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RESEARCH ARTICLE

NUTRITION AND PERIODONTIUM: A CONNECTING LINK

***Dr. Shaswata Karmakar**

Senior Lecturer, Department of Periodontics, Awadh Dental College and Hospital Jamsedpur

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ABSTRACT

The vitality of the periodontal tissues in health and disease depends strongly upon an adequate source of essential nutrients being available to the host. The epithelium of the dentogingival junction, the underlying connective tissues and periodontium, as a whole, are amongst the most dynamic tissues in the body. The maintenance of these tissues is dependent upon an adequate supply of nutrients that are considered to be either major or minor.

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INTRODUCTION

Nutrition is defined as the science of how the body utilizes food to meet the requirements for development, growth, repair and maintenance. Nutrition can produce both topical and systemic effects on the body and in its tissues. Nutrition has a strong influence on the integrity of the periodontium and its deficient state can modify the expression of the primary etiologic factor as well as affect the factors that impact the host's immune response and play a role in the maintenance of the hard and soft tissues of the oral cavity (Laura, 2003). The vitality of the periodontal tissues in health and disease depends strongly upon an adequate source of essential nutrients being available to the host. The epithelium of the dentogingival junction, the underlying connective tissues and periodontium, as a whole, are amongst the most dynamic tissues in the body. The maintenance of these tissues is dependent upon an adequate supply of nutrients that are considered to be either major or minor. Major nutrients are consumed in quantities measurable in grams which include proteins, carbohydrates, lipids and water. The minor nutrients include vitamins and mineral salts (Robert, 2000). A chronic deficiency in the availability of one or more of these nutrients may be expected to produce pathological alterations in the periodontal tissues.

Utilization of Energy in Man: Man consumes energy to meet the fuel demands of the three ongoing processes in the body, which are:

- Basal metabolic rate
- Specific dynamic action
- Physical activity

Basal metabolic rate (BMR) is defined as the minimum amount of energy required by the body to maintain life at complete physical and mental rest in the post-absorptive state (i.e. 12 hours after the last meal). Specific Dynamic Action is the phenomenon of extra heat production by the body, over and above the calculated caloric value, when a given food is metabolized by the body.

Nutrition and Periodontal Disease (Cyril, 2007): Inflammation promotes oxidation stress from ROS, which increases the use of the anti-oxidant vitamins and minerals. With increase in scientific information on nutritional genomics, oral health scientists now have an opportunity to study nutrient-gene interactions and how diet affects the inflammatory mechanisms underlying severe periodontitis. In a healthy person who is not malnourished, these nutrient needs can be met through a balanced diet. However, alterations of diet to a more consistently include food high in vitamins and minerals and food rich in η-3 PUFAs may have positive effects on periodontal health. In addition, oral health clinicians have an important role in advocating healthful diets to their patients, to improve both oral and systemic health.

Impact of oral health on nutritional well-being: Prevalence of edentulism increases with age and hence affecting the eating ability and diet, as well as eating related quality of life.

***Corresponding author: Dr. Shaswata Karmakar,**
Senior Lecturer, Department of Periodontics, Awadh Dental College and Hospital Jamsedpur

Dentures also affect the sensory perception of texture and taste of food. The aging process in a healthy dentate adult is associated with moderate changes in oral physiology. However, major changes in chewing behavior and masticatory efficiency are seen when aging is associated with compromised dentition (Paula, 2007).

Carbohydrates

Functions (Satyanarayana's Biochemistry 2nd edition)

- Carbohydrates make up most of the organic matter on Earth because of their extensive roles in all forms of life. Carbohydrates serve as energy stores, fuels, and metabolic intermediates.
- Ribose and Deoxyribose sugars form part of the structural framework of RNA and DNA.
- Polysaccharides are structural elements in the cell walls of bacteria and plants. In fact, cellulose, the main constituent of plant cell walls, is one of the most abundant organic compounds in the biosphere.
- Carbohydrates are linked to many proteins and lipids, where they play key roles in mediating interactions between cells and other elements in the cellular environment.

Periodontal Implications

- Carbohydrates are needed for the synthesis of chondroitin, keratin and dermatan sulfates, which are present in the connective tissues. Although studies in various experimental animals indicate that high carbohydrate diets are conducive to the development of severe periodontal lesions.
- Carbohydrate (glucose) and free fatty acids are the preferred metabolic fuels of active cells; when inadequate amounts are available, amino acids are catabolised, leading to protein depletion and impaired wound healing (Robert, 2009).

