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Review Article

New understanding of the systematic relation to the etiology of dental caries

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ABSTRACT

Dental caries is one of the most prevalent chronic diseases, affecting over half of the global population. The incidence and prevalence of caries have significantly increased in modern times. Various theories have been proposed to explain the etiopathogenesis of dental caries, but many questions remain unanswered despite their popularity. A healthy tooth is well-designed to withstand a harsh oral environment, as it cleanses itself from the inside out. Dental caries indicate that the tooth's fluid flow has been halted or reversed, compromising its defenses. The local process of enamel demineralization by bacterial acid is significantly influenced by nutrition, especially refined carbohydrates like sugar. However, the vulnerability of the tooth begins in the hypothalamus, where changes are initiated in the dentinal fluid flow. Therefore, nutrition plays a crucial role in both the systemic and local aspects of this process. The systemic concept of dental caries recognizes that the process is multifactorial. While reducing sugar intake and oral bacteria counts is important, enhancing the body's defenses with an antioxidant-rich diet, including fruits, vegetables, and vitamin K2, may be even more vital in reducing vulnerability to caries. This systemic approach represents a significant paradigm shift from the traditional 'acid theory' of dental caries, which focused primarily on the local effects of bacterial acid on tooth enamel. Acknowledging the multifactorial nature of dental caries has important implications for future prevention efforts. Instead of solely focusing on reducing sugar consumption and bacterial counts, promoting a diet rich in antioxidants and essential nutrients can strengthen the body's defenses against caries. This holistic approach could lead to more effective strategies for preventing dental caries and improving overall oral health.

1. Introduction

Dental caries is a prevalent oral disease characterized by the demineralization of the tooth's hard tissues. Traditional understanding of caries emphasizes the role of acids produced by bacterial fermentation of dietary carbohydrates.[1] However, the systemic theory of dental caries presents a broader perspective, considering systemic factors that influence caries development and progression. This review synthesizes current research on the systemic theory, focusing on key elements such as oxidative stress, matrix metalloproteinases (MMPs), and the role of vitamins in caries pathogenesis.[2]

Understanding dental caries involves multiple theories that consider enzymatic activity, bacterial metabolism, systemic health, and environmental factors. Each theory provides a unique perspective, contributing to a comprehensive understanding of tooth decay. The systemic concept represents a major paradigm shift from the traditional 'acid theory/parasitic theory ' of dental caries. The understanding of dental caries (tooth decay) has evolved significantly over time. Here's a summary of earlier theories earlier Theories of Dental Caries

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1. The worm theory: One of the oldest theories, dating back to ancient civilizations like the Sumerians and Egyptians. It proposed that tooth decay was caused by worms in the teeth.
2. Humoral theory: Originated in ancient Greece and Rome. The theory suggested that an imbalance of the body's four humors caused tooth decay..
3. Vital theory: Popular in the 18th and 19th centuries. It proposed that tooth decay originated from within the tooth itself due to internal factors.
4. Chemical theory (Parasitic theory): Proposed in the 19th century. It suggested that acids produced by microorganisms in the mouth were responsible for tooth decay.
5. Acidogenic (Chemico-Parasitic) theory: Proposed by W.D. Miller in the late 19th century. It combined chemical and parasitic elements. The theory suggested that acids produced by bacteria from carbohydrate fermentation caused demineralization of the tooth enamel.

2. Pathogenesis of Dental Caries

Dental caries is the localized destruction of tooth tissues (enamel, dentin, and cementum) due to metabolic activities in the oral biofilm. The process is characterized by the gradual demineralization of the tooth, driven by a disturbance in the physiological equilibrium within the biofilm or dental plaque. Without intervention, caries progress slowly until the tooth is destroyed.[3]

2.1. Biofilm and demineralization

Oral bacteria form a biofilm on the tooth surface, which is necessary but not sufficient for caries development. Fluctuations in pH within the biofilm lead to cycles of demineralization and remineralization; demineralization occurs when the pH drops, causing tooth minerals to dissolve. Regular disturbance of dental plaque through mechanical means, such as brushing, is essential to prevent caries progression.[4]

2.2. Enamel and caries

At eruption, enamel is highly mineralized, consisting mainly of hydroxyapatite crystals. Post-eruption, enamel undergoes chemical modifications, and its porosity allows for the diffusion of minerals like fluoride, which aids in its maturation. The enamel has inherent microscopic pores and structural variations that can influence its susceptibility to caries.[3]

2.3. Dentin reactions

Dentin, unlike enamel, is a vital tissue capable of responding to external stimuli. Tubular sclerosis, which involves the deposition of minerals in dentinal tubules, occurs as a defense against caries progression. Tubular sclerosis increases with age and exposure to mild stimuli, including caries.[5]

2.4. Pulpo-dentinal reactions

Early signs of dentin reaction include tubular sclerosis beneath the demineralized enamel, even before bacteria invade the dentin. Dentin demineralization spreads laterally along the enamel-dentin junction but remains confined to the contact area until a carious cavity forms.[3] Tubular sclerosis may serve to "wall off" the lesion, limiting further damage.

