NUTRITION: ENRICHING THE PERIODONTAL HEALTH

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ABSTRACT

The health of an individual is reflection of his nutritional status. Nutrition is identified as one of the key factors modulating host immune response. Studies have been done in this regard and also their positive effect on resolution of periodontal disorders. As a periodontal lesion is primarily a wound so an appropriate host function is essential for healing which ultimately develops from nutrition. A Balanced diet providing the macro and micro nutrients maintains the regular functions of the body. Therefore a deficient nutrition will lead to the advancement of periodontal diseases. The macronutrients play a central role in maintaining the overall health. However, micronutrients are also of major implication in the human body which includes all the vitamins, minerals etc. Vitamins which take up a major percentage of micronutrients have been attributed to counteract the oxidative stress which ultimately reduces the severity of periodontal disorders. Apart from this, some genetic pattern and its interrelationship with nutrition has an impact on immune response of the patient, which alters the pathogenic pathway of inflammatory diseases including periodontal disorders. Though there is tremendous literature on the effects of macro and micronutrients, this article gives an insight of mechanism of action of various micronutrients and some of the trace elements with their positive effects in resolution of periodontal disorders.

Keywords: Nutrition, nutrigenomics, oxidative stress, periodontal Health, probiotics, vitamins.

INTRODUCTION

Nutrition plays a very significant role in man’s development, his health and welfare. A rigorous knowledge of chemistry and metabolism of various nutrients is an essential expedient for a better understanding of nutrition and its role in various periodontal diseases. Gingivitis and periodontitis are chronic infectious microbial diseases characterized by a dysregulated host inflammatory or immune response to plaque microorganisms in susceptible individuals. Many essential nutrients have immune modulatory properties; hence nutrition has correlation to the natural resolution of the periodontal diseases. A variety of risk factors have been identified that modify the host response and thus disturb the biological balance from health to disease. These factors can be characterized as genetic, environmental, lifestyle and nutrition. Folate, Vitamin A and Vitamin C help in development and repair of connective and mucosal tissues. Diet provide all the essential nutrients which are required for maintaining the health like antioxidants, coenzymes in energy production and metabolic processes, and component of tissue structures that keep the body’s system functioning properly and maintain good overall health including oral health. It has been studied for many years that nutritional intake has an effect on the levels of inflammation in various inflammatory diseases including periodontitis. Though there is tremendous literature on the efficacy of micronutrients and the trace elements in periodontal infections this review article has been compiled with the purpose of highlighting the role of essential nutrients in the health of periodontium. The data was taken up from the Medline and Pubmed sources.
A Conspectus on Oxidative Stress Due to Nutrition

Oxidative stress has a pivotal role in the pathogenesis of a wide range of chronic inflammatory diseases including periodontitis. In health, a balance between oxidants and antioxidants is maintained in all tissues of our body. This balance is disturbed by excess production of oxidants or depletion of antioxidants leading to “oxidative stress” (Figure 2) responsible for the local tissue damage seen in periodontal diseases. Oxidative stress was recently defined as “an imbalance between oxidants and antioxidants in favor of the oxidants, leading to a disruption of redox signaling & control and/or molecular damage.” It results in tissue damage by altering the molecules, such as proteins, lipids and DNA, thus damaging cells directly, or by activating the redox-sensitive transcription factors within the cell that leads to downstream the gene expression changes and production of proinflammatory molecules. These cytokines or chemical messengers’ further intensify and preach the inflammatory response adding to local levels of oxidative stress. Increased consumption of simple sugars further amplifies oxidative stress by binding with the receptor of neutrophil cells. Firstly advanced glycation end products (AGE) are formed by excess glucose present in the blood which binds to proteins in tissues and the blood stream. The ligation of receptors of AGE (RAGE) present on the neutrophils occurs when AGEs activates the NADPH-oxidase enzyme complex known as “respiratory burst”, to generate oxygen radicals. Secondly excess fats when metabolized, produce increased levels of low density lipoprotein cholesterol (LDL), get oxidized and forms oxidized LDL, which in turn binds to complementary receptors present on the cell membrane of neutrophils, activating NADPH-oxidase and oxygen free radical formation, further adding to the oxidative stress burden. Thus controlling the consumption of these dietary sugars and fats, will aid in reducing the levels of oxidative stress and minimizing the inflammatory sequelae. Foods rich in antioxidants such as green leafy vegetables, fruits, dark chocolate, and cranberries etc may help to decrease the oxidative stress. In a recent randomized double blind clinical trial, analysis of clinical improvement of a powdered fruit and vegetable juice concentrate in the treatment of patients with chronic periodontitis was done. Conclusion was drawn that addition of fruit and vegetable concentrate results in improved pocket depth reduction following standard nonsurgical therapy when compared to a placebo control.

