Review Article

Nutritional Deficiencies and their Impact on Oral Health

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ABSTRACT:

Nutrition plays a fundamental role in the maintenance of oral and systemic health. The oral cavity, owing to its high cellular turnover and continuous exposure to microbial, mechanical, and chemical insults, is particularly susceptible to nutritional imbalances. Deficiencies of essential macro- and micronutrients adversely affect the development, integrity, and function of teeth, gingiva, oral mucosa, salivary glands, and supporting bone. Such deficiencies may manifest as enamel hypoplasia, dental caries, periodontal disease, mucosal lesions, xerostomia, and impaired wound healing. Emerging evidence from PubMed-indexed studies highlights strong associations between nutritional inadequacies—especially deficiencies of vitamins A, B-complex, C, D, calcium, iron, and zinc—and oral diseases [1–5]. Oral manifestations often serve as early indicators of systemic nutritional deficiency, allowing dental professionals to play a crucial role in early diagnosis and prevention. This review comprehensively discusses the role of nutrition in oral health, outlines the oral manifestations of specific nutrient deficiencies, and emphasizes their clinical relevance in dental practice.

KEY WORDS: Nutrition; Nutritional deficiencies; Oral health; Periodontal disease; Dental caries

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INTRODUCTION:

Oral health is an integral component of general health and quality of life. Oral diseases such as dental caries, periodontal disease, and oral mucosal lesions are among the most prevalent non-communicable diseases worldwide and represent a significant public health burden[15]. While dental plaque and microbial biofilms remain the primary etiological factors, increasing evidence suggests that nutritional status plays a critical role in the initiation, progression, and severity of oral diseases[2,9].

Nutrition influences tooth development, enamel mineralization, immune competence, tissue repair, and host resistance to infection[1,7]. The oral cavity, characterized by rapid epithelial turnover and constant exposure to environmental challenges, is particularly vulnerable to nutritional deficiencies. As a result, oral tissues frequently display early signs of nutritional inadequacy before systemic symptoms become apparent[14].

Changing dietary patterns, including increased consumption of refined carbohydrates and ultra-processed foods, have contributed to widespread micronutrient deficiencies, particularly among children, adolescents, elderly individuals, and socioeconomically disadvantaged populations[7,15]. Dentists are therefore uniquely positioned to detect early oral manifestations of nutritional deficiencies and initiate timely intervention. This review summarizes current evidence on nutritional deficiencies and their

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impact on oral health, emphasizing clinical relevance for dental practice.

Role of Nutrition in Oral Health:

Adequate nutrition is essential for the growth, development, and long-term maintenance of oral tissues. Nutrients are indispensable for the formation and mineralization of enamel and dentin, regulation of alveolar bone metabolism, preservation of periodontal ligament integrity, maintenance of salivary gland structure and function, and modulation of immune defense mechanisms within the oral cavity. Proteins, vitamins, and minerals collectively contribute to cellular turnover, collagen synthesis, antioxidant protection, and host resistance to microbial challenge. A balanced and nutrient-rich diet therefore plays a pivotal role in ensuring optimal regeneration of oral tissues, promoting effective wound healing, and enhancing resistance to both infectious and inflammatory oral diseases[1-3].

The relationship between nutrition and oral health is complex and bidirectional. Inadequate nutritional intake compromises immune function and tissue repair, predisposing individuals to a wide range of oral conditions, including dental caries, periodontal disease, oral mucosal lesions, and delayed healing following dental procedures. Conversely, the presence of oral diseases can negatively affect dietary intake by causing pain, discomfort, tooth loss, or impaired masticatory efficiency, leading to reduced food variety and compromised nutrient absorption. This vicious cycle may further aggravate existing nutritional deficiencies and contribute to disease progression. Consequently, maintaining nutritional adequacy throughout life is fundamental not only for preserving oral health but also for supporting overall systemic well-being[2,7].

Macronutrient Deficiencies and Oral Health:-

Protein Deficiency:

Proteins are fundamental to cellular growth, collagen synthesis, tissue repair, and immune defense, all of which are critical for maintaining the structural and functional integrity of oral tissues. Adequate protein intake supports continuous epithelial turnover, fibroblast activity, and synthesis of extracellular matrix components such as collagen and elastin, which are essential for gingival health and periodontal ligament stability. Protein deficiency, particularly in the form of protein–energy malnutrition, adversely affects oral tissues by impairing epithelial regeneration, reducing collagen production, and weakening both innate and adaptive immune responses.[1,9]

The oral manifestations of protein deficiency are diverse and clinically significant. These include atrophic and thin oral mucosa, increased mucosal fragility, delayed wound healing following dental extractions or periodontal therapy, heightened susceptibility to bacterial and fungal infections, and reduced salivary secretion due to salivary gland hypofunction[14]. In pediatric populations, chronic protein deficiency interferes with normal craniofacial growth and tooth development, leading to delayed tooth eruption, enamel hypoplasia, altered tooth morphology, and an increased risk of dental caries[7]. Furthermore, impaired immune competence associated with inadequate protein intake compromises the host's ability to control periodontal pathogens, thereby accelerating periodontal tissue breakdown and contributing to the progression and severity of periodontal disease[9].

