NUTRITION IN PERIODONTAL HEALTH AND DISEASE

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Abstract:

The term 'Nutrition' defined as the science of how the body utilizes food to meet the requirements for development, growth, repair, and maintenance. It can produce both local and systemic effects on the body and in its tissues. Nutrition has a strong influence on the integrity of the periodontium. A chronic deficiency in the availability of one or more of the nutrients may lead to produce pathological alterations in the periodontal tissues.

Various Studies have attempted to find a correlation between tooth loss, periodontal health, and nutrition. Moreover, bone formation and periodontal regeneration are also affected by numerous vitamins, minerals, and trace elements. The current review is aimed to update and evaluate the available data on impact of nutrition in periodontal health and disease.

Keywords: Carbohydrates, Lipids, Nutrients, Periodontal implications, Obesity, Diabetes mellitus.

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INTRODUCTION:

Nutrition derived from the diet helps in energy production and regulates different metabolic processes of the body. It also keeps the body systems functioning properly and maintains good overall health, including oral health. The term 'Nutrition' defined as the science of how the body utilizes food to meet the requirements for development, growth, repair, and maintenance. It can produce both local 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 primary etiologic factor as well as affect the factors that impact the host immune response and play a role in the maintenance of the hard and soft tissues of the oral cavity.[1] The maintenance of periodontal tissues is depend upon an adequate supply of nutrients that are considered to be either major or minor. The primary nutrients consumed are measurable in grams, which include proteins, carbohydrates, lipids and water. The minor nutrients are required in micrograms (µg) to milligrams (mg) and include vitamins and mineral salts.[2]

A chronic deficiency in the availability of one or more of these nutrients may lead to produce pathological alterations in the periodontal tissues.[3] So the dental professionals should evaluate nutritional status of their patients and emphasize its role in maintenance of periodontal health.[1] Nutritional deficiency alone cannot initiate periodontal disease. Rather it may predispose, accelerate, or otherwise increase its progression and have a significant impact on optimal functioning of the immune response. This article is an attempt to review the available literature to date and to implicate the role of nutrition in periodontal health and disease.

CLASSIFICATION:

1. Based on the requirement:

a) **Macronutrients:** The body needs these nutrients in large amounts to carry out various metabolic processes for energy production. Include proteins, carbohydrates, and fats that form basis of any diet.[3]

b) **Micronutrients:** Micronutrients require in small quantities (usually in amounts less than milligrams). And involved in regulating body's metabolism and energy processes, but not as substrates. It includes vitamins and minerals.[3]

2. Based on the chemical nature: The **dietary components** of food are classified according to its chemical nature like:

a) Carbohydrates
b) Proteins
c) Fats
d) Minerals
e) Vitamins
f) Dietary fiber
g) Water

3. Based on essentiality:

a. Essential nutrients: The essential nutrients required for the normal physiological function of the body, however, are not produced in the body or produced in lesser amounts; thus has to be obtained from a dietary source. In humans, there are nine amino acids, two fatty acids, thirteen vitamins, and fifteen minerals that are considered essential nutrients.[4]

b. Non-essential nutrients: These substances from food can be beneficial or toxic and can significantly impact health. For example, dietary fiber is not absorbed in the human digestive tract, but is important in maintaining the bulk of a bowel movement to avoid constipation. Bacterial metabolism of soluble fiber also produces short-chain fatty acids like butyric acid, which may be absorbed into intestinal cells as a source of calories.[5]

c. Conditionally essential nutrients: These are specific organic molecules synthesized by an organism, but during certain conditions in humans (premature birth, limited nutrient intake, rapid growth, and certain disease states) produced in inadequate quantities. Choline, inositol, taurine, arginine, glutamine, and nucleotides are classified as conditionally essential and are particularly important in neonatal diet and metabolism.[6]