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Vitamins can be Classified as

**Figure 3.**
SELECTED VITAMINS ESSENTIAL FOR PERIODONTAL HEALTH

Vitamin A.
A fat soluble vitamin supplying carotenoids (α carotene, β carotene, lycopene, cryptoxanthin and lutein) to our body which aids in normal growth, reproduction and maintenance of epithelial cells due to the presence of retinol and retinoic acid essential to prevent keratin synthesis. Also retinyl phosphate is crucial for the formation of mucopolysaccharides and compound of mucus secreted by epithelial surfaces to maintain the moist surface. Vitamin A also serves as an antioxidant. Deficiency of this vitamin leads to degenerative changes in epithelial tissues resulting in a keratinizing metaplasia. Vitamin A conglomeraes in the liver and serum levels are closely monitored, therefore deficient serum levels signify depletion of the liver stores. US Institute of Medicine states that 3-6 mg of β-carotene daily will maintain the blood levels of this vitamin and thus lower the occurrence of chronic diseases like periodontitis. A study conducted in older men with mild and severe form of periodontitis showed that periodontal disease was associated with low serum levels of α and β carotene.

Vitamin E.
It is a naturally occurring antioxidant named as Tocopherol acting as antioxidant vitamin. It protects free radical reactions and shields the cells and cell membranes from lipid peroxidation. It shelters the major content of cell membranes i.e. polyunsaturated fatty acid from peroxidation reactions. Deficiency of this vitamin would lead to delayed wound healing. Studies conducted on rats have shown that, systemic vitamin E accelerates the gingival wound healing. But no significant association has been found between serum vitamin E levels and periodontal disease in studies conducted on humans till date.

Vitamin C.
Ascorbic acid is a water soluble versatile vitamin playing a crucial role of a coenzyme in hydroxylation of proline and lysine while protocollagen is converted to collagen. The hydroxylation reaction is catalysed by lysyl hydroxylase and prolyl hydroxylase and this reaction is dependent on vitamin C. Bone consists of an organic matrix, collagen and the inorganic calcium & phosphate. Vitamin C is required for the synthesis of collagen and bone formation. It helps in iron absorption by forming ferrous hydroxide which breaks down into ferric ion gets converted into ferrous ion and absorbed in the intestine and finally synthesizes hemoglobin. Severe deficiency of vitamin C leads to a phenomena known as “Scurvy” a disease characterized by hemorrhagic diathesis, delayed wound healing, cessation of osteoid formation. Studies by Leggott et al regarding the effects of short term depletion and replacement of vitamin C showed no significant effects on periodontal disease. Chapple et al monitored serum values of vitamin C in periodontally diseased patients and concluded that the highest risk of periodontal diseases occurs when there is a deficiency of ascorbic acid in the body.

Vitamin D.
It is a fat soluble vitamin which functions like hormone as it is produced predominantly in the kidney and then circulates throughout the body. It comes in two forms: vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol). Calcitriol regulates the plasma levels of calcium and phosphate. Conversion of 25 (OH) D to its active form 1, 25-dihydroxy vitamin D (1, 25 (OH)2 D) by 1-hydroxylase take place in kidney and has a critical role in the continuance of bone and muscle health by regulating calcium metabolism. Over 200 genes are controlled by 1,25 (OH)2 D which encompasses those involved in remin production in the kidney, insulin production in the pancreas, release of cytokines from lymphocytes, production of cathelicidin in macrophages and growth and proliferation of both vascular smooth muscle cells and cardiomyocytes.

Vitamin D in immune modulation
The innate immune system can be repressed by vitamin D. It has a central effect on the reticence of differentiatation & maturation process, and immune stimulating capability of dendritic cells by downregulating the expression of Major Histocompatibility Complex Class II molecules. Vitamin D braces the effect of monocytes due to which it has been proved that it has an intricate role in immune hemostasis rather than a purely exploitive effect on the immune system. Vitamin D receptor expression increases due to the commencement of CD4+T cells due to which calcitriol is capable to regulate at least 102 identified genes which ultimately has a downstream impact on the levels of circulating chemokines and cytokines and thus it helps in humoral immunity also. Additionally vitamin D receptor agonist promotes the recruitment of CD4+CD25+T cells at inflammatory sites thus providing autoimmunity. In a study by Meng H et al, it has been proved that there is an inhibitory effect of 1, 25 (OH)2 D3 on lymphoid cell progenitors growth of T and B lineage along with the growth of malignant B-cell lineage lymphoid progenitors and that too without having any cytotoxic effect, thus proving the antineoplastic efficacy of vitamin D.