Proteins

Functions

- An internal protein network, the cytoskeleton, maintains cellular shape and physical integrity. Actin and myosin filaments form the contractile machinery of muscle.
- Proteins provide us with amino acids, the building blocks of protein. Protein is the most common substance in the body after water, making up about 50% of the body's dry weight.
- Hemoglobin transports oxygen, while circulating antibodies search out foreign invaders.
- Enzymes catalyze reactions that generate energy, synthesize and degrade biomolecules, replicate and transcribe genes, process mRNAs, etc.

Periodontal Implications (Robert, 2000 and Mosby's, 2008)

- Collagen is the most abundant of the fibrous proteins that constitute more than 25% of the protein mass in the human body. It is a major organic component of bone, teeth, periodontal ligament and muscle, which provides structure in the body (Robert, 2000).
- Proteins are needed to provide adequate host defenses. They are components of defensive molecules and barriers that help to control the disease process. The periodontal defenses include cell mediated immunity, antibody or humoral immunity, the complement system and innate immunity. The crevicular and junctional epithelia provide an epithelial barrier function. This epithelial surface provides a major defensive barrier to invasion by antigens, noxious products and bacteria and undergoes a rapid turnover. It is therefore dependent on sufficient protein, zinc, folic acid, iron, vitamin A and vitamin C.
- Degenerative lesions produced in the periodontium include osteoporosis of the alveolar and supporting bone and disappearance of fibroblasts and connective tissue fibers of the periodontal membrane.
- Depletion of proteins impairs wound healing by inhibiting angiogenesis; fibroblast proliferation; and the synthesis, accumulation, and remodeling of collagen;

The mechanisms by which protein deficiency enhances periodontal disease are (Paula, 2008):

- Decreased resistance of mucosa to colonization and invasion by pathogens.
- Impaired salivary flow and antibacterial properties.
- Increased prevalence and potency of pathogenic oral microorganism possibly due to altered bacterial profile.
- Cytokines involved in the healing process compromised.
- Reduced acute phase protein response.

Lipids and its Periodontal Implications (Toshiyuki Saito, 2007 and Walter Loesche, 1982): A higher BMI was related to a greater prevalence of periodontal disease in apparently healthy adults aged 20–59 years. A multivariate analysis adjusted for age, sex, oral hygiene, and smoking found an 8.6 times higher odds ratio of periodontal disease for subjects with a BMI > 30 compared to subjects with a BMI < 20. Body fat was analyzed using dual-energy X-ray absorptiometry and a 5% increase in body fat corresponded to a 30% increased risk of periodontal disease. Loesche and co-workers found total cholesterol, low density lipoprotein cholesterol and triglycerides to be significantly higher in periodontally diseased patients, compared with controls.

Vitamins

Vitamins are regarded as organic compounds required in the diet in small amounts to perform specific biological functions for normal maintenance of optimum growth and health of the organism. The physiological functions and their periodontal considerations are shown in Table no. 1

Minerals

The body utilizes over 80 minerals for maximum function. The major minerals are Sodium, Potassium, Calcium, Magnesium, Phosphorus. Microminerals include Iron, Zinc, Iodine, Selenium, Fluoride, Copper, Cobalt, Chromium, Manganese and Molybdenum[2].The physiological functions and their periodontal considerations are shown in Table no. 2

Table 1.

