The Association Between Postmenopausal Osteoporosis and Periodontal Disease

Isaac S. Gomes-Filho,* Johelle de S. Passos,* Simone S. Cruz,* Maria Isabel P. Vianna,† Eneida de M.M. Cerqueira,‡ Denise C. Oliveira,* Carlos Antônio S.T. dos Santos,* Julita Maria F. Coelho,* Fábio P. Sampaio,* Camila O.T. Freitas,* and Nelson F. de Oliveira*

Background: The clinical importance of systemic bone loss as a contributory factor to alveolar bone loss and the subsequent loss of teeth merits further study, given that osteoporosis and periodontal disease lead to significantly increased morbidity and mortality and higher public expenditure of funds. This case-control study evaluated the association between osteoporosis and periodontal disease.

Methods: The sample consisted of 139 postmenopausal women: 48 in the case group (with periodontal disease) and 91 in the control group (without periodontal disease). The diagnosis of periodontal disease was established following a complete clinical examination using measurements of probing depth, gingival recession and hyperplasia, clinical attachment loss, and bleeding index, and confirmed by panoramic radiography. The diagnosis of osteoporosis was made by reviewing densitometry reports obtained previously. Descriptive, stratified, and logistic regression analyses were applied to the data collected. Comparison of proportions was performed using the χ^2 and Fisher tests. Association measurements (odds ratios [ORs]) with and without adjustment for confounding factors and control for effect modifiers were obtained at a significance level of 5%.

Results: The $OR_{unadjusted}$ for the principal association was 2.58 (95% confidence interval [CI]: 1.01 to 6.82). In subgroup analyses of the stratified model, the $OR_{unadjusted}$ for low education was 6.40 (95% CI: 1.77 to 23.18). When adjusted for smoking habit and age, the $OR_{adjusted}$ was 7.05 (95% CI: 1.90 to 26.19), which also was statistically significant.

Conclusion: Postmenopausal women with osteoporosis and low educational levels have a greater chance of having periodontal disease than do those without osteoporosis. *J Periodontol 2007;78:1731-1740.*

KEY WORDS

Epidemiology; osteopenia; osteoporosis, postmenopausal; periodontal disease.

* Department of Health, Feira de Santana State University, Feira de Santana, BA, Brazil.
† Department of Social Dentistry, Federal University of Bahia, Salvador, BA, Brazil.
‡ Department of Biological Sciences, Feira de Santana State University.

The aging of the Brazilian population is one of the major public health challenges today. It has been stimulated by a process of demographic and epidemiologic transition that has resulted in a gradual change in mortality and fertility levels with resultant increases in life expectancy. This has been accompanied by changes in the patterns of health service use and steep increases in public costs.

The interconnection of socioeconomic conditions and social vulnerability with regard to aging is reflected in precarious states of health with prominence of high rates of osteoporosis and periodontal disease. These diseases are recognized as chronic and closely related to advanced age and have been highlighted within public health because of their impact caused by bone fractures and tooth loss. This situation becomes even more worrisome, given the possibility that these diseases may be related because they share common etiological agents that could affect or modulate their natural history.[1,2]

Osteoporosis is characterized by low bone mass and deterioration of the microarchitecture of the skeletal tissue, thus compromising trabecular and cortical bone material.[3] A variety of risk factors for the development of osteoporosis have been identified, thereby enabling early

doi: 10.1902/jop.2007.070057

identification of groups that are susceptible to this disease. Prominent among these are age, gender, race, estrogen deficiency, menopause, nutritional factors, body mass, heredity, physical activity, smoking habit, alcohol consumption, and some medications.[4,5]

In addition to these characteristics, osteoporosis has been shown to be a risk indicator that may contribute to the progression of periodontal disease.[6-9] When untreated, periodontal disease may lead to total destruction of the alveolar bone tissue accompanied by tooth loss. This discontinuous bone reabsorption characterizes periodontal disease as a locally specific clinical entity with periods of activity and quiescence.[10]

Given the multifactorial nature of periodontal disease, certain systemic conditions, e.g., osteoporosis, seem to be indicated as additional factors that predispose to this disease.[11] However, the individual's vulnerability to periodontal disease also must be considered because osteoporosis would not be the initial cause, but could affect its course through modification of the alveolar and trabecular bone tissue. This would put a host with uncontrolled inflammatory periodontal conditions into an even more fragile state.[1]

Some studies[12-15] indicated that osteoporosis at the oral level may be associated with alveolar bone loss, especially in the mandible. The association between osteoporosis and oral conditions also may include periodontal disease with excessive reabsorption of the alveolar margin, tooth loss, and fractures.[16-18]

Although some studies[7,9,19-21] that attempted to correlate osteoporosis with periodontal disease obtained significant results, others[22,23] did not. Within this perspective, the present study aimed to investigate the possible association between osteoporosis and periodontal disease among postmenopausal women.

