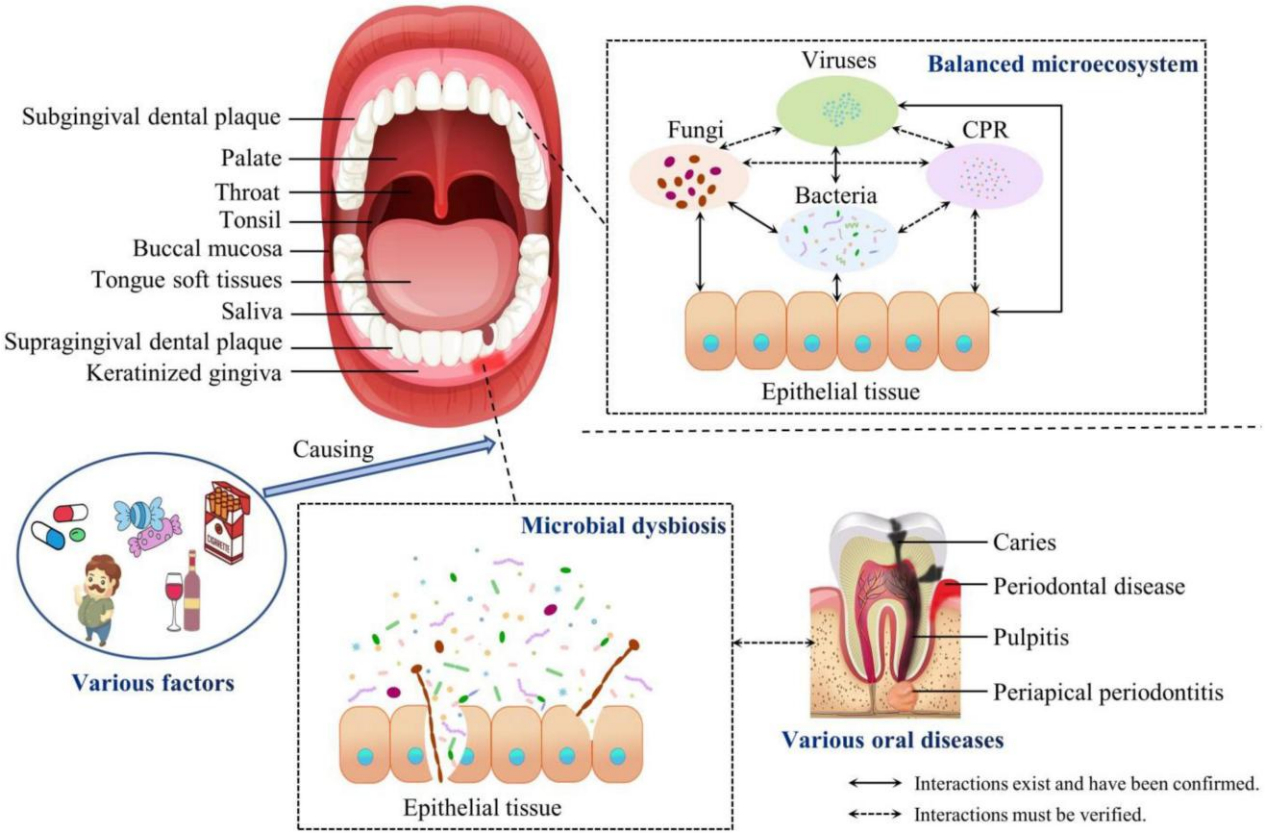
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Annotation: This article examines the contribution of disrupted microbial balance in the oral cavity to the formation and progression of dental caries. It outlines how alterations in bacterial communities modify biochemical processes, weaken protective mechanisms, and intensify demineralization. The study highlights the importance of early detection of microbial shifts and evaluates modern diagnostic and preventive strategies designed to stabilize the ecological state of the oral cavity. This section provides an analytical overview of how disturbances within the oral microbial community contribute to the formation of destructive processes affecting dental tissues. It emphasizes the significance of ecological instability in accelerating biochemical reactions that weaken enamel, promote acid accumulation, and disrupt natural defense responses. The analysis highlights the clinical value of recognizing early microbial imbalances and underscores the need for updated strategies aimed at restoring ecological harmony to minimize structural degradation.

