

Review

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E-mail: jbf1@cumc.columbia.edu**Volume 2 : Issue 5****Article Ref. #: 1000DOJ2123****Article History****Received:** September 5th, 2015**Accepted:** November 25th, 2015**Published:** November 30th, 2015**Citation**Yao SG, Fine JB. The potential role of systemic calcium in periodontal disease. *Dent Open J.* 2015; 2(5): 125-131. doi: [10.17140/DOJ-2-123](https://doi.org/10.17140/DOJ-2-123)**Copyright**

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The Potential Role of Systemic Calcium in Periodontal Disease

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Periodontal disease is a chronic inflammatory disease that affects the supporting structures of the tooth. While it is due to the interaction between a bacterial infection and host response, other factors such as genetics, diet and lifestyle choices are thought to contribute to the disease progression. Calcium is the most abundant mineral in the body. It is found in food, dietary supplements and some medications. There are many claims made as to calcium's health benefits. Both vitamin D and calcium are known to promote bone health and periodontal disease affects the alveolar bone. This paper reviews several studies have been conducted to determine if there are beneficial effects of the role of calcium in the risk and progression of periodontal disease. Studies looked at calcium intake, calcium in combination with periodontal maintenance or the effect of the levels of calcium in relation to periodontal disease. Intake of calcium was significantly and inversely associated with periodontal disease. This was in agreement with studies by several groups of researchers. Periodontal maintenance helps to maintain the effects of active periodontal therapy. Studies suggest that calcium supplementation be part of the periodontal maintenance. Other studies looked that decreased level of calcium may be a risk factor for the development of periodontal disease. While many studies have shown a beneficial effect, the complete role of calcium in the prevention or progression of periodontal disease still needs further research. Eventually, calcium may be added to the list of possible treatment supplementation for periodontal disease. The objectives of this review article will shade light on the relationship of calcium intake with the possible risk and progression of periodontal disease.

KEYWORDS: Calcium; Periodontitis; Vitamin D.**ABBREVIATIONS:** IOM: Institute of Medicine; RDA: Recommended Dietary Allowance; ULs: Upper intake levels; WHO: World Health Organization; CPR: Central Person Registry; COHSS: Copenhagen Oral Health Senior Study; DAHNES: Danish Health Examination Survey; KOMCHS: Kyushu Okinawa Maternal and Child Health Study; NHANES: National Health and Nutrition Examination Survey.**INTRODUCTION****PATHOGENESIS OF PERIODONTAL DISEASE AND CALCIUM'S ROLE IN HEALTH**

Periodontitis is a chronic inflammatory disease of the periodontium due to the interaction between a bacterial infection and the host response in a susceptible patient. It affects the supporting structures of the tooth: connective tissue, alveolar bone and periodontal ligament and results in loss of bone, bleeding and erythema of the gingival tissues and mobility of teeth with eventual tooth loss.¹ There is variability in the susceptibility of the patient which is re-

flected in the disease extent and severity. Approximately 30% of Americans display a moderate form of the disease and 10% have a severe form.² Methods of treating the disease include the mechanical removal of the bacteria, with or without antibiotic therapy, in combination with improved oral hygiene. Other factors have been suggested to contribute to disease development and progression, such as lifestyle choices: smoking, alcohol consumption, diet and genetic variability. Therefore, besides mechanical removal, other methods being explored to treat the disease include genetic therapy and changes in habits, both social and dietary.

Calcium is the most abundant mineral in the body. It is found in food, dietary supplements and present in some medications. Calcium is required for vascular, muscle, nerve functions and intracellular signaling. Serum calcium is regulated *via* cal-

citonin and the parathyroid hormone using the bone as a reservoir.³ According to the Institute of Medicine (IOM),⁴ the Recommended Dietary Allowance (RDA) for calcium range from 700 to 1300 mg/d for life stage groups of at least 1 year old, based on bone health. This was based on the calcium content of human breast milk for infants, calcium balance studies for those ages 1-50 years old and observation and clinical trial evidence for those older than 50 years. The tolerate Upper intake levels (ULs) range from 1000 to 3000 mg/d, depending on life stage group based on indicators including hypercalcemia, hypercalciuria, vascular and soft tissue calcification and nephrolithiasis. Table 1 summarizes the RDA and UL for calcium for gender and age.⁴ Food sources of calcium include dairy products, certain vegetables such as kale and broccoli and fortified foods.³ Table 2 lists food sources for calcium. There are many claims made as to calcium's health benefits in areas such as bone health or