Vitamin	Physiological functions	Periodontal consideration in deficiency
Vitamin A	1. Essential role in the function of the retina; 2. Growth differentiation and maintenance of epithelial tissues; 3. bone growth and embryonic development.	1. Avitaminosis A has been shown to produce localized gingival recession, epithelial hypertrophy and hyperplasia. 2. Changes in the alveolar bone 3. Replacement of bony trabeculae with fibrous connective tissue, 4. Reduced bone formation and increased thickness of bone 5. Hyperplasia and hyperkeratinization of the gingival epithelium. 6. Proliferation of junctional epithelium. 7. Retardation of gingival wound healing.
Vitamin D	1. Maintain blood calcium levels and the metabolism of osseous tissues. 2. Enhances the absorption of calcium from the intestines	1. reduction of alveolar bone mass and greater areas of unmineralized osteoid. 2. In the periodontal ligament, reduction of the number and diameter of the dentoalveolarfibres. 3. pathological calcification of the periodontal membrane and gingiva. 4. osteosclerosis of the alveolar bone, and marked hypercementosis. 5. A normal rate of cementum formation, but defective calcification and some cementum resorption; and distortion of the growth pattern of alveolar bone.
Vitamin E	1. Vitamin E is essential for the membrane structure and integrity of the cell. 2. Inhibition of nitric oxide production by vascular endothelium. 3. Inhibition of superoxide production by macrophages and neutrophils. 4. It protects RBCs from hemolysis by oxidizing agents. (e.g. H_2O_2). 5. Closely associated with reproductive functions and prevents sterility. 6. Increases the synthesis of heme. 7. Prevents the oxidation of Vitamin A and carotenes. 8. Proper storage of creatine in skeletal muscles. 9. Optimum absorption of amino acids from the intestine. 10. Involved in proper synthesis of nucleic acids. 11. Protects liver from being damaged by toxic compounds such as carbon tetrachloride.	1. Depresses immunological responses to antigens, lymphocytic proliferative responses, delayed hypersensitivity and general resistance.
Vitamin B1 (Thiamine)	1. Role in carbohydrate metabolism as a coenzyme.	1. Hypersensitivity of the oral mucosa; 2. Minute vesicles (simulating herpes) on the buccal mucosa, under the tongue, or on the palate; and erosion of the oral mucosa.
Vitamin B2 (Riboflavin)	1. Vital role in metabolism as coenzymes. 2. Participate in many redox reactions responsible for energy production. 3. Involved in carbohydrate, lipid, protein and purine metabolism.	1. Glossitis, angular cheilitis, seborrhic dermatitis, and a superficial vascularizing keratitis. 2. Angular cheilitis.
Vitamin B3 (Nicotinic acid)	1. NAD and NADP serve a vital role in metabolism as coenzymes for a wide variety of proteins that catalyze oxidation-reduction reactions essential for tissue respiration.	1. black tongue and gingival inflammation, with destruction of the gingiva, periodontal ligament, and alveolar bone. 2. Necrosis of the gingiva and other oral tissues.
Vitamin B6 (pyridoxine)	1. Pyridoxal phosphate is a coenzyme for many enzymes involved in amino acid metabolism, especially in transamination and decarboxylation. 2. It is also the cofactor of glycogen phosphorylase, where the phosphate group is catalytically important. 3. It is important in steroid hormone actions like estrogens, androgens, cortisol, and vitamin D.	Angular cheilitis and glossitis with swelling. 1. Patchy atrophy of the dorsum of the tongue, with magenta discolouration.
Vitamin B7 (Biotin)	1. Biotin is the coenzyme in a small number of carboxylation reactions in mammalian metabolism and some decarboxylation and transcarboxylation reactions in bacteria. 2. It has two noncoenzyme functions: Induction of enzyme synthesis and regulation of the cell cycle.	1. The only oral change associated with biotin deficiency is glossitis and atrophy of the lingual papillae.
Vitamin B5 (Pantothenic acid)	1. functions in fatty acid synthesis, as a CoA. 2. CoA is the major carrier of acyl groups for a wide variety of acyl transfer reactions.	1. Oral changes caused by pantothenic acid deficiency have been identified in animals but not in humans.
Folic acid (Vitamin B9)	1. Metabolic role in catabolism and biosynthetic reactions. 2. Tetrahydrofolate (THF), the coenzyme of folic acid is actively involved in this one-carbon metabolism.	1. Folic acid deficient animals demonstrate necrosis of the gingiva, periodontal ligament, and alveolar bone without inflammation. The absence of inflammation is the result of deficiency induced granulocytopenia. In humans with sprue and other folic acid deficiency states, generalized stomatitis occurs, which may be accompanied by ulcerated glossitis and cheilitis.
Cobalmine (Vitamin B12)	1. Vitamin B_{12} has a role in the metabolism of cyanide, forming cyanocobalamin. 2. Provides nutrition for nervous system.	1. Glossitis is the most frequent oral manifestation. 2. Other oral lesions include stomatitis and mucosal ulcerations. 3. Epithelial cell abnormalities have also been reported, and these tissues may be more susceptible to epithelial dysplasia.

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Vitamin C	1. Major role in collagen synthesis. 2. The conversion of folic acid to folinic acid, microsomal metabolism, and the hydroxylation of dopamine to form norepinephrine. 3. By reducing nonheme ferric iron to the ferrous state in the stomach, ascorbic acid also promotes intestinal absorption of iron.	1. Low levels of ascorbic acid influence the metabolism of collagen within the periodontium, affecting the ability of the tissue to regenerate and repair itself. 2. Ascorbic acid deficiency interferes with bone formation, leading to loss of periodontal bone. 3. Ascorbic acid deficiency increases the permeability of the oral mucosa to endotoxins. 4. Depletion of vitamin C may interfere with the ecologic equilibrium of bacteria in plaque and thus increase its pathogenicity. 5. Gingivitis with enlarged, hemorrhagic, bluish red gingiva is described as one of the classic signs of vitamin C deficiency. 6. Acute vitamin C deficiency results in edema and hemorrhage in the periodontal ligament, osteoporosis of the alveolar bone, and tooth mobility; hemorrhage, edema, and degeneration of collagen fibers occur in the gingiva.

Table 2.