Keywords: oral microbiome, dysbiosis, dental caries, biofilm, acidogenesis, demineralization, preventive dentistry.

Introduction:

The ecological composition of microorganisms inhabiting the oral cavity plays a fundamental role in preserving dental and periodontal health. Under normal conditions, a stable microbial community maintains a balanced environment that protects hard dental tissues from excessive acid exposure. However, external and internal factors can destabilize this community, resulting in dominance of pathogenic species capable of intensified carbohydrate fermentation and acid production. Such alterations contribute to prolonged decreases in pH, creating favorable conditions for enamel demineralization and the onset of carious lesions. Recent scientific attention has increasingly focused on how shifts in microbial diversity, density, and metabolic activity directly influence the pathogenesis of dental caries. Understanding these mechanisms is essential for developing more effective preventive and therapeutic measures. Within the oral cavity exists a complex ecosystem composed of numerous microorganisms that collectively participate in sustaining a stable biochemical environment required for maintaining the integrity of hard and soft tissues.



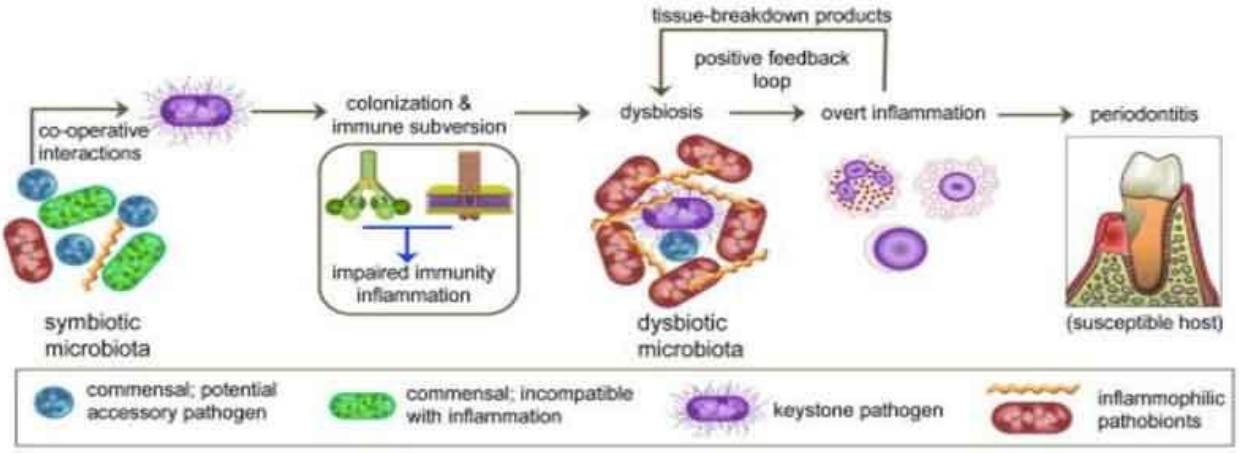
When physiological balance is maintained, beneficial microbial groups limit the activity of species capable of initiating detrimental processes. However, variations induced by lifestyle, diet, systemic conditions, or inadequate hygiene can alter these communities, giving rise to unfavorable shifts that intensify fermentation activity and reduce pH levels. As the environment becomes progressively more acidic, mineralized structures face constant chemical attacks, ultimately leading to irreversible damage. Understanding these ecological transformations is essential for interpreting the underlying mechanisms that facilitate carious progression and for designing more precise preventive and therapeutic measures.