Life stage group (age and gender)	RDA(mg/d)	UL(mg/d)
1-3 year, M+F	700	2500
4-8 year, M+F	1000	2500
9-13 year, M+F	1300	3000
14-18 year, M+F	1300	3000
19-30 year, M+F	1000	2500
31-50 year, M+F	1000	2500
51-70 year M	1000	2000
51-70 year F	1200	2000
71+ year, M+F	1200	1200

RDA: Recommended Dietary Allowances (intake that covers needs of $\geq 97.5\%$ of population)
UL: tolerable upper intake level (the highest daily median needs; indicates levels above which there is risk of adverse events)

Table 1: Calcium Dietary Reference.⁴

Food	Milligrams(mg) per serving	Percent DV
Yogurt, plain, low fat 8 oz	415	42
Mozzarella, part skim, 1.5 oz	333	33
Yogurt, fruit, low fat, 8 oz	313-384	31-38
Cheddar cheese, 1.5 oz	307	31
Milk, nonfat*, 8 oz	299	30
Soy milk, calcium-fortified, 8 oz	299	30
Milk, reduced fat (2% milk), 8 oz	293	29
Milk, buttermilk, lowfat, 8 oz	284	28
Milk, whole (3.25% milk fat), 8 oz	276	28
Orange juice, calcium-fortified, 6 oz	261	26
Cottage cheese, 1% milk fat, 1 cup	138	14
Frozen yogurt, vanilla, soft serve, ½ cup	103	10
Kale, raw, cooked, 1 cup	100	10
Kale, fresh, cooked 1 cup	94	9
Ice cream, vanilla, ½ cup	84	8
Bread, white, 1 slice	73	7
pudding, chocolate, ready to eat, refrigerated, 4 oz	73	7
Sour cream, reduced fat, cultured 2 tbl	31	3
Bread, whole-wheat, 1 slice	30	3
Cheese, cream, regular, 1 tbl	14	1

DV: Daily Value.

*Calcium content varies slightly by fat content; the more fat, the less calcium the food contains.

Table 2: Diet Chart for Calcium Intake.³

osteoporosis, cardiovascular disease, blood pressure regulation and certain cancers.³

Vitamin D and calcium are both known to promote bone health. Periodontal disease affects the alveolar bone. In our previous paper,⁵ we looked into the relationship between vitamin D and periodontitis, exploring the differences in the polymorphisms of the vitamin D receptor as well as effects associated with intake and concentration levels.

CALCIUM INTAKE IN RELATION TO PERIODONTAL DISEASE

A group of researchers in Denmark has done several studies looking at the intake of calcium in relation to periodontitis, plaque and tooth loss.⁶⁻¹⁰ The Danish Monica study (Monitoring Trends and Determinants in Cardiovascular Disease) is a prospective observational study from 1982-1983 to 1993-1994 conducted under the auspices of the World Health Organization (WHO) drawing from men and women (30-60 years old) living in Copenhagen County drawn from the National Central Person Registry (CPR). In one study (MONICA cohort study), they found that the intake of calcium below recommendations is associated with fewer teeth in both males and females. But that total and energy-adjusted calcium intakes were negatively associated with number of teeth and tooth loss in males only and after adjusting for confounders, the association remained moderately strong. However, it is unknown if the effect of dietary calcium is different in males and females and other factors may place a role in respect to tooth loss differences between the sexes, such as lifestyle choices.⁶ In another study by this group, which was an offshoot of the previous mentioned study (MONICA cohort study) they found that dairy calcium intake was associated with a decreased risk of tooth loss in both men and women and that in men this was still true after several adjustments such as age, education, smoking, alcohol, but in women it was only statistically significant after an adjustment for *Lactobacillus* count. Adjustment for total energy intake slightly attenuated the strength of the associations. The gender difference may be due to differential contribution of risk factors to the genders.⁷ Limitation of this study were the loss to follow up, lack of caries information and lack of data on calcium supplementation.⁷

