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The Role of Nutrition in Oral and Systemic Health: Bridging Food Science and Medicine

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ABSTRACT

The link between nutrition and health transcends mere systemic wellness, profoundly affecting oral health and reeling the complex interplay between food science and healthcare. Adequate nutrition preserves healthy teeth and gums, while nutritional deficiencies may cause cavities, gum disease, and enamel erosion. On the flip side, compromised oral health can also affect systemic ailments, including heart disease and diabetes, highlighting the reciprocal nature of this connection. Vital nutrients like calcium, vitamin D, and phosphorus are key for robust teeth and bones, whereas antioxidants and anti-inflammatory substances present in fruits and vegetables foster promote. In contrast, high sugar intake and unhealthy eating habits worsen dental health challenges, stressing the necessity of well-rounded nutrition. The fusion of food science and healthcare provides a comprehensive strategy for prevention and treatment, enhancing both oral and systemic health through dietary regimens customized to individual requirements. This cross disciplinary view emphasizes the importance of incorporating nutritional advice into healthcare to achieve optimal wellness.

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1-Introduction

The research community has become increasingly fascinated by the implicit link between effects like artery disease, stroke, and overall mortality. Proposed mediators for this connection include infection, chronic inflammation, and genetic susceptibility to both oral and systemic diseases [1]. Commonly hypothesized arbiters of this relationship incorporate disease, incessant irritation, and hereditary inclination to both verbal and systemic illness. Nutrition has been proposed as a potential mediator [2].

The research community has grown increasingly interested in the link between oral health and systemic effects such as coronary artery disease, stroke, and overall mortality. Proposed mediators for this connection include infection, chronic inflammation, and genetic susceptibility to both oral and systemic diseases [1]. Nutrition has also been suggested as a potential mediator [2]. The inflammation caused by periodontal pathogens is thought to contribute to atherosclerosis, a condition characterized by the buildup of plaques in the arteries. Diabetes Mellitus There is a bidirectional relationship between diabetes and periodontal disease. Diabetes can increase the severity of gum disease, while periodontal disease can exacerbate diabetes management due to its impact on blood sugar control. Managing oral health becomes crucial for individuals with diabetes to mitigate complications. Respiratory Infections Oral health can significantly influence respiratory health. Bacteria from periodontal disease can be aspirated into the lungs, leading to conditions such as pneumonia [3].

The effects of different oral health issues on nutritional status may be closely tied to both nutrient intake and overall nutritional health [4] Numerous studies have shown a connection between nutrient consumption, nutritional wellbeing, and a range of systemic diseases. Recent research has clearly indicated a negative correlation between the intake of fruits and vegetables and the onset of cardiovascular issues. A higher intake of fruits and vegetables has additionally been linked to a lower likelihood of stroke. Several investigations have also hinted at a protective effect of fruits and vegetables against cancer. Nevertheless, studies have also indicated no clear connection with certain types of cancer [5]. Consumption of saturated fats has been associated with cardiovascular issues and might elevate the likelihood of breast and colorectal cancers. Antioxidants and dietary fiber have been evidenced in both epidemiological and interventional studies to lower the odds of cardiovascular diseases. However, the results have not been as definitive as those related to fruits and vegetables. For both fruits and vegetables, as well as individual vitamins and minerals, the reduction of health risks occurs through various mechanisms, including shielding against free radical damage, regulation of cytokine production, improvement of endothelial functionality, and modification of coagulation factors [6].

The intermediary function of nutrition in the link between oral health and systemic diseases has piqued our curiosity in exploring the connections between prevalent

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oral issues and nutritional results. This article will succinctly assess and discuss the significance of nutrition and oral health and their relation to various ailments.
We will outline common criteria for nutritional evaluation employed in research and respond to inquiries about ho w particular oral health features relate to these nutritional results. We will encapsulate the methods, outcomes, and constraints of t he chosen studies.