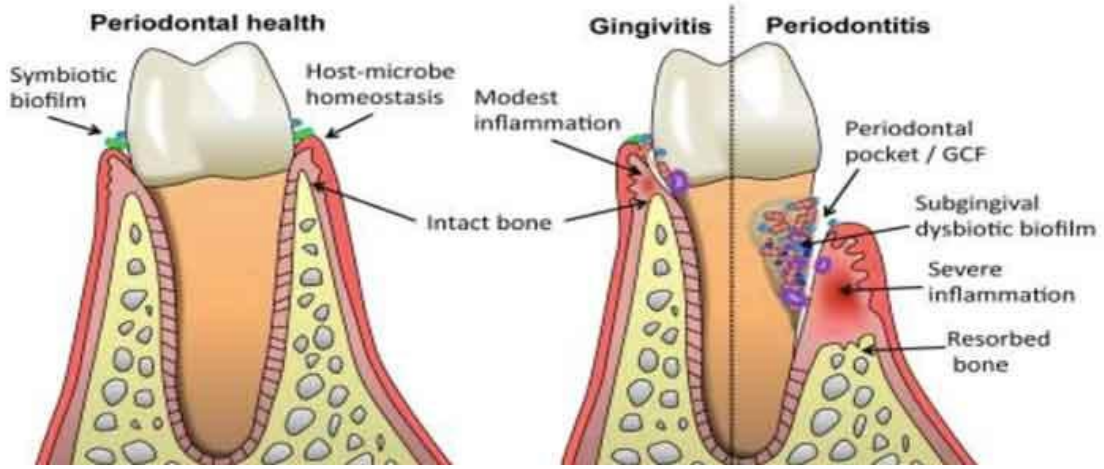
Research Methods and Materials:

The study involved a cross-sectional analytical review of clinical data, microbial assessments, and laboratory analyses from patients aged 12–30 presenting for routine dental examinations. Plaque samples were collected using sterile curettes and analyzed through polymerase chain reaction amplification and 16S rRNA sequencing to identify microbial composition. Salivary pH, buffering capacity, and flow rate were measured to evaluate functional changes. Clinical examinations followed WHO diagnostic criteria for dental caries. Statistical evaluation included correlation analysis to determine relationships between microbial patterns and carious severity. All procedures adhered to ethical research guidelines and obtained informed consent from each participant.

Results:

Examination of microbial communities revealed substantial decreases in beneficial commensals such as Streptococcus sanguinis and Veillonella species, accompanied by marked increases in Streptococcus mutans, Lactobacillus acidophilus, and Actinomyces species in individuals with active carious lesions.