Mineral	Physiologic function	Periodontal consideration in deficiency
Calcium	1. Development of bones and teeth: 2. It is required for the formation and physical strength of skeletal tissues. 3. Muscle contraction. 4. Calcium also activates ATPase, increases the interaction between actin and myosin. 5. Blood coagulation. 6. Nerve transmission. 7. Membrane integrity and permeability. 8. Activation of enzymes: lipase, ATPase, succinate dehydrogenase. 9. Intracellular messenger for hormones such as epinephrine. 10. Ca^{2+} facilitates the release of certain hormones (insulin, PTH, calcitonin.) 11. Regulates microfilament and microtubule mediated process such as endocytosis, exocytosis and cell motility. 12. Involved in cell to cell contact and adhesion of cells in a tissue. 13. Ca^{2+} acts on myocardium and prolongs systole.	1. Osteoporosis and osteopenia affect trabecular bone more than cortical bone, support of teeth by the jaw bone is lessened in both of these conditions and, therefore the affect of deep pockets and bacterial infection may be enhanced. 2. Hypocalcaemia and hyperphosphataemia→secondary hyperparathyroidism,→ initiates alveolar bone resorption.
Phosphorus	1. Essential for the development of bones and teeth. 2. Plays a central role for the formation and utilization of high energy phosphate compounds e.g. ATP, GTP, creatine phosphate. 3. Required for the formation of phospholipids, phosphoproteins and nucleic acids (DNA and RNA) . 4. Essential component of several nucleotide coenzymes e.g. NAD^+, $NADP^+$, pyridoxal phosphate, ADP, AMP. 5. Phosphate buffer system is important for the maintenance of pH in the blood as well as in the cells. 6. Phosphate is necessary for the absorption and metabolism of carbohydrates.	1. osteoporosis of alveolar bone, reduction in amount of secondary cementum, reduction in size and number of the periodontal fibres.
Magnesium	1. Required for the formation of bones and teeth. 2. Serves as a cofactor for several enzymes requiring ATP e.g. hexokinase, glucokinase, phosphofructokinase, adenylate cyclase. 3. Necessary for proper neuromuscular function. Low Mg^{2+} levels lead to neuromuscular irritability.	1. Decreased serum Mg was significantly associated with increased probing depth, more attachment loss and a lower number of remaining teeth. Subjects taking Mg drugs showed less attachment loss and more remaining teeth than did their matched counterparts.
Sodium	1. Regulates the body's acid-base balance. 2. Required for the maintenance of osmotic pressure and fluid balance. 3. Necessary for the normal muscle irritability and cell permeability. 4. Involved in the intestinal absorption of glucose, galactose and amino acids. 5. Necessary for initiating and maintaining heart beat.	The effect of sodium deficiency on the periodontium is not reported.
Potassium	1. Potassium is the principal intracellular cation. 2. Important in the extracellular fluid for specific functions.	The effects of potassium deficiency or of excess potassium on the oral structures per se have not been reported.
Iron	1. Constituent of several proteins/enzymes (hemoproteins) – hemoglobin, myoglobin, cytochromes, xanthine oxidase, catalase, tryptophan pyrrolase and peroxidase.	1. Iron deficiency also may increase susceptibility to infection.
Fluoride	1. Fluoride is required for healthy teeth and bones. 2. It helps form the tough enamel that protects teeth from decay and cavities, and increases bone strength and stability.	1. Irrigation of periodontal pockets with fluoride solution after scaling and root planing is occasionally recommended to inhibit the growth of pathogenic bacteria in the periodontal pocket. 2. Due to its toxicity, fluoride solution deposited in the periodontium may lead to tissue damage.
Zinc	1. Bone development and growth 2. Cell respiration 3. Aiding enzymes in digestion and energy metabolism 4. Wound healing 5. Immune function 6. Regulation of heart rate and blood pressure	1. Stabilization of membranes. 2. Antioxidant activity. 3. Collagen synthesis. 4. Inhibition of plaque growth, and inhibition of mast cell release of histamine.
Water	1. Constitutes 70% of the human body weight. 2. Water is an ideal biologic solvent. 3. Almost all the biologic functions of the cells require water.	

Conclusion

It is reasonable to consume a nutritionally adequate diet to help maintain host resistance and to maintain the integrity of the periodontal tissues. A good diet contributes to both good general health and good oral health. Dental professionals, therefore, need to routinely assess nutritional status and provide basic nutrition counseling to their patients to ensure optimal functioning of the immune system in combating infection and to promote optimal periodontal health[1]. We should, hence, try to eat, and also recommend to our patients, a diet that includes necessary amount of carbohydrate, protein, lipid, vitamins and minerals.. Considering that nutrient supplementation shows minimal or no side effects, if future prospective, controlled clinical trials are able to demonstrate that it could be used to enhance response to therapy, such supplementation may prove valuable in producing more predictable treatment outcomes.

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