A third study by these researchers was a cross-sectional study looking to see whether calcium intakes from dairy and non-dairy sources and absolute intakes of various dairy products were associated with periodontitis. They found that intakes of calcium and dairy foods were significantly and inversely associated with periodontitis while intakes of non-dairy calcium were not associated with periodontitis.⁸ These findings agree with earlier studies by Al-Zahrani MS¹¹ and Shimazaki Y et al.¹² Al-Zahrani MS found that intakes of dairy foods was inversely and significantly associated with periodontitis where periodontitis was defined as pocket depth ≥ 4 mm and attachment loss ≥ 3 mm. Shimazaki Y, et al. found that an increased intake of lactic acid/fermented foods was significantly associated with lesser mean pocket depth and attachment loss but no significant associations

were found with intakes of cheese, milk and other dairy foods. Limitation of this study was that it was a randomly selected subset of the study population from the Copenhagen Oral Health Senior Study (COHSS) and lack of detailed quantization of supplemental calcium intake.⁸

A cross-sectional study found that higher intakes of calcium and dairy servings are associated with lower plaque scores when vitamin D intakes are ≥ 6.8 $\mu\text{g}/\text{d}$. They believe that the better vitamin D intakes facilitate beneficial effects of higher calcium intakes, most likely by the enhancement of calcium absorption. But they cannot infer a causal relationship.⁹

This group of investigators performed another study investigating whether intakes of calcium, vitamin D, casein and whey were associated with periodontitis and the possibilities of interactions between them in relation to periodontitis.¹⁰ They used participants from the Danish Health Examination Survey (DAHNES, 2007-2008),¹³ which was a cross-sectional study in 13 out of 98 municipalities in Denmark, focusing on diet, smoking, alcohol and physical activity. Their final study population was 3,287 participants. This large population of men and women, age 18-95 years old is one of the strengths of the study and their findings may be generalizable to Western populations. They found that after adjusting for age, gender, education, smoking, sucrose intake, alcohol consumption, number of teeth, daily brushing, regular visits to the dentist and chronic illness that higher intakes of calcium, whey protein and casein were individually associated with a lower occurrence of severe periodontitis, but vitamin D intake was not directly associated with periodontitis. This finding that vitamin D intake alone was not associated with periodontitis differs from their earlier study⁹ and may be because vitamin D intakes were lower in this present study as compared to their earlier study. Other limitation of this study is its cross-sectional design and a lack of detailed information on calcium and vitamin D supplementation which may have resulted in an underestimation of calcium and vitamin D intake. While causality cannot be inferred because of the cross-sectional nature, it may be recommended that consumption of foods rich in calcium should be promoted and that further longitudinal studies should be conducted.¹⁰

Since calcium is found in dairy products, one study analyzed the relationship between periodontal condition and the detailed intake of dairy products in order to determine the type of dairy product that may have a beneficial effect on periodontal disease.¹² The dairy products were classified into 4 items: 1) milk (ordinary liquid, high-fat and low-fat milk), cheese, lactic acid foods (yogurt and lactic acid drinks) and other dairy products (skim milk and coffee whitener). They found that the intake of lactic acid foods was associated significantly with periodontal disease, especially in non-smokers. However, all the lactic acid foods available in Japan contain live lactic acid bacteria, including members of the genera *Lactobacillus* and *Bifidobacterium*. It has been reported that lactobacilli have a beneficial effect on health *via* their probiotic effect. The presence of the lactobacilli

is a difference between lactic acid foods and other dairy products, such as milk and cheese. Therefore, the beneficial effect the lactic acid foods have on periodontal disease may be based on the probiotic effect of the lactobacilli. Limitations of the study were that it was a cross-sectional design, the periodontal condition was not determined from six sites per tooth for the teeth present and dietary intake information was derived from a semi quantitative food frequency questionnaire. It is suggested that the routine intake of lactic acid foods may have some direct effect on periodontal disease. However, more studies need to be performed to determine the exact causal relationship between the two. This study¹² agrees with the earlier mentioned Danish study by Adegoye et al.⁸

A study in Japan assessed the relationship between calcium intake and prevalence of periodontal disease among young Japanese women.¹⁴ They used the data set from the Kyushu Okinawa Maternal and Child Health Study (KOMCHS). The KOMCHS is a prospective pre-birth cohort study looking into risk and preventive factors for maternal and child health problems. They found that a higher intake of calcium was independently associated with a lower prevalence of periodontal disease among young Japanese women. This is in partial agreement with the Third National Health and Nutrition Examination Survey (NHANES), that showed a significant inverse dose-response relationship between calcium intake assessed by a 24 hours diet recall and periodontal disease¹⁵ and a US cross-sectional study that reported an inverse correlation between dietary calcium intake assessed by a 24 hour dietary recall and periodontal index based on visual and radiographic data was borderline significant but serum calcium concentration was not significantly correlated.¹⁶ But is inconsistent by a German study that showed no associated between calcium intake assessed by means of a 7-day food record and periodontal disease.¹⁷