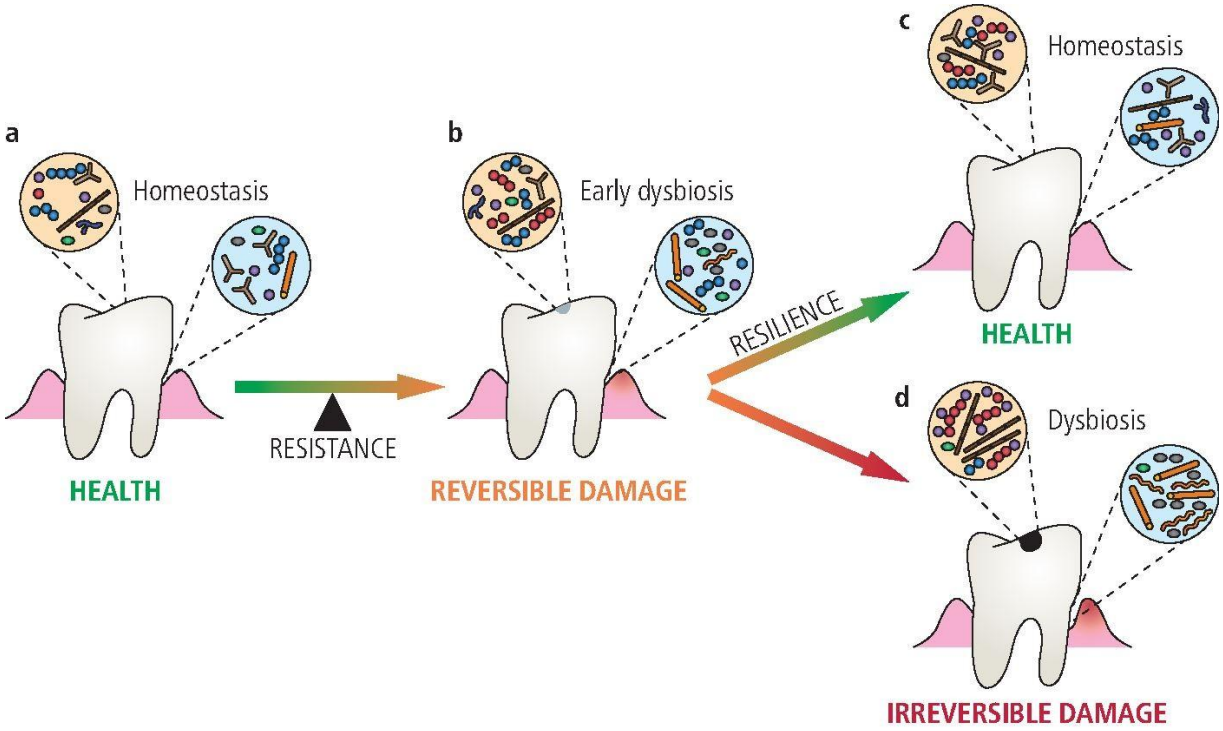




Participants exhibiting pronounced dysbiosis demonstrated significantly lower salivary buffering capacity and reduced resting pH compared with control subjects. Carious severity directly correlated with elevated proportions of acidogenic and aciduric bacteria. Sequencing data confirmed a notable decline in microbial diversity in subjects with multiple lesions. These findings collectively indicate that altered microbial ecology contributes to an environment conducive to continuous enamel demineralization. Analysis revealed that individuals presenting with pronounced demineralization exhibited a marked predominance of acidogenic species over protective commensals. Quantitative assessments demonstrated reduced diversity within microbial populations, accompanied by diminished buffering capacity and significant decreases in salivary pH. The correlation between lowered ecological variability and increased lesion severity was evident across all examined groups. Biochemical measurements indicated elevated concentrations of metabolic by-products responsible for enamel dissolution, while structural assessments confirmed accelerated progression of tissue breakdown in the presence of sustained ecological disruption.

Discussion:

The results support the concept that dental caries should be interpreted as a biofilm-mediated disease rooted in microbial ecological imbalance rather than simply the presence of particular pathogenic species.



Dysbiosis disrupts the regulatory interactions that restrain acid-producing bacteria, enabling them to dominate and exert metabolic activities that undermine enamel integrity. Reduced diversity further weakens resilience to environmental changes, making the biofilm more prone to rapid acidification. The strong association between buffering capacity and microbial composition highlights the crucial interplay between biological defenses and microbiological dynamics. Understanding these interactions facilitates more targeted interventions, such as modulation of microbial balance through probiotics, prebiotics, antimicrobial peptides, and approaches aimed at neutralizing acidogenic activity before irreversible tissue damage occurs. The obtained findings reinforce the concept that destructive dental processes are closely connected to ecological disturbances rather than the isolated presence of pathogenic organisms. Loss of microbial balance allows highly acid-tolerant species to dominate, intensifying metabolic activity that lowers pH beyond critical thresholds. Reduced diversity weakens adaptability, enabling rapid environmental deterioration. These observations emphasize the importance of ecological restoration as a primary approach to preventing structural compromise. Methods aimed at stabilizing microbial composition, improving salivary functionality, and altering environmental conditions hold considerable therapeutic potential. Incorporating ecological principles into clinical practice may significantly enhance long-term outcomes and reduce overall disease burden.

Conclusion:

This research demonstrates that disruption of oral microbial balance plays a central role in creating conditions favorable for dental caries development. Dominance of acid-producing bacteria, diminished microbial diversity, and compromised salivary protective mechanisms collectively contribute to accelerated enamel destruction. Strengthening ecological stability through early diagnostic monitoring, improved oral hygiene practices, dietary regulation, and the use of microbiome-modulating agents represents an effective strategy for reducing carious risk. Continued scientific investigation is vital for enhancing preventive protocols and developing innovative approaches for maintaining healthy oral ecosystems. The study demonstrates that ecological imbalance within oral microbial communities plays a decisive role in promoting processes that culminate in the breakdown of mineralized tissues. Elevated activity of acid-producing microorganisms, reduced population diversity, and impaired protective mechanisms collectively

accelerate destructive changes. Strengthening ecological stability through improved hygiene, dietary adjustments, early monitoring, and the use of agents that support balanced microbial interactions represents a central strategy for controlling disease development. Continued research focused on ecological preservation will contribute to more effective clinical practices and improved patient outcomes.

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