MATERIALS AND METHODS

Study Sample

Postmenopausal women ≥50 years of age who had gone to the Human Reproduction Assistance and Research Center, Feira de Santana, BA, Brazil, to undergo densitometry tests were approached and invited to have their oral condition assessed and to have any dental treatment necessary performed at Feira de Santana State University. Those who were interested were given referrals and received further information about the study protocol. If they accepted this offer, they signed a statement of free and informed consent to authorize their inclusion in the research. This study was approved by the Research Ethics Committee of the Science Development Foundation of Bahia, Salvador, BA, Brazil (protocol 047/2005).

Among the 174 women who sought assessment of their oral condition between June and November 2006, 35 were excluded from this study sample because they had diabetes (12), total edentulism (seven), less than four teeth in their mouth (five); had been menopausal for <1 year (10); or dropped out (one). Thus, the final sample consisted of 139 postmenopausal women who fulfilled the following eligibility criteria: aged ≥50 years; densitometry report produced ≤6 months earlier; in the postmenopausal phase for ≥1 year; at least four teeth; and did not have any systemic disease that might interfere with the inflammatory response, immune system, or bone metabolism, e.g., diabetes, renal insufficiency, or bone lesions (tumor or osteomyelitis) in the dental arches.

In this case-control study, the case group (N = 48) was composed of postmenopausal women who had periodontal disease, whereas the control group (N = 91) was composed of postmenopausal women without periodontal disease. The sample size had been estimated using a confidence interval (CI) of 95% and a power of 80% with a statistical software program,§ following the established osteoporosis prevalence rates of 17% for controls and 39% for cases.[9]

Data Collection Procedures

The postmenopausal women answered a questionnaire relating to sociodemographic, biologic, and lifestyle factors, such as age, race, income, education level, physical activity, calcium intake, smoking habit, alcohol consumption, age at menarche, age at menopause, time since menopause, parity, medical history, medications used, and oral habits.

Next, the women underwent a complete clinical periodontal examination including panoramic radiographs. All of the clinical measurements were obtained by a single examiner who was unaware of the woman's bone mineral density. The reproducibility and concordance of the clinical measurements were calculated by means of intra- and interexaminer κ indices.[24] For this, 10% of the participants underwent clinical periodontal reexamination by two examiners (the principal examiner and the gold standard examiner). First, the principal examiner made measurements on the individual; this examiner repeated the measurements within 1 week (intraexaminer evaluation). A substantial agreement[25] in the reproducibility of the clinical measurements of probing depth and recession/hyperplasia was noted, with κ values of 0.6017 and 0.6863, respectively, based on World Health Organization (WHO) standards.[26] The gold standard examiner also made these clinical measurements, which were compared to those from the principal

§ Epi-Info, version 6.04, Centers for Disease Control and Prevention, Atlanta, GA.

examiner to evaluate the interexaminer concordance. A substantial agreement in probing depth and recession/hyperplasia was noted, with κ values of 0.6080 and 0.6671, respectively.

Densitometry reports on the participants were requested to determine osteoporosis diagnoses; some of the information in these reports was extracted, e.g., weight, height, bone mineral density (g/cm^2), and T scores. The weight and height were used to calculate the body mass index (BMI).

The periodontal condition was evaluated by means of the clinical attachment loss measurement. This was obtained as the sum of the probing depth and recession measurements at six sites per tooth: mesio-vestibular, medio-vestibular, disto-vestibular, mesio-lingual, medio-lingual, and disto-lingual. The probing depth was recorded as the distance from the gingival margin to the most apical extent of probe penetration. Measurements of the height of the gingival margin in relation to the cemento-enamel junction were made using the same periodontal Williams probes‖ used for determining the probing depth. In cases of gingival recession, the reading in millimeters was taken to be positive, and the gingival margin was located apically to the cement-enamel junction. In addition to this, the bleeding on probing index was determined at the above-mentioned sites while obtaining the probing depth, by observing whether bleeding was present within 10 seconds after removing the graduated probe from the pocket or sulcus.

Diagnosis of Periodontal Disease

Identification of the cases and controls was provided by the clinical-radiographic diagnosis of periodontal disease, in accordance with the recommendations of Madianos et al.,[27] which were adapted as follows. After the clinical periodontal evaluation, radiographs were used only to confirm the clinical analysis. The women were considered to have periodontitis if they had at least four teeth with one or more sites having a probing depth ≥4 mm with clinical attachment loss ≥3 mm at the same site and bleeding on probing.[28] In borderline situations, in which the clinical descriptors came close to the criteria established but were insufficient to conclude that the individual had periodontitis (considering that a variety of local factors might impede correct evaluation of the descriptors, such as excessive dental calculi), radiographs were used to define the presence of periodontal disease. Periodontitis was considered to be present radiographically when the individual had periodontal bone reabsorption in four or more teeth, at one or more sites, ≥3 mm apical to the cemento-enamel junction.[29] The examiner was unaware of the individual's radiographic condition during the collection of clinical data, and the evaluation between clinical and radiographic findings was performed subsequent to the periodontal clinical analysis.