4. Based on its role:

1. **Energy giving foods:** The Carbohydrates, fats, and protein are considered calorie nutrients that serve as a metabolic substrate for energy and can perform the necessary functions. The vitamins, as well as the minerals, are considered non-calorie nutrients.
2. **Body building foods (Plastic or structural:** proteins, fats, and carbohydrates are called as body-building food. Proteins make up 20 % or 1/5 of the total body weight. Fat nutrients make up another 20 % or 1/5 of the body weight, while the carbohydrates make up about 1%.
3. **Protective foods (Regulators):** Vitamins and minerals are the nutrients that function to regulate body processes. The minerals make up 4%, and vitamins make up about 28 grams of the body weight, considering that they are not really a part of the structural components of the body.

5. Based on its nutritional value:

a. Cereals and millets,
b. Pulses
c. Nuts and oilseeds,
d. Vegetable
e. Green leafy vegetable
f. Non-leafy
g. Roots and tubers
h. Fruits
i. Milk and milk products
j. Animal foods—meat, fish, liver, egg, etc.
k. Carbohydrate foods,
l. Condiments and spices

MACRONUTRIENTS:

CARBOHYDRATES:

Carbohydrates or saccharides are the most abundant of the four major classes of biomolecules which plays chief role in providing energy to the

body. They are found throughout our body in the form of glycoprotein and glycosaminoglycans. Chemically, carbohydrates are simple organic compounds that are aldehydes or ketones with many hydroxyl groups added, usually one on each carbon atom that is not part of the aldehyde or ketone functional group.[7]

Carbohydrates are abundant in naturally occurring foods like table sugar: 99%, Cereals: 60-80%, Pulses: 50-60%, Roots and tubers: 20-40% Bread: 50-60%. Sugars and starches are the chief sources. In a well-balanced diet, carbohydrates should fulfill at least 40% of the caloric need of the body. Recommended Dietary Allowance for Adults is 130g per day.[8]

Classification:

1. Monosaccharides are those carbohydrates that cannot be hydrolyzed into simpler carbohydrates and have been classified as trioses, tetroses, pentoses, hexoses, or heptoses upon the number of carbon atoms; and as aldoses or ketoses depending upon whether they have an aldehyde or ketone group. Examples are glucose, galactose, and fructose.

Glucose is the essential carbohydrate; most dietary carbohydrate is absorbed into the bloodstream as glucose, and other sugars are converted into glucose in the liver. Glucose is the major metabolic fuel of mammals and a universal fuel of the fetus. It is the precursor for the synthesis of all the other carbohydrates in the body, including glycogen for storage; ribose and deoxyribose in nucleic acids; and galactose in lactose of milk, in glycolipids, and combination with protein in glycoproteins and proteoglycans.[9]

2. Disaccharides are condensation products of two monosaccharide units. Examples are maltose and sucrose.

3. Oligosaccharides are condensation products of two to ten monosaccharides; maltotriose is an example.

4. Polysaccharides are condensation products of more than ten monosaccharide units; examples are the starches and dextrins, which may be linear or branched polymers. Polysaccharides are sometimes classified as hexosans or pentosans, depending upon the identity of the constituent monosaccharides.

Periodontal Implications:

Carbohydrates are essential for the synthesis of ground substances such as chondroitin, keratin, and dermatan sulfates present in the connective tissues. Carbohydrates are protein sparing in that when inadequate amounts are available, amino acids are catabolized, leading to protein depletion and impaired wound healing.

Although studies in various experimental animals indicate that high carbohydrate diets are conducive to developing severe periodontal lesions, such experiments are difficult to interpret. For instance, it is difficult to separate effects resulting from the high carbohydrate contents from those attributable to the low protein content of such diets. Animals eat to satisfy their energy requirements primarily, and in the absence of force, feeding will not have enough protein from a predominantly carbohydrate diet to meet the requirements. In addition, many of them are of powdery consistency; this factor introduces a major variable about retention of food particles in the mouth. Also there is sufficient evidence that the ingestion of liquid or powdered food has an adverse effect on the structure and function of the salivary glands attributable to reduced masticatory function.[10]