2- Nutritional Components Essential for Oral Health

In 2016, the World Dental Federation redefined oral health, shifting from a limited focus on disease to a more expansive, multifaceted perspective. This new view encompasses the capability to communicate, grin, detect scents, savor, touch, chew, swallow, and express a wide array of emotions through facial gestures confidently and without discomfort or pain. Neglected oral care (e.g., tooth loss or poorly fitting dentures) may lead to discomfort and oral infections, significantly impacting one's quality of life [7]. These ramifications are often closely linked to decreased nutrient intake, behavioral effects on dietary choices, difficulties in communication, chewing issues, and a diminished appetite.
This section explores the essential nutritional components that support oral health and how they contribute to preventing oral diseases.
1. Calcium: building Strong Teeth Calcium is a vital mineral for maintaining strong teeth and bones. It plays a fundamental role in the development and maintenance of dental structures. Adequate calcium intake helps to support the enamel, the protective outer layer of the teeth, making them less susceptible to decay and erosion. Dairy products, leafy greens, and fortified foods are abundant in calcium, and sufficient intake of this mineral should be emphasized during childhood and adolescence when teeth are developing [8].
2. Vitamin D: enhancing Calcium Absorption Vitamin D works synergistically with calcium to promote optimal oral health. This vitamin enhances the absorption of calcium in the gut and helps in the remineralization of tooth enamel. A deficiency in vitamin D may lead to periodontal disease and tooth loss, as it compromises the immune system and affects bone density. Natural sources of vitamin D include sunlight exposure, fatty fish, and fortified foods. Thus, maintaining adequate vitamin D levels is crucial for preventing oral health issues [9].
3. Phosphorus: supporting Tooth Structure Phosphorus is another essential mineral that works collaboratively with calcium to create strong, healthy teeth. It is a critical component of hydroxyapatite, the mineral complex that comprises tooth enamel and dentin. Foods rich in phosphorus include meats, poultry, fish, eggs, nuts, and legumes. Including these foods in the diet can help maintain the structural integrity of teeth and support overall oral health [10].
4. Vitamin C: enhancing Gum Health Vitamin C is integral to oral health, particularly for maintaining healthy gums. This vitamin assists in collagen synthesis, which is vital for gum tissue integrity and healing. Insufficient vitamin C can lead to gum inflammation and periodontal disease. Citrus fruits, berries, bell peppers, and leafy greens are excellent sources of vitamin C. Regular consumption of these foods can significantly enhance gum health, reducing the risk of oral diseases [11].
5. Fiber: promoting Saliva Production Dietary fiber plays an indirect but significant role in oral health. High fiber foods stimulate saliva production, which serves as a natural defense mechanism against cavities and gum disease. Saliva neutralizes acids produced by bacteria in the mouth, aiding in the

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remineralization of enamel. Fruits, vegetables, whole grains, and legumes are all rich sources of dietary fiber that should be incorporated into a daily diet [10,11].

6. Sugars: moderation is Key While carbohydrates, including sugars, provide energy, excessive sugar intake is detrimental to oral health. Sugars foster the growth of harmful bacteria in the mouth, leading to the production of acids that erode enamel and cause cavities. It is essential to limit refined sugars and explore healthier alternatives, such as natural sweeteners and whole fruits, which also provide beneficial nutrients [12].

7. Iron: iron is critical for the formation of hemoglobin, influencing the blood supply to oral tissues. Its deficiency can lead to anemia, which may manifest as a pale and swollen tongue, as well as impaired wound healing, increasing the risk of infections in the oral cavity [9,12].

A comprehensive understanding of nutritional components essential for oral health underscores the significance of diet in preventing dental issues. Incorporating sufficient calcium, vitamin D, phosphorus, vitamin C, and dietary fiber into daily meals, while moderating sugar intake, can promote optimal oral health. Developing a balanced diet focused on these nutrients is crucial for both maintaining healthy teeth and gums, ultimately contributing to overall well-being. Maintaining oral health through nutrition is both effective and essential in the prevention of complications, making it a key priority for individuals seeking to improve their dental hygiene. [7]. Establishing nutritious eating patterns alongside consistent consumption of vital vitamins and minerals holds considerable importance for both overall and dental wellness. Given the scarce understanding among dental professionals about the significance of trace elements in nutrition [10]. For example, maintaining good oral health requires a balanced diet rich in essential nutrients that support strong and healthy teeth and gums. Calcium and phosphorus are crucial for building and maintaining tooth enamel, and dairy products, leafy greens, nuts, and fish are excellent sources. Vitamin D plays a key role in calcium absorption and helps develop healthy teeth and bones, and can be obtained from exposure to sunlight, fatty fish, and fortified foods. Vitamin C is vital for gum health, as it helps prevent inflammation and strengthen connective tissues. Citrus fruits, strawberries, and bell peppers are good sources. Additionally, vitamin A supports saliva production, which is essential for washing away food particles and bacteria, while fluoride strengthens tooth enamel and prevents cavities. Limiting sugary and acidic foods also helps protect teeth from decay [8].