Diagnosis of Osteoporosis

The diagnosis of osteoporosis was verified from the densitometry reports, and the criteria were those established by WHO at the Consensus Development Conference.[30] Osteopenia was defined as a bone mineral density T score (difference between the measured bone mineral density and the mean value for young white women in standard deviations [SDs]) of less than –1 SD or at least –2.5 SD. Osteoporosis was defined by a bone mineral density T score of less than –2.5 SD. Individuals were considered to be normal when the T score was at least –1 SD in one of the two segments analyzed (proximal femur and/or lumbar column). The individuals with osteopenia were grouped with those with osteoporosis to form an osteopenia/osteoporosis group representing low mineral density.

Data Analysis

A descriptive analysis of the principal independent variable (osteopenia/osteoporosis) and all covariables considered to be of interest was performed. For the categorical covariables, simple frequencies were obtained, and statistical differences were evaluated using the χ^2 and Fisher tests, with a significance level of 5%. The cut-off points for the covariables of age, age at menopause, age at menarche, time since menopause, BMI, number of children, number of people living in the home, and education were established by examining their distribution and, therefore, were based on median values. In the case of continuous periodontal variables, the *t* test was used to compare the groups.

Stratified analysis was applied to investigate which covariables were candidates to be effect modifiers, by means of stratum-specific measurements and the Breslow-Day test, with a significance of 20%. Analysis of possible confounding factors was performed by investigating simultaneous associations of the covariable with periodontal disease in non-exposed individuals (without osteoporosis) and with osteoporosis in healthy individuals (without periodontal disease).[31]

Logistic regression analysis was used to measure the association between osteoporosis and periodontal disease using odds ratios (ORs), assuming a 95% CI. The presence of effect-modifying covariables was investigated using the likelihood ratio test, with the significance level set at 5%. The backward strategy was used, in the logistic regression analysis of non-conditional type. Theoretical and empirical bases were considered in selecting potential confounding

‖ Hu-Friedy, Chicago, IL.

variables, which were taken to be the factors that would produce an alteration in the association measurement of ≥10%.[32]

After defining the final model, its goodness of fit was determined by the Hosmer-Lemeshow test, and its discriminating power was determined by calculating the area under the receiver operating characteristic curve.

Data analysis was performed using statistical software programs.¶#**

RESULTS

Descriptive Analysis

The general characteristics of the sample are shown in Table 1. The mean age of the postmenopausal women was 58.8 ± 6.4 years and the median was 58 years. Their mean age at menopause was 46.7 ± 5.2 years and median was 48 years. No statistically significant differences between the case and control groups were detected for any characteristic except for the number of children ($P = 0.03$) and the presence of osteopenia/osteoporosis ($P = 0.03$). It was observed that 71.9% of the postmenopausal women had osteopenia/osteoporosis; this proportion was greater in the case group (83.3%) than in the control group (65.9%).

Table 2 shows that no statistically significant differences between the case and control groups were detected for any of the oral conditions and lifestyle characteristics considered in this investigation.

The periodontal condition variables are presented in Table 3. The mean clinical attachment loss, probing depth, and bleeding on probing were significantly greater in the case group than in the control group ($P < 0.001$). In relation to the plaque index, there were no significant differences between the groups.

Logistic Regression Analysis

Table 4 presents the measurements for the association between osteoporosis and periodontal disease: unadjusted OR for the overall association and for education and with adjustment for age and smoking. The unadjusted OR for the principal association was 2.58 (95% CI: 1.01 to 6.82), thus showing a statistically significant association between osteoporosis and periodontal disease. Even after adjustment for age and smoking, the OR remained statistically significant ($OR_{adjusted} = 2.71$; 95% CI: 1.12 to 6.55). These findings were supported by the descriptive analysis of the periodontal condition, in which central trend and dispersion values of the clinical descriptors are presented for cases and controls (Table 3).

The postmenopausal women with ≤4 years of education who had osteoporosis presented 6.4 times more chance of having periodontal disease than did those without osteoporosis ($OR_{unadjusted} = 6.40$; 95% CI: 1.77 to 23.18). $OR_{adjusted}$ was 7.05 (95% CI: 1.90 to 26.19), and it also was statistically significant. Conversely, the postmenopausal women with >4 years of schooling who had osteoporosis presented a 52% less chance of having periodontal disease ($OR_{unadjusted} = 0.48$; 95% CI: 0.11 to 2.03) than did those without osteoporosis. $OR_{adjusted}$ was 0.50 (95% CI: 0.11 to 2.05). Although the osteoporosis findings indicated protection in the higher schooling level subgroup, this factor did not reach statistical significance.

DISCUSSION

The principal finding from this study indicated that postmenopausal women with osteoporosis had more chance of developing periodontal disease than did those without osteoporosis. This is corroborated by the findings of many investigations.[7,9,19-21,33,34] Conversely, other studies[22,23,35,36] on this subject did not find any association between bone mineral density and periodontal disease.

