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## Osteoporosis and Periodontal Disease: Association and Mechanisms

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### Review Article

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#### ABSTRACT

Systemic bone loss has been proposed as a risk factor for periodontal disease with increasing evidences that osteoporosis and the underlying loss of bone mass characteristic of this disease is associated with periodontal disease and tooth loss. Periodontal disease is a microbial infection, but the exact etiology of the disease may be multi-factorial. Risk factors associated with periodontal disease include accumulation of dental plaque and host-response abnormalities, involving smoking and many systemic diseases like diabetes, respiratory diseases, cardiovascular diseases, adverse pregnancy outcome and osteoporosis.

### INTRODUCTION

Periodontal disease and osteoporosis are multifactorial in their etiology and involve a large strata of the population in India and all over the world. Osteoporosis is a systemic skeletal disease characterized by low bone mass and micro-architectural deterioration of the bone scaffold that results in increased bone fragility and susceptibility to fractures <sup>[1]</sup>. In osteoporosis, the bone mineral density (BMD) is reduced, bone micro-architecture is disrupted and the amount and variety of non-collagenous proteins in bone is altered <sup>[2]</sup> while, periodontitis is an inflammation of the supporting tissues of the teeth, usually leading to loss of bone and periodontal ligament and is a major cause of tooth loss and edentulousness in adults <sup>[3]</sup>. Systemic loss of bone density in osteoporosis including that of the jaw may provide a host system that is increasingly susceptible to infectious destruction of periodontal tissues <sup>[4]</sup>. Loss of alveolar bone is a prominent feature of periodontal disease while severe osteoporosis could be suspected of being an aggravating factor in cases of excessive periodontal destruction. It has been hypothesized that the breakdown of periodontal tissue may, in part, be related to systemic conditions that also predispose the patient to osteoporosis/osteopenia <sup>[5]</sup>.

Osteoporosis: Classification: Osteoporosis means literally “porous bone”, a condition, where there is “too little bone” to provide mechanical support. Osteoporosis was once thought to be a part of a natural aging process in women. Today, it is not considered to be age dependent or gender specific <sup>[6]</sup>. Osteoporosis is defined as a skeletal disorder characterized by compromised

bone strength predisposing an individual to an increased risk of fractures <sup>[7,8]</sup>. Bone strength primarily reflects the integration of bone density and bone quality. Bone density is expressed as grams of mineral per unit area or volume, and in any given individual, is determined by peak bone mass and amount of bone loss. Bone quality refers to architecture, turnover, damage accumulations (Example: Microfractures) and mineralization. The standard deviation is determined by certain established criteria namely: T-score which is defined as the number of standard deviations above or below the average bone mineral density (BMD) value for young healthy white women and Z-score which is defined as the number of standard deviations above or below the average BMD for age and sex matched controls (**Table 1**).

**Table 1.** Following classification is based on standard deviation.

<b>World Health Organization ( WHO ) Diagnostic Guidelines for Interpretation of Bone Mass Measurements in Caucasian Women <sup>[8]</sup></b>
1. <b>Severe osteoporosis:</b> Bone mineral density (BMD) more than 2.5 standard deviations (SD) below the mean value of peak bone mass in young women and the presence of fractures.
2. <b>Osteoporosis:</b> BMD more than 2.5 SD below the mean value of peak bone mass in young normal women.
3. <b>Low bone mass (osteopenia):</b> BMD within -1 SD and -2.5 SD of the mean value of peak bone mass in young normal women.
4. <b>Normal:</b> BMD not more than 1 SD below mean value of peak bone mass in young normal women.

The various methods for assessing bone are as follows <sup>[9,10]</sup>

A) Systemic bone:

a) Absorptiometry

- Single photon absorptiometry
- Dual photon absorptiometry

b) Dual Energy X-Ray Absorptiometry (DEXA)

c) Quantitative Computed Tomography (QCT)

d) Measurement from radiographs

- Measurement of cortical thickness and other indices
- Fractal dimension

e) Ultrasound

B) Intra-oral Sites (Research tools):

a) Adaptation of absorptiometry or DEXA

b) Measurement from panoramic films

c) Cortical thickness and other indices

d) Measurement from intra-oral films

e) Measurement of bone or ridge height

f) Apparent bone density expressed as arbitrary units based on the reference wedge

g) Digital subtraction radiography (changes in bone height (mm) or density ( $\text{mg}/\text{mm}^2$ ))

h) Fractal dimension

i) Microdensitometry

j) Pixel intensity analysis

Co-risk factors for osteoporosis and periodontal disease: Osteoporosis and periodontal disease share common risk factors. Prevalence of both osteoporosis and tooth loss increase with advancing age in women. Risk factors for osteoporosis can be divided into non-modifiable and modifiable risk factors. The non-modifiable risk factors for osteoporosis include gender, age, early menopause, small body frame, race and heredity while lack of calcium and vitamin D, lack of exercise, smoking and alcohol consumption are modifiable risk factors. In addition, there are other risk factors such as diabetes, diet and hormone levels that affect systemic bone level and may also affect periodontitis <sup>[11]</sup>. While the pathogenesis of osteoporosis and periodontitis differ, these diseases, are thought to share several common risk factors as depicted below (**Table 2**).

**Osteoporosis-Prevention Strategies:** It is important to identify the risk factors for individual patients and develop preventive strategies for them. There are general principles and recommendations for prevention formulated by the National Osteoporosis Foundation.