Vitamin D in bone metabolism
A structural and a functional component of teeth and bone are hydroxyapatite crystals which are produced by calcium and vitamin D, thus it has an essential role in bone and calcium metabolism. A number of molecules specifically receptor activator of NF-kB ligand (RANKL) and a RANKL antagonist (osteoprogenitor) are formed by osteoblasts and other cells like activated CD4+T lymphocytes, also calcium and vitamin D are chief regulators of bone remodeling.
Vitamin B.
It includes Thiamine (B1), Riboflavin (B2), Niacin (B3), Pyridoxine (B6), Cobalamin (B12), Biotin and Folic acid.[1] Most common oral changes which occur due to Vitamin B-complex deficiencies are gingivitis, glossitis, glossodynia, angular cheilitis and inflammation of the entire mucosal surfaces of oral cavity. A thiamine deficiency causes minute vesicles on the buccal mucosa, under the tongue and on the palate and erosion of the mucosal surfaces. A riboflavin deficiency will cause glossitis and angular cheilitis. It has been studied that monkeys suffering from riboflavin deficiency has shown severe lesions including rona on the gingival and periodontal tissues. However it has been studied that the gingiva can be involved in niacin deficiency also in the condition known as aniacinosis in which the clinical picture like NUG can be seen. Whereas authors postulated that the gingival changes associated with pregnancy and after the intake of oral contraceptives are related to the low levels of folic acid in the gingival and periodontal tissues. An association between phenytoin induced gingival enlargement and the lower levels of folic acid has also been suggested.

Other Constituents of Diet

- **Dairy foods**: They provide calcium and vitamin D and also other important nutrients for maintaining the health of bone.[3] It has been shown that by consuming 55g or more of dairy foods there is a significant difference in periodontal status.[30]
- **Magnesium**: It plays a key role in ion transport through membranes of cells thus helps in stabilization of the membranes.[3] Studies have proved that there is a higher risk of developing periodontal disease that has low levels of serum magnesium levels.[30]
- **Grains**: They provide fiber, vitamin B and magnesium. It has been shown that the risk of occurrence of periodontal disease is more in patients who consume fewer amounts of grains.[31]
- **Dietary fiber**: Fiber is very essential component of our diet that helps for proper control of glucose and has a regulating action on glycemic control.[32] Patients consuming low amount of dietary fiber are at a higher risk for developing periodontal disease.[33]
- **Alcohol**: It produces acetaldehyde after metabolism in the body and this is toxic to the tissues.[3] The progression of periodontal disease is seen more in patients who consume alcohol as compared to nonalcoholics.[34]
- **Soy**: These are rich sources of genistein and daidzein which are isoflavones. They provide cell mediated immunity.[35] In a study of Tanaka et al significant reduction of periodontal disease was seen in patients consuming soy.[36]
- **Polyphenols**: They are phytochemicals which include catechins, anthocyanidins, flavonoids and isoflavonoids. They have anti-inflammatory and antimicrobial properties and include green tea, cranberries, grapes, blueberries and chocolates.[37, 38]

In a study conducted on Japanese men, a significant regression is seen in periodontal disease after consuming green tea.[39]

- **Complementary supplements**: Constituents like garlic[40], ginger[41], ginseng[42], Echinacea[43] have antimicrobial and antioxidant actions. In-vitro studies depict their inhibitory actions on periodontal pathogens.[44, 45, 46, 47]

**Essential Fatty Acids**
Omega 3 and omega 6 are polyunsaturated long chain essential fatty acids present in the lipid membranes of various cells and are derived from the diet. These fatty acids are antecedent of eicosanoids. Eicosanoids consists of n-3 fatty acids eicosapentanoic acid, docosahexanoic acid and alpha-linolenic acid, and the n-6 fatty acid gamma-linolenic acid.[3] The endogenous lipid mediators procured from these fatty acids are lipoxins, resolvins, protectins, and maresins which are biosynthesized during the resolution phase of acute inflammation.[48] Lipoxins are derived from endogenous fatty acid (arachidonic acid) and has potent anti-inflammatory and resolution actions.[49, 50, 51] Resolvins, protectins and maresins are derived from dietary fatty acids especially ω-3 fatty acids.[48] Resolvins are synthesized from eicosapentanoic acid and docosahexanoic acids present in the diet.[52, 53]