Some points from our study should be highlighted. Although the statistical power of the study was set at 80%, we were able to detect a significant positive association between osteoporosis and periodontal disease, even after adjustment for age and smoking. This indicated that the power adopted for this study was sufficient for rejection of the nullity hypothesis.

However, with regard to the association measurement and its confidence interval in the subgroup analysis, there is a need to increase the numbers of cases and controls to make the sample more appropriate for testing the hypothesis. It should also be stressed that there was some difficulty in obtaining an eligible sample, given the exclusion criteria. These need to be reviewed, considering that among postmenopausal women, aging is accompanied by increases in morbidity due to chronic diseases. Thus, the generalization from the data also is limited in this respect.

The variety of information obtained in relation to socioeconomic conditions, health, and lifestyle defined the profile of the postmenopausal women in this study. It is recognized that bone mineral density may be influenced by factors relating to individuals, their daily lives, and their dietary habits.[17]

Another important point regarding association studies is that effect and outcome measurements need to be precise. To ensure the reliability of the exposure measurement (osteoporosis) and to avoid false-positives as much as possible, all of the densitometry tests were performed at the same osteoporosis diagnosis service, using the same equipment and

¶ SPSS, version 10, SPSS, Chicago, IL
# Epi-Info, version 6.04.
** R, version 2.3.1, Bell Laboratories, Vienna, Austria.

Table 1.

General Characteristics of the Study Population

Characteristics	Controls (N = 91)	Cases (N = 48)	Total (N = 139)	*P* Value*
Age (years)				
≤58 (N [%])	48 (52.7)	27 (56.3)	75 (54.0)	
>58 (N [%])	43 (47.3)	21 (43.7)	64 (46.0)	0.69
Mean ± SD	58.6 ± 6.1	59.2 ± 6.9	58.8 ± 6.4	
Median	58	57.5	58	
Range	50 to 73	51 to 80	50 to 80	
Age at menarche (years)				
≤13 (N [%])	47 (51.6)	25 (52.1)	72 (51.8)	
>13 (N [%])	44 (48.4)	23 (47.9)	67 (48.2)	0.96
Mean ± SD	13.5 ± 1.9	13.1 ± 1.7	13.3 ± 1.8	
Median	13	13	13	
Range	9 to 17	9 to 16	9 to 17	
Age at menopause (years)				
≤48 (N [%])	52 (57.1)	29 (60.4)	81 (58.3)	
>48 (N [%])	39 (42.9)	19 (39.6)	58 (41.7)	0.71
Mean ± SD	46.9 ± 5.4	46.5 ± 4.8	46.7 ± 5.2	
Median	48	48	48	
Range	34 to 61	34 to 56	34 to 61	
Time since menopause (years)				
≤11 (N [%])	48 (52.7)	24 (50.0)	72 (51.8)	
>11 (N [%])	43 (47.3)	24 (50.0)	67 (48.2)	0.76
Mean ± SD	11.9 ± 8.0	11.9 ± 7.3	11.9 ± 7.7	
Median	11	11	11	
Range	1 to 45	2 to 31	1 to 45	
Type of menopause				
Natural (N [%])	54 (59.3)	34 (70.8)	88 (63.3)	
Surgical (N [%])	37 (40.7)	14 (29.2)	51 (36.7)	0.18
Marital status				
Single/separated/divorced (N [%])	19 (20.9)	12 (25.0)	31 (22.3)	
Married/living with partner (N [%])	49 (53.8)	18 (37.5)	67 (48.2)	0.24
Widowed (N [%])	23 (25.3)	18 (37.5)	41 (29.5)	0.66
Skin tone				
Black (N [%])	28 (30.8)	18 (37.5)	46 (33.1)	
White/yellow (N [%])	26 (28.6)	8 (16.7)	34 (24.5)	0.14
Brown (N [%])	37 (40.6)	22 (45.8)	59 (42.4)	0.85
Nulliparous				
No (N [%])	83 (91.2)	43 (89.6)	126 (90.6)	
Yes (N [%])	8 (8.8)	5 (10.4)	13 (9.4)	0.75
Children (N)†				
≤5 (N [%])	55 (66.3)	20 (46.5)	75 (59.5)	
>5 (N [%])	28 (33.7)	23 (53.5)	51 (40.5)	0.03
Mean ± SD	5.2 ± 2.8	5.7 ± 3.2	5.4 ± 2.9	
Median	4	6	5	
Range	1 to 14	1 to 14	1 to 14	
Family income (N [%])				
≥1 minimum monthly salary	84 (92.3)	44 (91.7)	128 (92.1)	
<1 minimum monthly salary	7 (7.7)	4 (8.3)	11 (7.9)	0.89

Table 1. (continued)