However, the previous studies were greatly different as well as the average calcium intake between Japanese and Western populations. Even though this study used a homogenous subject group in gender and age and was able to control for relevant confounding factors, there were several limitation. Limitations were that it was a cross-sectional design, they could not estimate participation rate, could not assess the differences between participants and non-participants because the information was not available, data on serum calcium concentrations were not available, it was unknown if intra- and inter-examiner consistency was established and periodontal disease prevalence may have been underestimated since they used a partial mouth recording. Despite the limitations, this study suggests that calcium intake may be associated with periodontal disease and that calcium intake may have beneficial effects even at the fairly low levels of intake in a Japanese diet. This study further supports for more calcium/periodontal disease studies.¹⁴

EFFECT OF CALCIUM LEVELS ON PERIODONTAL DISEASE

Via self-reported questionnaires, another study tried to

determine the levels of calcium and vitamin D oral supplementation in adult patients in university based, periodontal disease maintenance programs. They found that unlike calcium, there was no significant difference between men and women in the amount of vitamin D supplementation. Although benefits of calcium and/or vitamin D include strengthening the bone, stimulating an antimicrobial effect and providing an immunosuppressive effect, the authors feel that controlled studies need to be conducted to establish the extent of adequate intakes of calcium and vitamin D.¹⁸

Khalili and Biloklytska¹⁹ were evaluated the salivary calcium concentration, they was analyzing the whole unstimulated saliva of patients with early, moderate and severe generalized chronic periodontitis and healthy patients. They found that calcium concentration was related to the severity and disease progression of the three patient groups when compared to the healthy controls. They suggest that calcium concentration may be a risk factor in patients with generalized chronic periodontitis. However, more studies of salivary/serum ratio need to be done to find out the exact role of calcium concentration in generalized chronic periodontitis patients.¹⁹

A longitudinal study in Japan among the elderly, found a lower serum calcium/magnesium (Ca/Mg) ratio was significantly associated with periodontal disease progression in smokers over 6 years.²⁰ They had looked both into serum calcium and the Ca/Mg ratio. The serum calcium was significantly lower in smokers compared to the non-smokers. A high Ca/Mg ratio was significantly associated with fewer periodontal disease events. There was a clear dose-response relationship between the Ca/Mg ratio quartiles for periodontal disease events among the smokers. In non-smokers, there was no significant tendency between periodontal disease events and serum calcium level or Ca/Mg ratio. This study is partially differing from an earlier study by Meisel et al²¹ where an increase serum Mg/Ca ratio was significantly associated with less attachment loss and that periodontal parameters were inversely related to serum calcium concentrations. However, this study was cross-sectional. The discrepancy between the smokers and non-smokers may be due to the effects of smoking on the systemic immune response and homeostasis.²⁰

A study in India compared salivary calcium levels in Indian subjects with chronic, generalized periodontitis to healthy controls.²² They excluded smokers and tobacco chewers as well as those with systemic diseases, such as diabetes. Buffering capacity, pH and flow rate were not examined in the study. They collected unstimulated whole saliva, which predominantly bathes the oral cavity. However, this may be a limitation because unstimulated saliva it is difficult to standardize due to variance in local stimuli and daily variation. The mean salivary calcium level in the case group was significantly higher than in the control group. However, ethnicity can affect plaque composition and subgingival calculus and therefore periodontal disease and this study was performed in a group of ethnically similar subjects from western India. This study indicates that the calcium

level of saliva could possibly be an indicator for the development of periodontal disease, but more large scale prospective studies still need to be conducted.²²