Vitamin Deficiencies and Oral Manifestations:-

Vitamin A:

Vitamin A plays a pivotal role in epithelial differentiation, maintenance of mucosal integrity, and regulation of both innate and adaptive immune responses. It is essential for normal keratinocyte maturation and the preservation of a healthy, non-keratinized oral epithelium that serves as a protective barrier against microbial invasion. Deficiency of vitamin A results in abnormal keratinization and epithelial atrophy of the oral mucosa, leading to clinical manifestations such as xerostomia, mucosal dryness, and increased vulnerability to oral infections, including candidiasis[1,3].

In addition to its effects on epithelial tissues, vitamin A deficiency impairs immune function by altering lymphocyte activity and reducing antibody production. Compromise of the epithelial barrier function facilitates microbial penetration and promotes a pro-inflammatory environment within the gingival tissues. Consequently, individuals with vitamin A deficiency may exhibit increased gingival inflammation, heightened plaque-induced inflammatory responses, and a greater susceptibility to periodontal disease progression[2]. These findings highlight the importance of adequate vitamin A intake in maintaining oral mucosal health and periodontal stability.

Vitamin B-Complex:

B-complex vitamins act as coenzymes in cellular metabolism and are essential for mucosal integrity.

- **Vitamin B1 (Thiamine):** Burning mouth sensation

and neuromuscular disturbances[14].

- **Vitamin B2 (Riboflavin):** Angular cheilitis, cheilosis, and magenta tongue[14].
- **Vitamin B3 (Niacin):**Glossitis, stomatitis, and ulcerative lesions seen in pellagra[7].
- **Vitamin B6 (Pyridoxine):**Cheilosis, glossitis, and perioral dermatitis[14].
- **Vitamin B9 (Folate):** Gingivitis, mucosal ulcerations, and increased periodontal inflammation[12].
- **Vitamin B12 (Cobalamin):** Atrophic glossitis, recurrent aphthous ulcers, and burning mouth syndrome[12,14].

Recent studies demonstrate a significant association between folate and vitamin B12 deficiencies and periodontal disease severity, attributed to impaired DNA synthesis and reduced tissue turnover[12].

Vitamin C:

Vitamin C (ascorbic acid) is a critical micronutrient involved in collagen synthesis, antioxidant defense, and modulation of immune responses, all of which are essential for maintaining the structural integrity of periodontal tissues. It functions as a cofactor for prolyl and lysyl hydroxylases, enzymes necessary for the hydroxylation of collagen, thereby ensuring proper formation and stability of connective tissue fibers within the gingiva and periodontal ligament. Vitamin C also acts as a potent antioxidant, neutralizing reactive oxygen species generated during inflammatory processes and protecting oral tissues from oxidative damage.

Deficiency of vitamin C disrupts connective tissue metabolism, resulting in compromised gingival and periodontal support. Clinically, this manifests as swollen, spongy, and bleeding gums, increased gingival fragility, delayed wound healing following dental procedures, and, in severe deficiency states such as scurvy, progressive periodontal breakdown with increased tooth mobility and eventual tooth loss[5,14]. Furthermore, vitamin C deficiency impairs immune cell function, including neutrophil activity and chemotaxis, thereby reducing the host's ability to control periodontal pathogens.

Epidemiological studies have consistently demonstrated an inverse relationship between dietary vitamin C intake and periodontal disease severity, with lower intake levels associated with increased gingival inflammation, attachment loss, and periodontal pocket depth[5,18]. These findings underscore the importance of adequate vitamin C intake in preserving periodontal health and preventing the progression of inflammatory periodontal diseases.

Vitamin D:

Vitamin D plays a central role in the regulation of calcium and phosphate homeostasis and is therefore essential for normal mineralization of teeth and maintenance of alveolar bone integrity. Through its active form, 1,25-dihydroxyvitamin D, it facilitates intestinal absorption of calcium and phosphate and regulates bone remodeling by influencing osteoblast and osteoclast activity. In addition to its skeletal effects, vitamin D exerts important immunomodulatory functions by enhancing innate immunity and modulating inflammatory responses within periodontal tissues.