General Characteristics of the Study Population

Characteristics	Controls (N = 91)	Cases (N = 48)	Total (N = 139)	*P* Value*
Source of own income (N [%])‡				
Formal/informal work	24 (40.0)	9 (26.5)	33 (35.1)	
Pension	36 (60.0)	25 (73.5)	61 (64.9)	0.19
Education (years)§				
>4 (N [%])	34 (37.8)	20 (41.7)	54 (39.1)	
≤4 (N [%])	56 (62.2)	28 (58.3)	84 (60.9)	0.66
Mean ± SD	6.1 ± 3.4	5.9 ± 3.7	6.0 ± 3.5	
Median	4	4	4	
Range	0 to 14	0 to 14	0 to 14	
People living in the home (N)§				
≤3 (N [%])	48 (52.7)	30 (63.8)	78 (56.5)	
>3 (N [%])	43 (47.3)	17 (36.2)	60 (43.5)	0.21
Mean ± SD	3.7 ± 2.1	3.1 ± 1.5	3.5 ± 1.9	
Median	3	3	3	
Range	1 to 12	1 to 7	1 to 12	
BMI (kg/m^2)§				
≤25 (N [%])	53 (58.9)	32 (66.7)	85 (61.6)	
>25 (N [%])	37 (41.1)	16 (33.3)	53 (38.4)	0.37
Mean ± SD	25.9 ± 5.5	24.7 ± 4.1	25.5 ± 5.1	
Median	25	24	25	
Range	18 to 56	18 to 37	18 to 56	
Hyperparathyroidism (N [%])				
No	88 (96.7)	48 (100)	136 (97.8)	
Yes	3 (3.3)	0 (0)	3 (2.2)	0.55
Heart disease (N [%])				
No	83 (91.2)	45 (93.8)	128 (92.1)	
Yes	8 (8.8)	3 (6.2)	11 (7.9)	0.75
Hypertension (N [%])				
No	37 (40.7)	17 (35.4)	54 (38.8)	
Yes	54 (59.3)	31 (64.6)	85 (61.2)	0.55
Arthritis (N [%])				
No	76 (83.5)	44 (91.7)	120 (86.3)	
Yes	15 (16.5)	4 (8.3)	19 (13.7)	0.21
Osteoporosis/osteopenia (N [%])				
No	31 (34.1)	8 (16.7)	39 (28.1)	
Yes	60 (65.9)	40 (83.3)	100 (71.9)	0.03
Use of medication (N [%])				
No	18 (19.8)	11 (22.9)	29 (20.9)	
Yes	73 (80.2)	37 (77.1)	110 (79.1)	0.67
Osteoporosis treatment (N [%])				
No	70 (76.9)	37 (77.1)	107 (77.0)	
Yes	21 (23.1)	11 (22.9)	32 (23.0)	0.98
Spinal column pain (N [%])				
No	14 (15.4)	12 (25.0)	26 (18.7)	
Yes	77 (84.6)	36 (75.0)	113 (81.3)	0.17

Table 1. (continued)

General Characteristics of the Study Population

Characteristics	Controls (N = 91)	Cases (N = 48)	Total (N = 139)	*P* Value*
Family history of osteoporosis (N [%])§				
No	57 (62.6)	36 (76.6)	93 (67.4)	
Yes	34 (37.4)	11 (23.4)	45 (32.6)	0.10
Occurrence of fractures (N [%])‖				
No	76 (84.4)	41 (87.2)	117 (85.4)	
Yes	14 (15.6)	6 (12.8)	20 (14.6)	0.66

* Statistical significance: $P \leq 0.05$.
† Excluding 13 individuals without children.
‡ Excluding 45 individuals who reported that they did not have any income of their own.
§ One observation was lost.
‖ Two observations were lost.

under technical quality control, with the aim of obtaining greater uniformity of results.

With regard to effect measurement, because periodontal disease is etiopathogenically complex, choosing a clear and precise definition involves a methodological question that is crucial for association studies. Rigor in obtaining effect measurements requires comprehensive examination of all teeth, meticulously following an established clinical protocol.[28]

To classify the periodontal disease, the clinical periodontal examination (consisting of measurements of probing depth, clinical attachment loss, and bleeding on probing as criteria established for the presence of periodontitis) was supplemented by measurements from panoramic radiographys. This was a way of widening the safety margin in detecting the women with periodontal disease.[27] Radiography also was used in combination with clinical periodontal measurement for studying the association between osteoporosis and periodontal disease.[6,7,37]

The greater frequency of periodontal disease among women with osteoporosis when their educational level was ≤4 years showed the greater vulnerability of these women. Conversely, the women with >4 years of schooling seemed to be more protected with regard to this association. However, the latter finding did not reach statistical significance, probably because the stratification was done on a sample that was too small for this. Educational level, a characteristic that determines the way an individual is incorporated into society, probably is decisive with regard to self-care and the capacity to assimilate information relating to disease prevention and health promotion. Moreover, the high correlation between greater schooling and greater purchasing power ultimately is reflected in better access to health services, including dental services.