According to the previous mentioned study,²² showing positive correlations between high salivary calcium content and periodontitis and another study²³ was showing a positive correlation between high salivary calcium content and chronic cigarette smoking, another group evaluated the existence of disturbances in calcium metabolism and absorption induced by smoking.²⁴ They quantitatively assessed the variations in salivary calcium level between non-smokers and smokers with periodontitis and relating to their periodontal status. They selected 50 male patients from the outpatients reporting to the Department of Periodontics, Yenepoya Dental College (YDC) & Hospital Mangalore and divided them into two groups: smokers (Group I) vs. non-smokers/non-tobacco users (Group II), all with chronic generalized periodontitis. They found that the mean calcium content of the saliva was significantly higher for Group I as compared to Group II. This suggests an existence of an altered calcium metabolism and absorption among periodontitis patients and is more pronounced in smokers. This finding agrees with other studies by Sevon, et al.²⁵ and Macgregor, et al.²³ though the assessment was done using stimulated saliva as opposed to whole saliva as in this study. Kiss, et al.²⁶ found a positive correlation in female smoker patients with periodontitis and higher salivary calcium, but it may be an influence of the hormonal shifts shown in females. Group I also had higher calculus scores emphasizing that plaque sample with increased calcium content mineralizes quickly and showed increased periodontal pockets. Elevated salivary calcium in smokers adds another reason how smoking plays a role in the progression of periodontitis. It seems that salivary calcium plays a significant role in regard to calculus formation and level of attachment, as shown in this study. Limitations of this study are that the severity of periodontitis was not standardized and serum calcium level was not assessed.²⁴

Another study from India looked for any influence of calcium and vitamin D supplementation in periodontitis treatment outcome in otherwise healthy subjects whose serum calcium and vitamin D levels are in the normal range.²⁷ The primary objective was to evaluate the effect of vitamin D and calcium supplementation in the management of periodontitis. A secondary objective was to assess whether calcium and vitamin D oral supplementation influences alveolar density. It was a non-randomized clinical trial, where both groups received full mouth prophylaxis, subgingival scaling, root planning and curettage and then one group also received 500 mg calcium and 250 IU vitamin D supplementation for 3 months. Both groups showed significant change in the periodontal parameters and bone density after 3 months with highly significant results for the supplementation group. These results strongly recommend that calcium and vitamin D can be given as an adjunct to scaling and root planning for better periodontal outcomes and that vitamin D and calcium supplementation has a got a slight positive effect in the periodontal treatment. Limitations of the study were the

3 months time frame and that medically compromised subjects with periodontitis were not included.²⁷

CALCIUM IN COMBINATION WITH PERIODONTAL MAINTENANCE

Periodontal maintenance is important in sustaining the results after active periodontal therapy. Patients are often scheduled for maintenance at regular intervals. One study by Miley DD, et al.²⁸ looked to see whether the use of calcium and vitamin D oral supplementation by those in a periodontal disease maintenance program would have an impact on clinical parameters of periodontal health. They found that all the periodontal parameters assessed (gingival index, probing depth, attachment loss, bleeding on probing, furcation involvement) were worse in those who did not take oral supplementation compared to those who did. However, it has been argued that taking supplementation reflects better general health. This study suggests that calcium and vitamin D supplementation should be part of maintenance programs. However, more longitudinal studies need to be done.²⁸

As a follow up to this study, the group tried to determine if such differences persisted over one year in the same study population.²⁹ They looked at plaque index, gingival index, calculus index probing depth, Cementoenamel junction-gingival margin distance (CEJ-GM attachment loss), bleeding upon probing and furcation involvement and found that all the clinical parameters were worse in the non-takers at baseline and mostly remained worse throughout the study. However, adjusting for 4 covariates (race, smoking, alcohol and gender), the results changed marginally with the effect of taking the supplements significant at baseline, decreasing to borderline at 6 months and then decreasing again to not significant at 12 months. A weakness of the pilot study was the inclusion of patients with minimal attachment loss and bone loss and also the number of patients (23 out of 51) taking relatively low amounts of vitamin D (≥ 400 international units/day). While data from this pilot study cannot support/refute recommendation for higher doses of vitamin D supplementation, it may imply that vitamin D supplements may reduce the severity of periodontal disease if used in doses higher than those currently in supplements, supporting the need for more randomized clinical trials on the effects of vitamin D on periodontitis.²⁹

CONCLUSION

Calcium in the human bodies found in the bones and teeth. Periodontal disease affects the alveolar bone that supports the teeth. The disease is a complex relationship between host, bacterial, behavioral and environmental factors. The intake of food and nutrients, such as calcium has been shown to play a role in this complex relationship. However, further studies to elucidate the role of calcium in periodontal disease progression still need to be done.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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