On the other hand, carbohydrates act as peril for periodontal tissue by forming major component of dental Plaque, which is the main etiological factor for the progression of periodontal disease. Carbohydrates like salivary glycoprotein and polysaccharides matrix makes chief constituent of plaque biofilm. This polysaccharide matrix is a natural habitat of periodontal pathogens including porphyromonas gingivalis, prevotella intermedia, tannerella forsythia and treponema denticola. Regular maintenance of oral hygiene by various mechanical plaque control measures has the potential of improving periodontal health.[11]

PROTEINS:

Proteins make about 50% of the body's dry weight and are called as the building blocks of our body. A total of twenty-two different amino acids exist in protein molecule and hundreds to thousands

of these amino acids are attached to each other in long chains to form a protein. Essential amino acids like histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine are involved for protein synthesis. These amino acids should present in daily diet for protein synthesis. Excess amino acids are utilized for energy production. Protein provides 4kcal of energy per gram. The RDA for protein is 0.8 g per day per kg body weight for adults.[2]

Periodontal implications: Periodontium is comprised of connective tissue of gingiva, periodontal ligament, alveolar bone and cementum. Collagen fibers made of proteins form the most important component of all periodontal structures. Other cytoskeletal proteins like keratin and myosin give structural strength to cells and tissues. Proteins are components of defense mechanism and also form 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 acts a major defensive barrier for invasion of antigens, harmful products produced by bacteria. If the patient is undernourished, their nutritionally deficient status could cause a reversible loss of barrier function and diminished resistance to disease.[2]

The effect of protein-energy malnutrition (PEM) on periodontal disease was extensively reviewed by Enwonwu, who observed that aggressive periodontal disease was more prevalent and severe in undernourished populations than well-nourished ones.[12] Depleted nutritional reserves in tissues are associated with lower immunity. The immune depression that occurs in PEM promotes vulnerability of the periodontium to inflammatory stimuli from plaque.

The mechanisms by which PEM enhances periodontal disease are:

a) Decreased resistance of mucosa to colonization and invasion by pathogens.

b) Impaired salivary flow and antibacterial properties.

c) Increased prevalence and potency of pathogenic oral microorganism possibly due to altered bacterial profile.

d) Cytokines involved in the healing process compromised.[13]

Thus proteins play important role in growth, development and functioning of cells**.**

LIPIDS:

Lipids are a heterogeneous group of compounds which forms important component of living tissue. They have the common property of being relatively insoluble in water.[11] The main role of lipids is to provide energy, energy storage, and thermal insulation. The body requires two essential fatty acids: linoleic and linolenic acid. Fats are also needed to absorb fat soluble vitamins like A, D, E, and K. The recommended fat intake is around 20-30% of the daily caloric requirement containing about 50% of polyunsaturated fatty acids.

Obesity is characterized by excess deposition of fats/adipose tissue which secretes proinflammatory cytokines pointing towards same pathophysiology with chronic periodontitis. Various studies have showed the association between obesity and periodontitis in humans.[14]

The Mechanism Connecting Obesity and Periodontal Disease:

Obesity affects host immunity. It has been reported that obese-hypertensive rats are more likely to have periodontitis than normal rats and that the periodontal blood vessels of these rats show intimal thickening, indicating diminished blood flow. A high-cholesterol diet has been associated with the proliferation of junctional epithelium, with increasing bone resorption in rat periodontitis. As a high-cholesterol diet leads to fat accumulation directly, an elevated serum cholesterol level may be a reason for the relationship between obesity and periodontal disease. Upper body obesity, i.e. abdominal adiposity, has greater adverse effects on health than lower body obesity. Visceral fat accumulation, which is frequently observed in upper body obesity, increases the risk of cardiovascular disease and type 2 diabetes. An increase in visceral fat is associated with insulin resistance and increased liver fat. An increase in the waist-to-hip ratio is reported to be a predictor of hepatic steatosis independent of BMI.[15]

