

Inter-relationship of calcium, Vitamin D, and fluoride in periodontal health: An overview

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ABSTRACT

Many dental diseases are the result of developmental and maturation defects of teeth. Few of them are prenatal and postnatal calcification defects, developmental disturbances due to endocrine abnormalities, influence of dietary factors, mottled and hypoplastic enamel, caries, and loose teeth. Calcium is considered an important element for the proper development and maintenance of calcified dental tissues and the body; however, knowledge its role in the development and progression of periodontitis is very important. In this review, article general concepts of diet, nutrition, and relationship between calcium and periodontal disease have been discussed.

Key words: Calcium, hypoplastic enamel, periodontal disease, postnatal calcification, Vitamin D

INTRODUCTION

A balanced diet is important for general health and well-being of the body and helps in recovery from many diseases and dental diseases are no exception. It has been seen that individuals who take poor diet or are undernourished, suffer from dental diseases and tend to lose their teeth early.^[1,2] Diet also plays an important role in local and systemic responses of the body and it can affect the stages of tooth development, maturation of enamel, and the dentine. After the eruption of tooth, the type food is also important for the maintenance of tooth structure. Process of caries development can be altered by modifying the diet rather than nutrition. After complete formation and eruption of tooth, dietary fluoride modifies surface layer of exposed enamel, cementum, and dentin. Thus, during growth and development, fluoride aids in making the tooth resistant to caries and makes it resistant to decalcification. However, the role of diet in the development and progression of periodontal disease is not well understood.

ESSENTIAL FACTORS OF CALCIFICATION (EFC) AND THEIR EFFECTS ON TOOTH STRUCTURE

Calcium, phosphorous, fluoride, and Vitamin D principally take part in the development of hard tissues of the body - the bone and the tooth structure and we have named them as EFC. Calcium is of utmost importance among these factors and accounts for about 40% of the total body mineral and 99%, of which is found in the skeleton. Most of the mineral exist in the form of hydroxyapatite ($\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$). Calcium is regulated by various hormones such

as parathyroid hormone, calcitonin, and Vitamin D and act as a critical determinant in nerve conduction and blood clotting. It acts as a supporting material in bone, plays a key role in cellular signaling pathways, functions as a cofactor for some enzymes in the coagulation pathways and muscle contraction. Calcium remains in equilibrium with bone, extracellular water, and soft tissue, by regular turnover through continuous absorption and deposition.

Biogenic amorphous calcium phosphate is peculiar substance which is found in milk and dental enamel. It helps prevent the breakdown of tooth enamel, thus prevents dental caries, stimulates recalcification, thus repairs enamel by stimulating recalcification and attracts fluoride leading to increased amount of fluoride. The incorporation of fluoride into the enamel boosts its resistance to tooth decay and exhibits restorative effects on enamel.

Adequate amount of calcium and phosphate is essential for the development of enamel, dentine, and cementum because the diet provides more than enough phosphorus; calcium is the most likely nutrient to be deficient during tooth development. The delivery of adequate amount of calcium during development is essentially dependent on the maintenance of the normal calcium concentrations in the extracellular fluids. Since the homeostatic mechanism controlling the extracellular calcium ion concentration is highly efficient, only the most severe form of calcium deprivation can result in hypomineralization of dental tissues. The dental tissues do not participate in the systemic calcium homeostatic mechanism that results in calcium withdrawal from the bone. Genetic defects, transient

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Received: 09-12-2017

Revised: 20-12-2017

Accepted: 22-01-2018

oxygen deprivation, or deficiencies of nutrients may result in the formation of abnormal enamel, dentin, and cementum.

Vitamin D regulates balance between calcium and phosphorus by stimulating intestinal absorption, bone resorption, and renal reabsorption.^[1] Vitamin D can also help to abate inflammation in gingival and periodontal diseases. Deficiency of calcium or Vitamin D in diet is risk factors of osteoporosis. Many systemic conditions such as celiac disease and hyperthyroidism are also risk factor for osteoporosis and can be evaluated by bone density scanning.

Thus, Vitamin D may be also a risk factor for developing periodontal disease by its effect on bone mineral density and its immune modulatory properties. There are evidences which suggest a correlation between some Vitamin D receptors, periodontitis, and bone metabolism. Deficiency of Vitamin D may cause decreased bone mineral density which may be predisposing factor for alveolar bone resorption and reflected as periodontitis.^[3]

Fluoride increases the resistance to solubility of calcified tissues. Its stimulatory effects on osteoblasts result in the formation of osteoid which subsequently undergoes mineralization.^[4] Thus, the mineralization of the osteoid tissue would be subsequently mineralized leading to an increase in bone density. Thus, it is used in the treatment of osteoporosis.^[1] Teeth having higher concentration of fluoride have an increased resistance to decalcification. Remineralization of enamel can be attributed to salivary fluoride to some extent.

EFFECTS OF CALCIUM AND VITAMIN D AND PERIODONTAL DISEASE

Periodontitis is a chronic inflammatory disease of the periodontium which develops due to altered host response in the patient and actions bacterial enzymes. The result is tooth supporting structures such as connective tissue, alveolar bone, and periodontal ligaments are adversely affected. This is manifested by erythema of gingival tissue, gingival bleeding, tooth mobility, and ultimately tooth loss.^[5] However, the expression and extent of diseases vary individual to individual depends on the susceptibility of the patient. There is variability in the susceptibility of the patient which is reflected in the disease extent and severity. This condition is best treated by oral prophylaxis which includes mechanical removal bacterial plaque and calculus, oral hygiene measures, and occasionally supportive antibiotic therapy. Certain other factors such as genetic factors, habits smoking and alcohol consumption, and food consumption are other factors which contribute in the development and progression of periodontal disease which make the treatment complex.