3-The Impact of Diet on Oral Diseases: Caries, Periodontal Disease, and Beyond

Drawing from more than a century of investigation, there is clear proof that dietary fermentable carbohydrates (sugars, starch) are an essential contributor, but by themselves, not a comprehensive cause for the onset and advancement of caries [11]. Variations in the cariogenic properties of different carbohydrates exist, even though only minor differences are observable in biofilm acid production. In this context, sucrose merits particular focus due to its rapid conversion into acid and its ability to be transformed into extracellular glucans, fructus, and intracellular reserve substances [12]. The cariogenic potential of starch varies significantly depending on the bioavailability of starches in processed foods. The concentration and bioavailability of carbohydrates in foods, in addition to the composition and stickiness of the diet, are further influential elements [13]. Behavioral aspects can play a role in the emergence or prevention of diseases. The frequency of carbohydrate consumption and physiological elements like oral clearance, biofilm makeup,

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and salivary buffering capability have garnered significant focus over time. Evidence suggests that a diet where sugars account for less than 10% (50 g / day) of total caloric intake (E) is linked to reduced incidences of caries. Although the certainty of this evidence is low, there are signs that a noteworthy connection exists between sugar consumption and caries, even with free sugar intake below 5% E (25 g / day) [14]. The working group endorses the objective of eradicating sugars from current diets but acknowledges that even achieving daily consumption levels between 25–50 g / day will pose challenges due to the added free sugars in the form of mono and disaccharides in food and drinks [15]. Since "nutrition" acts both locally and systemically, lack of dietary micronutrients such as vitamin D, calcium, phosphates and vitamin K, has a negative impact upon tooth mineralization and tooth quality and size, and may also affect caries risk later in life through other mechanisms [16].

Research from both association studies and controlled clinical depletion experiments suggests that diet plays a significant role in periodontal disease. Deficiencies in micronutrients are found to have an inverse relationship with periodontal wellness. Multiple studies conducted across various populations have demonstrated a consistent inverse correlation between dietary vitamin C consumption, plasma vitamin C levels, and the prevalence of periodontitis, even after accounting for confounding variables [17]. Furthermore, it has been established that a deficiency in vitamin C can result in excessive bleeding of the gums [18]. Lower levels of serum magnesium/calcium, reduced antioxidant micronutrient levels, and decreased intake of docosahexaenoic acid have also been significantly linked to increased prevalence of periodontal diseases [19]. Although there is mixed evidence regarding the impact of vitamin D intake and serum concentrations on periodontal health (van der Velden et al. 2011), combining vitamin D supplementation with calcium has been shown to lessen tooth loss and enhance periodontal health [20]. At the macronutrient level, emerging data suggests that a diet high in carbohydrates poses a greater risk of inflammation and, consequently, gingival bleeding [21], I adopting a Paleolithic diet leads to a reduction in gingival bleeding [22]. Considering that the underlying mechanisms may differ between these two ailments, fermentable carbohydrates stand out as the most significant shared dietary risk factors for tooth decay and gum diseases [23]. In the case of tooth decay, this relates mainly to the fermentation process that occurs within the dental biofilm, leading to the production of harmful acids. For gum diseases, the predominant biological process appears to be glucose and advanced glycation end products inciting a state of heightened inflammation in white blood cells [24]. Additionally, research indicates that deficiencies in micronutrients can affect both conditions at various life stages. There is evidence to suggest that a lack of vitamin D may cause enamel hypoplasia or hypo mineralization, ultimately increasing the risk of tooth decay [25]. Furthermore, vitamin D deficiency has been linked with periodontitis in observational studies. A systematic review of randomized trials indicates that supplementation of vitamin B6 can diminish the incidence of tooth decay [26]. With regard to gum diseases, findings from a cohort study revealed that a deficiency of vitamin B12 was associated with the progression and damage of periodontal disease [27]. The vulnerability to tooth decay fluctuates significantly throughout an individual's life. Dietary habits evolve over time, especially concerning exposure to specific fermentable carbohydrates. An increase in tooth decay prevalence correlates with the frequency of sugar consumption and also varies according