MICRONUTRIENTS:

VITAMINS:

Vitamins are 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. There are around 15 vitamins essential for humans. They are of two types fat- soluble – A, D, E and K and water-soluble – C and B-complex. Vitamin A plays an essential role in the healthy vision, differentiation and maintenance of epithelial tissues, and for bone growth and embryonic development. Vitamin D can be considered as a conditional vitamin as it can be synthesized in the body following exposure to sunlight. It maintains level of calcium and phosphorus in the blood serum. Vitamin K is essential for the normal biosynthesis of several factors required for blood clotting. Vitamin E is essential for the membrane structure and integrity of the cell and inhibition of protein kinase C and subsequent platelet aggregation. The B-complex vitamins may be sub-divided into energy releasing (B1, B2, B3, B5, B6, B7) and hemopoietic (B9 and B12). Vitamin B complex helps in cell metabolism, repair, and proliferation. Vitamin C is primarily required for the synthesis of collagen. Also it prevents oxidative damage by acting as a ROS scavenger.

Periodontal implications:

The effects of vitamin A deficiency on periodontal structures have studied for over 50 years as a result of animal experiments in the soft tissues. It plays important role in tissue integrity. Avitaminosis A has been shown to produce localized gingival recession, epithelial hypertrophy, hyperkeratinization and hyperplasia in monkeys, guinea pigs and dogs. Fransen explained in his theory the main effects of vitamin A deficiency is to suppress bone resorption by inhibiting osteoclast function. Osteoblast function may also be reduced although if the magnitude of suppression is greater in favour of the resorbing cells then bone deposition will continue albeit at a slower rate. The more significant factor for consideration in animal studies is therefore the time interval over which the bone changes.[16]

The Deficiency of vitamin D leads to reduced bone mineral density, osteoporosis, and the progression of periodontal diseases and causes resorption of jawbone. The periodontal effects of overdosing with vitamin D in dogs have also been described by Becks stating increased osteoblastic activity, pathological calcification of the periodontal membrane and gingiva, osteosclerosis of the alveolar bone, and marked hypercementosis.[3]

Vitamin B9 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.

Acute vitamin C deficiency results in edema and hemorrhage in the periodontal ligament, osteoporosis of the alveolar bone, tooth mobility, hemorrhage, edema, and degeneration of collagen fibers occur in the gingiva.

MINERALS:

Minerals are essential for good health. The body utilizes over 80 minerals for maximum function. Evidence of mineral malnutrition are various minor and serious health conditions such as energy loss, premature aging, diminished senses, and degenerative diseases like osteoporosis, heart disease, and cancer. In many cases, these could be prevented with proper mineral supplementation.

Nutritionally minerals are grouped into two categories: bulk or essential minerals, also called macrominerals (> 100 mg/day), and trace minerals or microminerals (< 100 mg/day). The major minerals are sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), phosphorus (Ph) and sulfur (S). Although only minute quantities of trace minerals are needed, they are nevertheless important for good health. Microminerals include iron (Fe), zinc (Zn), iodine (I), selenium (Se), fluoride (F), copper (Cu), cobalt (Co), chromium (Cr), manganese (Mn) and molybdenum (Mo).[2]

THE ROLE OF NUTRITION IN MODULATING INFLAMMATION

The effect of systemic or any localized inflammation is the acute phase response (APR). Proinflammatory cytokines produced in response to local inflammation travel through the blood and

stimulate liver cells to synthesize and secrete acute phase proteins (APPs) such as C reactive protein (CRP). This APR is at the interface of the interactions between nutrition and immunity in infections. Systemic inflammation elicits changes in body composition, alters the use of various macronutrients (i.e. fats, carbohydrates and protein) and increases cellular consumption of important vitamins and minerals (i.e. micronutrients). Systemic inflammation also promotes the breakdown of protein and fat and loss muscle mass, and it stimulates the liver to produce more APPs. These changes increase the body's demand for nutrients from food, particularly in malnourished people.[17]

The APR also promotes production of specific APPs, with increased release of many inflammatory mediators, proliferation of immune cells and several metabolic changes. In the process, micronutrients such as vitamin A, iron, copper, selenium and zinc are compartmentalized to the tissues, lost from the body or blocked from cellular use.