Lipoxygenase mediated pathway biosynthesizes protectins and a reaction takes place which forms 17 S-hydroxyperoxide containing intermediate which is hastily picked by leucocytes and converted into 10, 17 – Dihydroxydocosahexanoic acid, known as protectin D1 or neuroprotectin.[54, 55] Maresins are formed from macrophage phagocytosis of apoptotic cells.[56] Maresins stimulates efferocytosis also has regenerative functions.[48] It has been proved that consumption of fatty acids containing eicosapentanoic and docosahexanoic acids increases the level of n-3 polyunsaturated fatty acid in RBCs and WBCs and protects the hemolysis reaction of erythrocytes preserving the membrane integrity of RBCs.[57, 58, 59]

Recommended dietary allowances (RDA) of some important nutrients for periodontal health.[7]

<table>
<thead>
<tr>
<th>NUTRIENT(S)</th>
<th>RDA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrates</td>
<td>400 g</td>
</tr>
<tr>
<td>Fats</td>
<td>70 g</td>
</tr>
<tr>
<td>Proteins</td>
<td>56 g</td>
</tr>
<tr>
<td>Essential fatty acids</td>
<td>4 g</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>1,000 µg</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>5 µg</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>10 µg</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>60 mg</td>
</tr>
<tr>
<td>Thiamine</td>
<td>1.5 mg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>2 mg</td>
</tr>
<tr>
<td>Pyridoxine</td>
<td>2 mg</td>
</tr>
<tr>
<td>Folic acid</td>
<td>150 µg</td>
</tr>
<tr>
<td>Cobalamin</td>
<td>2 µg</td>
</tr>
</tbody>
</table>
Probiotics and Prebiotics

Probiotics is an adequate intake of live microorganisms which shows favorable effects on host where as a prebiotic is a discriminate simmered component which alters the action of alimentary tract microflora that has positive health effects. Probiotics enhances the innate immunity and alters the inflammatory pathway by activating the antigen presenting cells. Additionally it inhibits the process of apoptosis by maintaining the tight cell junctions of epithelium. Twetman S et al. showed the inhibitory response of lactobacillus containing chewing gum on Porphyromonas gingivalis, Prevotella intermedia and Aggregatibacter actinomycetemcomitans which are considered as a pathogenic organism of periodontal diseases. There are natural diet products which has probiotic and prebiotic functions. Various fermented food which provides us a probiotic effect are turnips, cabbage, Kombucha tea, ginger beer, California bees, coconut kefir and dairy products. Also there are natural sources which has a probiotic action like soybeans, raw oats, unrefined barley, inulin containing food like onions, wheat, garlic, banana and chicory root.

Coenzyme Q10 (CQ10)

It is a natural coenzyme present in the inner membrane of mitochondria and plasma lipoproteins. If functions to produce ATP which is a bioenergizer. Also, CQ10 scavenges the free radicals and ROS (reactive oxygen species) reducing the collagen degradation. Thus CQ10 functions like a potent antioxidant and should be a part of our diet. There are many vegetables which are a rich source of CQ10 like broccoli, spinach, cauliflower and legumes like peanut, walnut and also animal food like red beef etc.

Nutrigenomics

It is the confluence of the nutrition and the hereditary genomic pattern for better understanding the role of genes in periodontal diseases. Tissues like liver and muscle which oxidizes fatty acids secretes peroxisome proliferator activated receptor alpha gene in which polymorphism has been identified in several populations. The transcriptional response of this gene to dietary fatty acid intake is affected.

The considerable alliance between interleukin 1 genotype (IL-1B-511) was seen in periodontitis subjects suffering from diabetes mellitus (DM) in African and American origin. It has been confirmed by recent studies that interleukin-1A (interleukin-1A-889) and interleukin-1B (interleukin-1B+3954 and interleukin-1B-511) are associated with periodontitis in patients with type 2 DM. Another genome which has seen relating diabetes and periodontitis is Zinc transporter gene. It has been found that Zinc transporter gene (SLC30A8, coding for ZnT8) may has its role in insulin storage and function. This genome i.e. SLC30A8 major allele has its influence on beta cell function and thus in type 2 DM. This information put forward the fact that Zinc supplementation may alter periodontal disease progression by altering the expression of ZnT8 transporter gene.

CONCLUSION

Nutrition plays a key role in healing of periodontal tissues. Considerable amount of recent researches have shown potential role of various nutrients in the management of periodontal diseases. Genetic makeup of an individual is also an attributing factor for various systemic diseases that ultimately affects the natural host mechanism for the resolution of inflammation in periodontitis. The need of the hour is to consider the dietary intake of our patients and also the host inflammatory response for the better treatment outcome and for the general health of patients suffering from periodontal diseases.

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