The variables of smoking and age were kept in the model, although there was an empirical lack of confounding effect, because there is strong theoretical evidence regarding their impact on clinical attachment loss and alveolar bone height loss[7,38,39] and on density changes during the postmenopausal period.[40,41]

The oral condition of these postmenopausal women could be inferred from their mean (± SD) number of teeth: 13.81 ± 6.61. The correlation between tooth loss and osteoporosis was not explored more deeply, even with the finding of fewer teeth in women with osteoporosis. It is known that these losses may have been influenced by other non-periodontal causes, but there was imprecision in the responses to questions about the reasons for the missing teeth. These losses also could be explained by another aspect of the women's social vulnerability: the scarcity of material resources for ensuring access to education, work, and health care. Low access to dental services (87.1% of the present sample were not visiting a dentist periodically) is one example. Likewise, 60.9% had never received guidance on oral hygiene methods from dentists, and > 69.8% were not using dental floss. Furthermore, a majority of these women had not visited a dentist for a clinical evaluation during the last 2 years.

Finally, it is important to emphasize that the literature on this topic indicates that osteoporosis is not an etiological factor for periodontitis, but it may affect the severity of preexisting periodontal disease when inflammatory mediators act in a host with a suppressed immune system and poor bone resistance.[2,6,42] By controlling the bacterial biofilm, tooth loss due to periodontal disease may be reduced, even if the maxillary bones have been weakened through systemic bone loss.[43]

CONCLUSIONS

The findings from the present investigation showed that postmenopausal women with osteoporosis and low educational levels have a greater chance of having

Table 2.

Oral Condition and Lifestyle Characteristics of the Study Population

Characteristics	Controls (N = 91) N (%)	Cases (N = 48) N (%)	Total (N = 139) N (%)	*P* Value*
Smoking habit				
No	85 (93.4%)	44 (91.7%)	129 (94.8%)	
Yes	6 (6.6%)	4 (8.3%)	10 (7.2%)	0.71
Alcohol consumption				
No	69 (75.8%)	37 (77.1%)	106 (76.3%)	
Yes	22 (24.2%)	11 (22.9%)	33 (23.7%)	0.87
Coffee consumption				
No	13 (14.3%)	5 (10.4%)	18 (12.9%)	
Yes	78 (85.7%)	43 (89.6%)	121 (87.1%)	0.52
Milk consumption				
No	48 (52.7%)	30 (62.5%)	78 (56.1%)	
Yes	43 (47.3%)	18 (37.5%)	61 (43.9%)	0.27
Practice of physical activity				
I have never done this	31 (34.1%)	20 (41.7%)	51 (36.7%)	
I do this or have done this	60 (65.9%)	28 (58.3%)	88 (63.3%)	0.38
Last visit to dentist				
≤2 years	47 (51.6%)	18 (37.5%)	65 (46.8%)	
>2 years	44 (48.4%)	30 (62.5%)	74 (53.2%)	0.11
Guidance on oral hygiene†				
No	56 (61.5%)	28 (59.6%)	84 (60.9%)	
Yes	35 (38.5%)	19 (40.4%)	54 (39.1%)	0.82
Periodic consultation with dentist				
No	79 (86.8%)	42 (87.5%)	121 (87.1%)	
Yes	12 (13.2%)	6 (12.5%)	18 (12.9%)	0.91
Tooth loss due to caries				
No	4 (4.4%)	5 (10.4%)	9 (6.5%)	
Yes	87 (95.6%)	43 (89.6%)	130 (93.5%)	0.28
Tooth loss due to periodontal disease				
No	83 (91.2%)	41 (85.4%)	124 (89.2%)	
Yes	8 (8.8%)	7 (14.6%)	15 (10.8%)	0.30
Tooth loss due to trauma				
No	87 (95.6%)	47 (97.9%)	134 (96.4%)	
Yes	4 (4.4%)	1 (2.1%)	5 (3.6%)	0.67
Use of dental floss				
No	65 (71.4%)	32 (66.7%)	97 (69.8%)	
Yes	26 (28.6%)	16 (33.3%)	42 (30.2%)	0.56

* Statistical significance: $P \leq 0.05$.
† One observation was lost.

periodontal disease than do those without osteoporosis.

Although a positive association between osteoporosis and periodontal disease was found, and despite the incipient evidence linking osteoporosis and periodontitis, additional studies are needed to elucidate this topic. These might include other types of study design, possibly with intervention before menopause, with long-term follow-up, and investigation of oral conditions during the postmenopausal phase.

ACKNOWLEDGMENTS

The authors thank the women who participated in this study for their contribution to the investigation. The authors also thank the manager, Dr. Marcelo Esteve, of the Human Reproduction Assistance and Research

Table 3.