**Table 2.** Risk factors for Osteoporosis and Periodontal Diseases <sup>[12,13]</sup>

	<b>Osteoporosis</b>	<b>Periodontal disease</b>
<b>Hereditary/genetics</b>	Female gender Caucasian/ Asian race Family history Menopause Petite body build Suboptimal peak bone	Age Race Familial aggregation IL-1 polymorphism
<b>Dietary factors</b>	Low intake of calcium Low intake of vitamin D High intake of caffeine, protein, salt, phosphate	Low intake of Calcium Low intake of vitamins C, E, A, selenium
<b>Environment</b>	Smoking Alcohol Physical inactivity	Smoking Alcohol Stress
<b>Systemic factors</b>	Diabetes mellitus Multiple myeloma Connective tissue diseases	Diabetes mellitus Osteoporosis Hormonal changes

1. All women should be counselled on the risk factors.
2. An evaluation of bone mineral density should be performed on all post-menopausal women who present with fractures to determine the diagnosis and disease severity.
3. Bone mineral density testing is recommended for all post-menopausal women younger than 65 years, who have one or more risk factors for osteoporosis in addition to menopause.
4. Bone mineral density testing is recommended for all women 65 years and older regardless of additional risk factors.
5. All diagnosed patients are counselled to obtain an adequate dietary intake of calcium.
6. Regular weight bearing and muscle strengthening exercises to reduce the risk of falls and fractures are recommended.
7. Patients should be advised against smoking and smoking cessation should be implemented.
8. Alcohol intake should be at a moderate level (about one drink per day for women and two drinks per day for men).
9. All post-menopausal women who present with hip fractures or vertebral fractures should be considered candidates for osteoporosis treatment.

Pharmacological options for osteoporosis prevention and treatment include Hormone Replacement Therapy (HRT), alendronate, and raloxifene for prevention and calcitonin for treatment <sup>[14]</sup>. Clinicians, including dentists, should inform and motivate the public to make and sustain life style changes relating to exercise, diet, tobacco, and alcohol use. The National Osteoporosis Foundation as well as the National Academy of Sciences recommends a daily intake of 1200 mgs of dietary calcium and 400-800 IU of vitamin D. Tobacco use should be discouraged and current smokers should be encouraged to quit on their own or participate in smoking cessation programmes. Counselling and treatment should be offered to patients with excessive alcohol consumption as part of the life style modifications to prevent osteoporosis <sup>[15]</sup>. The beneficial effects of physical activity and weight bearing exercises have been well documented <sup>[16-18]</sup>.

Chemotherapeutic agents for treatment of osteoporosis and oral bone loss: Several pharmacological agents are available to increase bone mineral density and therefore treat or prevent osteoporosis. They include Hormone Replacement Therapy (HRT), bisphosphonates, calcitonin, selective estrogen receptor modulators, parathyroid hormone or combination of these agents. There is sufficient evidence in the literature to demonstrate that depending on the drug and the patient population, treatment reduces the risk of vertebral fractures by 30-65% and non-vertebral fractures by 46-53% <sup>[19]</sup>.

Mechanism of association between osteoporosis and periodontitis: Mechanisms by which osteoporosis or systemic bone loss may be associated with periodontal attachment loss, loss of alveolar bone height and tooth loss continue to be explored. First, low bone mineral density in the oral bone may be associated with low systemic bone. This low bone density or loss of bone mineral density may lead to a rapid resorption of alveolar bone along with periodontal disease caused by periodontal bacteria as it intensifies the bone loss. Second, systemic factors affecting bone remodeling may also modify local tissue response to periodontal infections. Individuals with systemic bone loss are known to have increased systemic production of cytokines (i.e. Interleukin-1 and Interleukin-6) that may have an effect on bone throughout the body, including the bones of oral cavity. Periodontal infection has been shown to increase the local cytokine production that, in turn, increases local osteoclast activity resulting in increased bone resorption. Third, genetic factors that predispose a person to systemic bone loss also influence or predispose a person to periodontal destruction. Lastly, certain lifestyle factors such as cigarette smoking and suboptimal calcium intake, amongst others, may put individuals at risk for development of both osteopenia and periodontal disease <sup>[20]</sup>. It has been hypothesized that osteoporosis may cause decreased alveolar bone density, which in turn, may be more susceptible to resorption by the effect of co-existing or subsequent periodontal infection and inflammation <sup>[21]</sup>.

### **Dietary calcium and vitamin D supplementation**

Effects of dietary calcium and vitamin D have been widely studied. Nishida et al. surveyed the dietary intake of calcium and periodontal examination on 12,000 adults. It was found that there was inverse association between dietary calcium intake and level of periodontal disease, controlling for smoking and age. The prevalence of periodontal disease was 30% to 60% higher, depending on gender, in individuals with calcium intake below 800 mgs compared to those with calcium intake above 88 mgs. While this data supports a link between low dietary calcium and higher prevalence of periodontal disease, limitations of the study included the lack of information on the contribution of calcium supplements to total calcium intake and the cross-sectional design<sup>[22]</sup>. Again, a study by Richard et al. concluded that estrogen supplementation may lower gingival inflammation and rate of clinical attachment loss in osteopenic/osteoporotic population<sup>[23]</sup>.

Future research: Currently marketed osteoporosis therapies including bisphosphonates and selective estrogen modulators are efficacious but inconvenient for the patients because of the need for frequent administration and the risk of adverse effects. The active immunization strategy against TRANCE/RANKL using C-TRANCE-VLPs may offer a safe, efficient and cost-effective new therapeutic option for the treatment of osteoporosis<sup>[24]</sup>.

## **CONCLUSION**

The effects of osteoporosis on both systemic health and oral health need to be well understood. As a health care provider, the dentist could serve as a pre-screener of patients with the potential for osteopenia or osteoporosis. Familiarity with the risk factors could help identify these individuals and aid in an earlier diagnosis and immediate treatment required.

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