Deficiency of vitamin D has been associated with several adverse oral outcomes, including enamel hypoplasia, delayed tooth eruption, reduced alveolar bone density, and an increased susceptibility to periodontal disease[4,8]. Insufficient vitamin D levels may impair bone metabolism and compromise the host's ability to mount an effective immune response against periodontal pathogens, thereby contributing to periodontal tissue destruction. Recent systematic reviews and observational studies support a significant association between vitamin D deficiency and the prevalence and severity of periodontitis, particularly in adults and elderly populations[4,8]. However, evidence linking vitamin D deficiency with dental caries remains inconsistent, with studies reporting variable findings, possibly due to differences in study design, population characteristics, and confounding dietary and environmental factors. These observations highlight the importance of maintaining adequate vitamin D levels for periodontal health while underscoring the need for further research to clarify its role in caries prevention.

Vitamin K:

Vitamin K plays a crucial role in blood coagulation and bone metabolism by acting as a cofactor for the γ-carboxylation of glutamic acid residues in several clotting factors and bone-related proteins, including osteocalcin. Adequate vitamin K levels are therefore essential for maintaining hemostasis as well as supporting bone mineralization within the alveolar process. Deficiency of vitamin K compromises the synthesis of functional clotting factors, resulting in impaired coagulation.

Clinically, vitamin K deficiency may manifest

as increased gingival bleeding, spontaneous hemorrhage of the oral mucosa, and prolonged bleeding following dental extractions, periodontal procedures, or oral surgical interventions [14]. Such bleeding tendencies can complicate periodontal therapy and delay post-operative healing. Furthermore, reduced activation of osteocalcin associated with vitamin K deficiency may adversely affect alveolar bone health, potentially contributing to periodontal bone loss. These findings underscore the importance of assessing vitamin K status, particularly in patients with bleeding disorders, malabsorption syndromes, liver disease, or those receiving long-term anticoagulant therapy, to ensure safe and effective dental and periodontal management.

Mineral Deficiencies and Oral Health:

Calcium and Phosphorus:

Calcium and phosphorus are major mineral constituents of teeth and alveolar bone and play a fundamental role in the mineralization of enamel, dentin, and supporting osseous structures. These minerals exist in the form of hydroxyapatite crystals, which provide hardness and structural stability to dental hard tissues and the alveolar process. Adequate intake of calcium and phosphorus is therefore essential for maintaining tooth integrity, preserving alveolar bone mass, and ensuring the long-term stability of the periodontium.

Deficiencies in calcium and phosphorus impair mineralization processes, resulting in reduced bone density, increased tooth mobility, and a heightened susceptibility to periodontal disease[11,16]. Insufficient mineral availability compromises alveolar bone remodeling and weakens periodontal support, thereby facilitating periodontal attachment loss. Moreover, low dietary calcium intake, particularly when combined with vitamin D deficiency, has been shown to accelerate periodontal bone loss and increase the risk of tooth loss, especially among older adults[11]. These findings underscore the importance of adequate calcium and phosphorus intake, along with optimal vitamin D status, in maintaining periodontal health and preventing progressive bone destruction.

Iron:

Iron deficiency anemia is one of the most prevalent nutritional disorders worldwide and has significant implications for oral health. Iron is a critical component of hemoglobin and myoglobin, and it also plays a key role in cellular metabolism, immune function, and tissue oxygenation. Inadequate iron intake or absorption disrupts these processes, leading to systemic manifestations and notable oral signs.

Oral manifestations of iron deficiency include atrophic glossitis characterized by a smooth, erythematous, and tender tongue, angular cheilitis, pale oral mucosa, and increased susceptibility to oral infections, particularly candidiasis[14,20]. The compromised oxygen-carrying capacity and reduced immune competence in iron-deficient individuals impair tissue repair and host defense mechanisms, exacerbating oral mucosal vulnerability. Several clinical studies have reported higher periodontal indices, such as increased probing depth and attachment loss, along with greater prevalence of mucosal lesions in individuals with iron deficiency anemia[20]. These findings suggest that iron deficiency not only affects mucosal health but may also contribute to the progression of periodontal disease, highlighting the importance of early recognition and nutritional intervention in at-risk populations.

Zinc:

Zinc is an essential trace element that plays a critical role in numerous physiological processes, including immune function, cellular proliferation, wound healing, and maintenance of taste perception. Within the oral cavity, zinc contributes to the regulation of inflammatory responses, supports collagen synthesis, and enhances epithelial regeneration, all of which are vital for periodontal health[3,14].

Deficiency of zinc impairs these processes, leading to delayed oral wound healing, dysgeusia (altered taste sensation), increased susceptibility to infections, and heightened periodontal inflammation [3,14]. Mechanistically, inadequate zinc levels disrupt the activity of zinc-dependent enzymes and transcription factors that regulate oxidative stress and inflammatory cytokine production. Emerging evidence suggests that zinc deficiency may enhance oxidative stress within periodontal tissues, exacerbating tissue destruction and contributing to the progression of periodontitis[13].