The pathogenesis of dental caries involves complex interactions between microbial biofilms, tooth structure, and systemic factors. Effective management requires a comprehensive approach that includes maintaining oral hygiene, disrupting biofilm regularly, and considering the dynamic nature of enamel and dentin responses.[6]

3. Systemic Factors in Dental Caries

3.1. Matrix metalloproteinases and caries

Matrix metalloproteinases (MMPs) are enzymes that play a significant role in the breakdown of extracellular matrix components. In the context of dental caries, MMPs such as MMP-8, MMP-2, MMP-9, MMP-3, MMP-14, and MMP-20 are found in the pulp, odontoblasts, and dentine.[7] These MMPs contribute to the degradation of dentinal collagen, which is a crucial step in the progression of caries from the dentin-pulp complex to the enamel surface. The systemic theory suggests that the activity of these MMPs is influenced by systemic conditions such as oxidative stress and nutritional deficiencies, which can exacerbate the caries process.[8]

3.2. Oxidative stress and dental caries

Oxidative stress results from an imbalance between reactive oxygen species (ROS) and the body's antioxidant defenses. This imbalance leads to cellular damage and inflammation, contributing to various diseases, including dental caries. High levels of oxidative stress in the oral cavity can disrupt dentinal fluid flow, leading to increased susceptibility to bacterial acids. The role of oxidative stress in dental caries is supported by studies showing higher total antioxidant capacity (TAC) in caries-active individuals compared to caries-free individuals.[9]

3.3. Salivary antioxidants

Saliva plays a crucial role in maintaining oral health by providing a medium for the transport of nutrients and the removal of waste products. It also contains antioxidants that neutralize ROS. Studies have shown that children with

higher caries activity tend to have higher levels of salivary antioxidants, possibly as an adaptive response to increased oxidative stress.[10,11] This suggests that salivary antioxidant levels could be a marker for caries activity and overall oral health.

3.4. Role of vitamins in caries progression

3.4.1. Vitamin K2

Vitamin K2 is essential for the activation of proteins involved in calcium metabolism, which is crucial for maintaining bone and dental health. It has been proposed that vitamin K2 deficiency can lead to impaired mineralization of teeth, making them more susceptible to caries.[12] The systemic theory of dental caries posits that adequate levels of vitamin K2 are necessary to regulate the activity of MMPs and maintain the structural integrity of dentin and enamel.

3.4.2. Vitamin K1

While vitamin K1 is primarily involved in blood clotting, it also plays a role in bone health.[13] However, its impact on dental health is less pronounced compared to vitamin K2. Ensuring sufficient intake of both forms of vitamin K is important for overall health, including the prevention of dental caries.

3.5. Nutritional and Lifestyle Factors

3.5.1. Diet and dental caries

Dietary habits have a profound impact on dental health. High sugar intake is a well-established risk factor for dental caries due to its role in promoting bacterial fermentation and acid production.[14] Moreover, nutritional deficiencies, particularly in vitamins and minerals, can weaken the body's defenses against caries. A diet rich in micronutrients and low in fermentable carbohydrates is essential for preventing dental caries.

3.5.2. Sleep and stress

Sleep quality and stress levels also influence the development of dental caries. Poor sleep and high stress can lead to systemic acidosis, a condition where the body's pH becomes more acidic.[15] This acidic environment can enhance the activity of MMPs and increase the susceptibility of teeth to demineralization.[7] Managing stress and ensuring adequate sleep are important strategies for maintaining oral health.

4. Conclusion

The systemic theory of dental caries expands the understanding of caries beyond the traditional model of bacterial acid attack. It highlights the importance of systemic factors such as oxidative stress, MMP activity, and nutritional status in the development and progression of dental caries. By addressing these systemic factors, it may be possible to develop more effective preventive and therapeutic strategies for dental caries. Further research is needed to fully elucidate the complex interactions between systemic health and dental caries and to translate these findings into clinical practice.

In summary, a comprehensive approach to dental caries prevention and treatment should consider not only local factors within the oral cavity but also broader systemic influences. This holistic perspective can lead to better outcomes in oral health and overall well-being.

This review incorporates findings from multiple studies and highlights the interconnectedness of systemic health and dental caries. By understanding and addressing these systemic factors, healthcare providers can enhance preventive care and improve patient outcomes in dental health.

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6. Conflict of Interest

None.

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