Distribution of the Periodontal Condition Variables of the Postmenopausal Women, Divided Into Cases and Controls (N = 139)

Variables	Controls (N = 91)	Cases (N = 48)	Total (N = 139)	*P* Value*
Plaque index (%)				
Mean ± SD	23.2 ± 23.0	27.3 ± 23.7	24.7 ± 23.3	0.347
Range	0 to 96.4	0 to 93.7	0 to 96.4	
Bleeding on probing index (%)				
Mean ± SD	24.8 ± 18.3	41.6 ± 20.4	30.6 ± 20.6	<0.001
Range	0 to 87.5	2.4 to 97.2	0 to 97.2	
Probing depth (mm)				
Mean ± SD	2.1 ± 0.4	2.8 ± 0.6	2.4 ± 0.6	<0.001
Range	1.3 to 3.2	1.6 to 5.1	1.3 to 5.1	
Clinical attachment loss (mm)				
Mean ± SD	2.9 ± 0.9	3.8 ± 1.3	3.20 ± 1.2	<0.001
Range	1.4 to 5.7	2.0 to 8.4	1.4 to 8.4	

* Statistical significance: $P \leq 0.05$.

Table 4.

Association Measurements Between Osteoporosis and Periodontal Disease

Periodontal Disease	Unadjusted OR (95% CI)	*P* Value*	Adjusted OR† (95% CI)	*P* Value*
Overall	2.58 (1.01 to 6.82)	0.030	2.71 (1.12 to 6.55)	0.027
Education ≤4 years	6.40 (1.77 to 23.18)	0.005	7.05 (1.90 to 26.19)	0.004
Education >4 years	0.48 (0.11 to 2.03)	0.318	0.50 (0.11 to 2.05)	0.322

* Statistical significance: $P \leq 0.05$.
† Age and smoking status.

Center which these women attended, and all of the staff at this institution. The Research Support Foundation of the State of Bahia and Feira de Santana State University provided financial support for this research.

REFERENCES

1. Garcia RI, Henshal MM, Krall EA. Relationship between periodontal disease and systemic health. *Periodontol 2000* 2001;25:21-36.
2. Yoshihara A, Seida Y, Hanada N, Miyazaki H. A longitudinal study of the relationship between periodontal disease and bone mineral density in community-dwelling older adults. *J Clin Periodontol* 2004;31: 680-684.
3. World Health Organization. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis. Report of a WHO Study Group (Technical reports series). Geneva, Switzerland: WHO; 1994: 1-129.
4. North American Menopause Society. Management of osteoporosis in postmenopausal women: 2006 position statement of The North American Menopause Society. *Menopause* 2006;13:340-367.
5. Kamel HK. Postmenopausal osteoporosis: Etiology, current diagnostic strategies, and nonprescription interventions. *J Manag Care Pharm* 2006;12(Suppl. A): S4-S9, quiz S26-S28.
6. Payne JB, Reinhardt RA, Nummikoski PV, Patil KD. Longitudinal alveolar bone loss in postmenopausal osteoporotic/osteopenic women. *Osteoporos Int* 1999; 10:34-40.
7. Tezal M, Wactawski-Wende J, Grossi SG, Ho AW, Dunford R, Genco RJ. The relationship between bone mineral density and periodontitis in postmenopausal women. *J Periodontol* 2000;71:1492-1498.
8. Haimov-Kochman R, Kochman T, Stabholz A, Hochner-Celinkier D. Biphosphonate and estrogen replacement therapy for postmenopausal periodontitis. *Isr Med Assoc J* 2004;6:173-177.
9. Inagaki K, Kurosu Y, Yoshinari N, Noguchi T, Krall EA, Garcia RI. Efficacy of periodontal disease and tooth loss to screen for low bone mineral density in Japanese women. *Calcif Tissue Int* 2005;77:9-14.