There are many advantages of calcium and/or Vitamin D in relation to periodontal disease. They help in strengthening of bone, stimulating antimicrobial effects^[6] and having an immunosuppressive effect. Patients on periodontal maintenance should be counseled about calcium and Vitamin D intake would require performing dietary analyses. Accurate estimates of total intakes of calcium and Vitamin D can be assessed by diet analysis, sunlight exposures, or (in the case for Vitamin D) by serum levels.

An alarming prevalence of Vitamin D deficiency in otherwise healthy adults and a reappearance of Vitamin D deficiency-induced rickets have been documented.^[6] It is now believed that daily supplementation with Vitamin D at levels (800–1000 IU/20 and 25 µg/day) is safe and propitious.

Several studies have been conducted to study and establish the inter-relationship of exogenous calcium and the development and progression of periodontal disease. A Danish cohort study revealed that intake of calcium below the recommended amount was associated with partial anodontia in both males and females, but energy-adjusted calcium intake was a number of teeth and tooth loss in males only. However, after adjusting the energy cofounders, they found that the association was moderately strong.^[7] In another cohort study, it was found that dairy calcium intake was associated with a decreased risk of tooth loss in both men and women but with gender differences, i.e., more in male than female. However, the weakness of the study is loss to follow-up the subject and lack of data on calcium supplementation.^[7,8]

Adegboye *et al.* performed a cross-sectional study to determine the role of calcium intakes from dairy and non-dairy sources and from other dairy products and their association with periodontitis.^[9] This study revealed that intakes of dairy products and calcium-rich foods were significantly and inversely associated with periodontitis. Further, the consumption of non-dairy calcium was not associated with periodontitis. In another study, Adegboye *et al.*, studied the role of dental plaque and calcium and dairy products and the Vitamin D on dental plaque.^[10] They found that it was associated with poor plaque scores. Similarly, Nishida *et al.* found that a higher calcium intake was associated with reduced the prevalence of periodontal disease in Japanese women.^[11]

Role of salivary calcium on periodontal health has also been studied. Khalili and Biloklytska evaluated the role of concentration of salivary calcium concentration on periodontal disease.^[12] They found that calcium may be a risk factor for progression of periodontal diseases in generalized chronic periodontitis, but they could not establish the exact role in initiation of periodontal disease. However, Acharya *et al.* could not confirm the role of salivary calcium in the treatment of chronic periodontitis.^[13]

Varghese *et al.* performed the quantitative assessment of salivary calcium profile in smokers and non-smokers who were suffering from periodontitis.

They found that the level of calcium was significantly higher in smoker as compared to non-smokers. They concluded that an alternative mechanism for calcium absorption might be functioning in smokers. Thus, raised salivary calcium level in smokers is another reason which depicts the mechanism by which smoking leads to the progression of periodontitis.^[14]

In a non-randomized control trial, the influence of calcium and Vitamin D supplementation was studied in healthy individuals with the aim to assess the role of calcium and Vitamin D supplementation in the management of periodontitis and the bone density. Exogenous supplementation of 500 mg calcium and Vitamin D 250 IU for 3 months revealed significant change in periodontal parameters and the bone density. This indicates the positive role of calcium and Vitamin D in the management

of periodontal diseases.^[15] In another study, supplementation of calcium and Vitamin D showed positive effects on periodontium and periodontal parameters were found to be worse in these individuals who did not take oral supplementation of calcium and Vitamin D.^[16]

Although there are some indications in all the studies that there are beneficial effects of supplementation of calcium and Vitamin D, all the studies so far done have various limitations. In fact, randomized clinical trials yet have to be done to establish the definite role of these two elements.

Further, it has been reported that increased periodontal attachment loss is associated with decreased intakes of both calcium and Vitamin D. Insufficient intake of calcium lead to increased risk of periodontal destruction and could be associated to decreased alveolar bone density. Insufficient intake of Vitamin D could be a risk factor for periodontal disease, it can be due to change in bone mineral density or immune modulatory effects of Vitamin D. Vitamin D reduces inflammation by decreasing cytokine production, it also induces antimicrobial cathelicidin production.^[1] It is now believed that calcium/Vitamin D intakes affect the health of periodontium and tooth retention.

CONCLUSION

Periodontitis is a chronic inflammatory disease of the periodontium which develops due to altered host response in the patient and actions of bacterial enzymes. However, it is also influenced by behavioral and exogenous factors. The intake of calcium and Vitamin D is although important for tooth development and the mineralization of bone and teeth (including alveolar bone) and its deficiency affects both the structures including alveolar bone. The studies so far done have shown the positive effects of exogenous supplementation of calcium on periodontal tissues with certain limitations. On the basis of review of studies, we conclude that calcium, Vitamin D, and fluoride together play an important role in periodontal health and protection from periodontal diseases and myth of role of calcium in dental health appears to be true.

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How to cite this Article: Bey A, Kirmani M, Zia A, Ahmed SS. Inter-relationship of calcium, Vitamin D, and fluoride in periodontal health: An overview. *Asian Pac. J. Health Sci.*, 2018; 5(1):39-41.

Source of Support: Nil, **Conflict of Interest:** None declared.