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to sugar consumption patterns. Tooth decay risk is particularly high among young children during the early years following the eruption of primary and permanent teeth. Early childhood tooth decay may stem from poor feeding practices (increased sugar exposure during weaning, bottle feeding, or prolonged nighttime breastfeeding) [28]. Increased consumption of sweets and soft drinks during adolescence heightens the risk of tooth decay. Although the evidence is limited, there may be a higher risk for adults based on various work environments (restaurants, food laboratories, and shift work). After retirement, dietary patterns may shift toward softer diets with increased sugar consumption. Starches are considered a risk factor for tooth decay in root surfaces, especially concerning for seniors [29].

Tooth decay risk can escalate in any age group due to physiological changes, including decreased nutrient absorption and diminished chewing function, which are often associated with higher medication use [30]. Nowadays, dietary guidelines are frequently provided to augment conventional medical treatments. As energy needs decline with age, dietary intake may also decrease, raising the risk of micronutrient deficiencies [31]. It is vital to ensure that diets, especially for frail and dependent older individuals, maintain optimal quality to aid in disease prevention. Currently, the influence of dietary risk factors on periodontal diseases throughout the lifespan remains uncertain [32].

4- The Role of Micronutrients in Maintaining Oral and Systemic Health

Numerous studies involving both animals and humans have effectively illustrated the influence of certain micronutrients on the inflammatory response of the host by reducing inflammatory markers and ultimately mitigating bone loss [33]. A comparable pattern was noted in one investigation included in this systematic review by Ehlers et al. (2011), where the authors observed that the C-reactive protein (CRP) levels, an indicator of inflammatory activity, exhibited a smaller increase among participants consuming nutritional supplements, alongside a slightly beneficial effect on gingival inflammation when contrasted with the control group, which comprised dental students facing significant examination pressure [34]. In another examination within this systematic review, it was found that the intensity of periodontal disease escalated with a reduced intake of vitamins A, B1, C, E, as well as iron, folate, and phosphorus [35]. Although the precise mechanisms linking nutrition to periodontal disease remain partially understood, Chapple et al. identified a negative correlation between overall antioxidant properties and periodontal disease, providing insight into the intricate connection between nutrition and inflammation that leads to periodontal disease [36]. These discoveries are bolstered by evidence that acknowledges the antioxidant capabilities of vitamins A, B1, C, and E [37].

The research conducted by Dodington et al. investigated the impact of nutritional intake on the recovery of periodontal health among both smokers and nonsmokers suffering from chronic generalized periodontitis after undergoing scaling and root planning. The researchers noted a substantial decrease in probing depth associated with increased consumption of fruits and vegetables, α tocopherol, vitamin C, β carotene, as well as EPA and DHA among nonsmokers, whereas such a correlation was absent in smokers. This relationship may be partly due to their higher intake of antioxidants from fruits and vegetables. Furthermore, the results indicated that whole food sources laden with antioxidants proved to be significantly more advantageous than supplements containing

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isolated compounds for optimal periodontal recovery. Positive effects of EPA and DHA supplements were also recorded among participants in this investigation, which might be elucidated by the influence of a downstream metabolite of DHA, Resolving D1, known to reduce inflammatory mediators in an in vitro study on periodontal ligaments [38].

A study conducted by Adegboye et al. uncovered the beneficial impacts of elevated dietary calcium and dairy consumption (within recommended limits) on plaque levels among seniors aged 65 and older who also had higher vitamin D consumption (exceeding 6.8 μg/d). This correlation was evident even after controlling for various confounding variables, and participants with lower vitamin D intake (below 6.8 μg/d) did not exhibit this relationship between dietary calcium and plaque levels. This aligns with prior research suggesting an inverse correlation between increased consumption of calcium, dairy products, and vitamin D, and a decrease in dental caries and periodontitis [39]. Given that Adegboye et al. stratified the effect of calcium intake based on vitamin D levels, it appears that a greater intake of vitamin D can enhance the positive effects of elevated calcium consumption, likely by boosting calcium absorption. This is supported by findings from Laky et al., who noted that vitamin D deficiency was more prevalent among individuals with severe periodontal disease than among healthy adults [40]. In another study included in this systematic review, the second highest level of vitamin D intake (3.2–6.0 μg) was associated with a reduction in the severity of periodontal disease compared to the highest level of intake (≥ 6.0 μg), indicating a potential optimal range of 3.2–6.0 μg for vitamin D intake [41]. This underscores the necessity for further research into the ideal levels of vitamin D for promoting oral health and preventing periodontal disease [42].