10. Lindhe J. *Clinical Periodontology and Implant Dentistry* (in Portuguese). Rio de Janeiro, Brazil: Guanabara-Koogan; 1999:189-225.
11. Nishimura F, Takahashi K, Kurihara M, Takashiba S, Murayama Y. Periodontal disease as a complication of diabetes mellitus. *Ann Periodontol* 1998;3:20-29.
12. Goldberg AF, Gergans GA, Mattson DE, Rudman D. Radiographic alveolar process/mandibular height ratio as a predictor of osteoporosis. *Gerodontics* 1988;4: 229-231.
13. Kribbs PJ. Comparison of mandibular bone in normal and osteoporotic women. *J Prosthet Dent* 1990;63: 218-222.
14. Kribbs PJ, Smith DE, Chesnut CH 3rd. Oral findings in osteoporosis. Part I: Measurement of mandibular bone density. *J Prosthet Dent* 1983;50:576-579.
15. Kribbs PJ, Smith DE, Chesnut CH 3rd. Oral findings in osteoporosis. Part II: Relationship between residual ridge and alveolar bone resorption and general skeletal osteopenia. *J Prosthet Dent* 1983;50:719-724.
16. Goodson JM. Clinical measurements of periodontitis. *J Clin Periodontol* 1986;13:446-455.
17. Jeffcoat MK, Chesnut CH. Systemic osteoporosis and oral bone loss: Evidence shows increased risk factors. *J Am Dent Assoc* 1993;124:49-56.
18. Mohammad AR, Iones JD, Brunsvold MA. Osteoporosis and periodontal disease. A review. *J Calif Dent Assoc* 1994;22:69-75.
19. Von Wowern N, Klausen B, Kollerup G. Osteoporosis: A risk factor in periodontal disease. *J Periodontol* 1994;65:1134-1138.
20. Mohammad AR, Bauer RL, Yeh C-K. Spinal bone density and tooth loss in a cohort of postmenopausal women. *Int J Prosthodont* 1997;10:381-385.
21. Persson RE, Hollender LG, Powell LV, et al. Assessment of periodontal conditions and systemic disease in older subjects. I. Focus on osteoporosis. *J Clin Periodontol* 2002;29:796-802.
22. Elders PJ, Habets LL, Netelenbos JC, van der Linden LW, van der Stelt PF. The relation between periodontitis and systemic bone mass in women between 46 and 55 years of age. *J Clin Periodontol* 1992;19:492-496.
23. Klemetti E, Collin HL, Forss H, Markkanen H, Lassila V. Mineral status of skeleton and advanced periodontal disease. *J Clin Periodontol* 1994;21:184-188.
24. Bulman JS, Osborn JF. *Statistics in Dentistry*. London: BDJ; 1989:57-80.
25. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977;33: 159-174.
26. World Health Organization. *Oral Health Surveys: Basic Methods*. Geneva, Switzerland: WHO; 1997:39-44.
27. Madianos PN, Bobetsis GA, Kinane DF. Is periodontitis associated with an increased risk of coronary heart disease and preterm and/or low birth weight births? *J Clin Periodontol* 2002;29:22-36.
28. Gomes-Filho IS, Sarmento VA, Rosing CK, et al. Periodontal disease clinical diagnosis criteria (in Portuguese). *J Bras Clin Odonto Int* 2005;9:88-89.
29. Bari AE, Freitas A. Radiographic features of periodontal lesions. In: Freitas A, Rosa JE, Souza IF, eds. *Dental Radiology* (in Portuguese). São Paulo, Brazil: Artes Médicas; 1998:412-435.
30. Consensus Development Conference. Diagnosis, prophylaxis, and treatment of osteoporosis. *Am J Med* 1993;94:646-650.
31. Rothman KJ, Greenland S. *Modern Epidemiology*. Philadelphia: Lippincott; 1998:13-93.
32. Greenland S, Morgenstern H. Confounding in health research. *Annu Rev Public Health* 2001;22:189-212.
33. Wactawski-Wende J, Grossi SG, Trevisan M, et al. The role of osteopenia in oral bone loss and periodontal disease. *J Periodontol* 1996;67:1076-1084.
34. Ronderos M, Jacobs DR, Himes JH, Pihlstrom BL. Associations of periodontal disease with femoral bone mineral density and estrogen replacement therapy: Cross-sectional evaluation of US adults from NHANES III. *J Clin Periodontol* 2000;27:778-786.
35. Lundstrom A, Jendle J, Stenstrom B, Toss G, Ravald N. Periodontal conditions in 70-year-old women with osteoporosis. *Swed Dent J* 2001;25:89-96.
36. Pilgram TK, Hildebolt CF, Dotson M, et al. Relationships between clinical attachment level and spine and hip bone mineral density: Data from healthy postmenopausal women. *J Periodontol* 2002;73:298-301.
37. Daltaban O, Saygun I, Bal B, Balos K, Serdar M. Gingival crevicular fluid alkaline phosphatase levels in postmenopausal women: Effects of phase I periodontal treatment. *J Periodontol* 2006;77:67-72.
38. Bergstrom J. Tobacco smoking and risk for periodontal disease. *J Clin Periodontol* 2003;30:107-113.
39. Ojima M, Hanioka T, Tanaka K, Inoshita E, Aoyama H. Relationship between smoking status and periodontal conditions: Findings from national databases in Japan. *J Periodontal Res* 2006;41:573-579.
40. Baron JA, Farahmand BY, Weiderpass E, et al. Cigarette smoking, alcohol consumption, and risk of hip fracture in women. *Arch Intern Med* 2001;161:983-988.
41. Vestergaard P, Mosekilde L. Fracture risk associated with smoking: A meta-analysis. *J Intern Med* 2003;254: 572-583.
42. Geurs NC, Lewis CE, Jeffcoat MK. Osteoporosis and periodontal disease progression. *Periodontol 2000* 2003;32: 105-110.
43. Dietrich T, Joshipura KJ, Dawson-Hughes B, Bischoff-Ferrari HA. Association between serum concentrations of 25-hydroxyvitamin D3 and periodontal disease in the US population. *Am J Clin Nutr* 2004;80:108-113.

Correspondence: Dr. Isaac Suzart Gomes-Filho, Avenida Getúlio Vargas, 379, Centro, Feira de Santana, Bahia 44. 025-010, Brazil. Fax: 55-75-3623-0661; e-mail: isuzart@gmail.com.

Submitted January 27, 2007; accepted for publication March 28, 2007.