Proinflammatory cytokines stimulate APR and promote major changes in protein and amino acid metabolism. Amino acids released from muscle and other tissues may be inadequate for synthesis of the APPs and essential proteins and, thus, must be supplemented from dietary sources. In particular, requirements for specific amino acids such as arginine (a substrate for nitric oxide synthesis), sulfur amino acids, cysteine and methionine may be increased. Tissue repair after an inflammatory process also may increase the requirement for the nonessential amino acid glycine, which is an important component of collagen.[17]

Increased production of ROS necessitates elevated requirements for the nutrients involved in antioxidant defenses: zinc, copper and selenium. Inflammatory states promote a decrease in the amount of systemic glutathione (reduced glutathione [GSH]) levels.[17]

Many other micronutrients- such as beta-carotene and vitamins A, C and E become depleted during inflammation. In addition to their roles in various immune functions, these vitamins are involved in the maintenance of structural and functional integrity of epithelial tissues and physiological or metabolic parameters relevant to periodontal health.

Generally, omega-3(η-3) poly unsaturated fatty acids (PUFAs), which are found in fish such as salmon walnuts, mono unsaturated fatty acids, which are found in avocados, olive oil and canola oil reduce proinflammatory cytokine production. Adequate dietary intake of η-3 PUFAs metabolites may serve as "stop signals" for preventing neutrophil mediated tissue damage. Studies in animals suggest a positive, modulating effect of η-3 PUFAs on gingival inflammation. Studies in humans are limited but have been less promising.[17]

ROLE OF NUTRITION INACTIVATION OF PROINFLAMMATORY CASCADES:

Refined carbohydrates from diet, processed foods rich in glucose and lipids get absorbs rapidly in the bloodstream can be a major cause of chronic inflammation. Elevated glucose and lipid levels leads to an increase in the production of acetyl CoA. The increased acetyl CoA stimulates the mitochondria to produce excess superoxide in electron transport chain. This superoxide gets converted in hydrogen peroxide leading to increase in ROS inside the cell. Generated Reactive oxygen species leads to oxidative stress. It is noted that "postprandial dysmetabolism" plays a role in the genesis of chronic inflammation. Researchers have been applied the term "meal induced inflammation" to postprandial oxidative stress and have demonstrated its association with recorded increase in CRP and proinflammatory cytokines.[18]

NUTRITION AND PERIODONTAL DISEASE:

Inflammation promotes oxidation stress from ROS, which increases the use of the anti-oxidant vitamins and minerals. As evidence mounts regarding the relationship between severe PDs and biomarkers of systemic inflammation, dyslipidemia and endothelial dysfunction, it stands to reason that nutrition may serve the important role in periodontal and systemic inflammation. 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 under lying 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.

Systemic inflammation alters the utilization of fats, carbohydrates and protein and accelerates the metabolic consumption of key antioxidant vitamins and minerals. Because of the role key nutrients play in both the modulation of inflammation and the promotion of wound healing, oral health scientists and oral health clinicians would do well to focus more attention on the interface between nutrition and periodontal diseases.

SUMMARY:

A good diet is important for overall wellbeing of individual. It is required to consume a nutritionally adequate diet to help maintain host resistance and to maintain the integrity of the periodontal tissues. We should try to encourage our patients to have a diet that focuses on reducing our intake of refined carbohydrates and includes eating more whole grains, fruits, vegetables and dietary sources of calcium. In conclusion, although periodontal disease is not a nutritional deficiency disease per se, malnutrition is likely to play a role in either predisposing the host to the progression of preexisting periodontal lesions, influence the outcome of periodontal treatment, or both.

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