4.1. The Interplay Between Micronutrients and Systemic Health

A. Immune Function: Micronutrients such as vitamins A, C, D, and E, along with minerals like zinc and selenium, have well documented roles in modulating the immune system. A robust immune system is essential for combating infections, including oral diseases. Thus, adequate intake of these micronutrients is beneficial for both oral and systemic immunity [43].

B. Inflammatory Response: Deficiencies in certain micronutrients may exacerbate inflammatory responses in various tissues, including the gums. For instance, adequate zinc status has been correlated with reduced inflammation and better periodontal health. Micronutrients help regulate inflammatory pathways, thus having systemic implications in conditions like cardiovascular diseases [44].

C. Bone Health: The combination of calcium, magnesium, phosphorus, and vitamins D and K is essential for maintaining bone health. The jawbone's health is crucial not only for oral integrity but also for systemic skeletal health. Osteoporosis, often linked with vitamin D deficiency, can directly impact oral health by leading to tooth loss [45].

4.2. Consequences of Micronutrient Deficiencies

A. Oral Manifestations: Micronutrient deficiencies can lead to a variety of oral health problems, such as:

1. Periodontal Disease: Insufficient vitamin C can increase the risk of gingival diseases.
2. Delayed Healing: Lack of vitamins A and C may prolong healing after dental surgery.
3. Altered Taste Sensation: Deficiencies may impact taste buds, affecting appetite and nutrition [44].

B. Systemic Health Issues: Oral health is intricately linked to systemic health. Poor

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oral hygiene can contribute to systemic conditions such as:

1. cardiovascular diseases: Inflammation promoted by periodontal disease can increase the risk of heart disease.
2. Diabetes Management: There exists a bidirectional relationship between diabetes and periodontal disease. Poorly controlled diabetes can impair immune response and exacerbate gum problems [46]. Finally, according to the topics presented, essential in maintaining oral health and preventing systemic diseases. Their influence extends beyond the oral cavity, affecting overall health through immune modulation, inflammatory response regulation, and support of vital physiological functions. Ensuring adequate intake of various micronutrients through a balanced diet is essential for maintaining optimal oral and systemic health. It is crucial for individuals to be aware of the importance of micronutrients and to strive for a healthy and balanced diet that meets these needs.

5- Future Directions

Emerging pathways in the connection between nutrition and oral as well as systemic wellness are poised to emphasize individualized nutrition plans, the amalgamation of food science with tailored medicine, and enhancements in functional dietary options. With the advent of nutrigenomics, personalized dietary guidance rooted in genetic information is becoming increasingly attainable, enabling people to maximize both oral and general wellbeing. Furthermore, there is a rising enthusiasm for creating functional foods and dietary supplements tailored to specific health issues, such as probiotics for maintaining oral microbiome equilibrium or anti-inflammatory agents to combat chronic illnesses. Nevertheless, obstacles remain, including the necessity for rigorous clinical studies to validate health claims, addressing economic disparities in the availability of nutritious food options, and linking healthcare practitioners with nutrition specialists. Cooperation among food scientists, healthcare providers, and lawmakers will be vital to surmounting these hurdles and guaranteeing that nutrition-oriented strategies are effectively enacted for enhanced health results.

6- Conclusion

The intricates relationship between nutrition, oral, and systemic health underscores the need for a cohesive approach that bridges food science and medicine. By recognizing the significance of nutrition in maintaining oral health and its implications for systemic well-being, healthcare professionals can develop comprehensive strategies to promote better health outcomes. Through collaboration, education, and preventive care, it is possible to enhance the understanding and practice of nutrition as a cornerstone in achieving optimal health for individuals and communities alike.

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