Clinically, this underscores the importance of ensuring adequate zinc intake, particularly in patients with chronic periodontal disease, malabsorption

disorders, or dietary insufficiencies, to support immune competence and oral tissue repair.

Fluoride:

Fluoride is a key micronutrient that plays a critical role in the prevention of dental caries by enhancing enamel remineralization and increasing resistance to acid-induced demineralization. It incorporates into hydroxyapatite crystals of enamel to form fluorapatite, which is more resistant to dissolution by acids produced by cariogenic bacteria. In addition, fluoride exhibits antimicrobial properties by inhibiting bacterial enzymes and reducing acid production in dental biofilms[10].

Inadequate fluoride exposure, whether due to insufficient dietary intake, lack of fluoridated water, or suboptimal use of fluoride-containing dental products, is associated with an increased risk of dental caries, hypomineralization of enamel, and reduced enamel strength. Populations with low fluoride exposure often present with higher caries prevalence and more severe enamel defects, which can compromise masticatory function and increase susceptibility to further oral infections[10]. Adequate fluoride intake through community water fluoridation, dietary sources, and topical applications remains a cornerstone of preventive dentistry and a critical factor in maintaining long-term oral health.

Dietary Patterns and Oral Health:

While individual nutrients play crucial roles in maintaining oral health, overall dietary patterns have a profound and often synergistic impact on oral tissues. Diets rich in fruits, vegetables, whole grains, lean proteins, and dairy products provide a wide array of vitamins, minerals, and bioactive compounds, including antioxidants and anti-inflammatory phytochemicals, which collectively support periodontal health, enhance immune function, and promote tissue repair[6,18,19]. Adequate intake of these foods helps maintain connective tissue integrity, strengthens alveolar bone, and reduces susceptibility to periodontal inflammation.

Conversely, dietary patterns characterized by high consumption of refined sugars, processed foods, and saturated fats are strongly associated with an increased prevalence of dental caries, gingivitis, and periodontitis[7,10]. Frequent exposure to fermentable carbohydrates promotes acid production by cariogenic bacteria, leading to enamel demineralization and progression of dental caries. High-fat, low-nutrient diets may exacerbate systemic and local inflammation, further compromising periodontal tissues.

Emerging evidence suggests that adherence to Mediterranean-style dietary patterns—rich in fruits, vegetables, whole grains, nuts, fish, and olive oil—is associated with reduced periodontal inflammation, lower bleeding on probing, and improved clinical attachment levels[6,11]. These dietary approaches provide a combination of essential micronutrients, antioxidants, and anti-inflammatory compounds that act synergistically to maintain oral health. Collectively, these findings underscore the importance of evaluating diet holistically, rather than focusing solely on individual nutrients, and highlight the potential of dietary interventions as adjuncts in the prevention and management of oral diseases.

Clinical Implications for Dental Practice:

Oral manifestations frequently serve as early indicators of systemic nutritional deficiencies, often appearing before more generalized signs of malnutrition or systemic disease become evident[1,14]. Recognition of these signs by dental professionals can facilitate early diagnosis and timely intervention, potentially preventing more severe complications. For instance, conditions such as atrophic glossitis, angular cheilitis, enamel hypoplasia, and gingival bleeding may reflect deficiencies in iron, B-complex vitamins, vitamin C, or vitamin K, respectively.

Dental practitioners should therefore integrate dietary assessment and nutritional screening into routine clinical examinations. A comprehensive evaluation should include detailed dietary history, assessment of masticatory function, and consideration of systemic conditions that may affect nutrient absorption or metabolism. Interdisciplinary collaboration with physicians, dietitians, and other healthcare providers is essential to ensure a holistic approach to patient care, particularly in cases involving chronic systemic diseases, malnutrition, or complex periodontal conditions[2,9].

Incorporating nutritional counseling into dental practice can enhance patient outcomes by addressing modifiable risk factors for oral diseases. Evidence-based supplementation, tailored to

individual patient needs, may be indicated in cases of documented deficiencies or increased physiological demand. For example, supplementation with vitamin D and calcium may support alveolar bone health, while vitamin C and zinc can aid in tissue repair and immune function. Overall, integrating nutrition-focused preventive strategies and patient education into standard dental care can improve both oral and systemic health outcomes, reinforcing the pivotal role of nutrition in comprehensive dental practice[15].

CONCLUSION:

Nutritional deficiencies exert a profound influence on oral health, affecting both hard and soft tissues of the oral cavity. Deficiencies in essential vitamins and minerals compromise immune function, tissue repair, and bone metabolism, thereby increasing susceptibility to oral diseases. Early recognition of nutrition-related oral manifestations allows timely intervention and improved patient outcomes. Integrating nutritional awareness into dental education and clinical practice is essential for achieving optimal oral and systemic health.

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