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Osteoporosis/osteopenia as an independent factor associated with periodontitis in postmenopausal women: a case–control study

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Abstract

Summary This study investigated whether osteoporosis/osteopenia has an influence on the progression of periodontitis in postmenopausal women. The findings highlight that postmenopausal women with osteoporosis/osteopenia had a greater chance of presenting periodontitis than those with normal bone mineral density, particularly among nonusers of osteoporosis medications and women with a greater number of remaining teeth, showing that osteoporosis/osteopenia has had an influence on the progression of periodontitis.

Introduction This study investigated whether osteoporosis/osteopenia has an influence on the progression of periodontitis in postmenopausal women and explored the effects of use of osteoporosis medication and tooth loss on this association.

Methods This case–control study involved 521 postmenopausal women, with minimum age of 50 years, in Feira de Santana, Bahia, Brazil. Sociodemographic characteristics, health conditions/medications, and lifestyle habits were recorded. A complete periodontal examination was performed and periodontitis was diagnosed. Bone mineral density was evaluated through lumbar spine and femoral bone densitometry, obtained using dual-energy X-ray absorptiometry. Logistic regression was used to calculate the strength of association between the occurrences of osteoporosis/osteopenia and periodontitis.

Results Women with osteoporosis/osteopenia were twice as likely to present periodontitis, as were those with normal bone mineral density, even after adjusting for smoking, age, family income, and last visit to dentist (odds ratios $(OR)_{adjusted}=2.24$, 95 % CI [1.24–4.06], $p=0.008$). Among nonusers of osteoporosis medication ($OR_{adjusted}=2.51$, 95 % CI [1.33–4.73], $p=0.004$) and women with at least 10 remaining teeth ($OR_{adjusted}=2.50$ 95 % CI [1.18–5.27], $p=0.02$), the odds ratio was higher and statistically significant.

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Conclusions These findings highlight that postmenopausal women with osteoporosis/osteopenia had a greater chance of presenting periodontitis than those with normal bone mineral density, particularly among nonusers of osteoporosis medications and women with a greater number of remaining teeth.

Keywords Associated factor · Bone density · Menopause · Osteoporosis · Periodontitis

Introduction

According to the World Health Organization, one in six women aged 50 has osteoporosis of the hip, and the prevalence increases to 50 % at 80 years of age [1]. The vulnerability of older women with osteoporosis is due to the menopausal transition, in which there is a reduction in the estrogenic effect, thus resulting in accelerated bone resorption that outstrips the rate of bone formation.

Osteoporosis is characterized by loss of bone mineral density. The molecular mechanisms underlying this bone loss, relative to estrogen deficiency, are related to overproduction of resorptive cytokines, such as receptor activator of nuclear factor kappa-B ligand (RANKL), tumor necrosis factor (TNF-α), and interleukins (IL-1β and IL-6) [2]. Recently, osteoporosis/osteopenia has been linked to periodontitis [3–5].

Periodontitis involves chronic bacterial infection that affects the tissues around the teeth and results in pain, gingival bleeding, tooth mobility, connective tissue loss, and alveolar bone destruction which may lead to tooth loss. Its occurrence is due to accumulation of bacteria on the outer surface of the teeth and results in imbalance between bacterial invasion plus other external factors and the host's defensive capability. Its prevalence and severity appear to increase with age [6], thus contributing to public health problems as the most common dental problem in the world, after caries.

It has been suggested that stimulation of inflammatory mediators during the menopause period can promote an exacerbation of a coexisting periodontal inflammation cascade, thereby reducing alveolar bone and increasing tooth loss [7, 8]. High presence of inflammatory markers, like RANKL and osteoprotegerin (OPG), has recently been detected in women with osteoporosis and periodontitis [9]. These mediators probably represent the common biological mechanisms that interrelate these two diseases.

The plausibility of the impact of osteoporosis/osteopenia on oral conditions has been investigated in clinical and epidemiological studies. However, these data are insufficient and contradictory with regard to confirming this hypothesis, such that while some demonstrate no association [10–13], others point

to a significant association [3, 4, 14–16] between osteoporosis/osteopenia and periodontitis. Faced with such a contradiction and given the fact that the knowledge is still inconsistent on the subject, the realization of further studies is justified, with adequate methodological quality, including the evaluation of new elements, such as the use of medication for osteoporosis, in order to expand the knowledge base in this topic area.

In this regard, the main objective of the present study was to evaluate the influence of osteoporosis/osteopenia (exposure) on the progression of periodontitis (outcome) in postmenopausal women. In addition, the aim was to further explore this association in terms of stratification for use of osteoporosis medication and number of missing teeth.

Methods

This was a case–control study on the presence of periodontitis in postmenopausal women who were treated at the Human Reproduction Assistance and Research Center, a leading diagnostic clinic for osteoporosis in Feira de Santana, Bahia, Brazil, a public institution that only serves women with low socioeconomic status and provides the necessary medications to restore the health of the bone (bisphosphonate or hormone replacement therapy and/or supplements based on calcium and vitamin D). Thus, there is no self-medication in this group since they cannot use their own resources to purchase these drugs. This study was approved by the Research Ethics Committee of Feira de Santana State University, Bahia, Brazil (protocol 199/2009).

Research subjects

Postmenopausal women treated at the osteoporosis diagnostic service and who accepted the invitation to undergo oral assessment and subsequent dental follow-up at Feira de Santana State University, Bahia, were divided into a case group (women with periodontitis) and a control group (without periodontitis), after they had signed an informed consent statement.

The inclusion criteria comprised: presence of at least four teeth, minimum age of 50 years, menstrual cycle ceased at least 1 year earlier, and presentation of a recent densitometry report obtained from the service. Women who underwent a previous periodontal treatment within the last 6 months; presented systemic disease that might interfere with the inflammatory immune response and bone metabolism, e.g., diabetes or thyroid dysfunction; or used/use medications that might interfere with bone metabolism, such as corticosteroids, were excluded.

Sample size

The sample size was calculated by using a confidence level of 95 %, study power of 80 %, 1:3 ratio between cases and

controls, and osteoporosis frequency of 17 % among the controls and 39 % among the cases [17]. Thus, the estimated minimum sample size was 332 individuals (cases of periodontitis=83 and controls=249).

Data-gathering procedures

The eligible subjects were interviewed through a structured questionnaire to obtain sociodemographic, biological, and life-style factors, such as age, ethnicity/racial group, income, schooling level, use of osteoporosis medication, early meno-pause, years since menopause, medical history, smoking habits, alcohol consumption, physical activity (workout/running/walk-ing/aerobics, on a weekly basis), oral habits, and treatment-related concepts (cause of tooth loss). Use of osteoporosis medication was defined as hormone replacement therapy or bisphosphonate and/or supplements based on calcium and vitamin D. The questionnaires were administered by trained researchers, so that issues arising could be dealt with.

All teeth were examined, except the third molars, using a manual periodontal probe graduated in millimeters (Williams Hu-Friedy, USA) at six sites per tooth [18]. The probing depth was measured as the distance from the gingival margin to the position of greatest penetration of the probe. The clinical attach-ment loss consisted of the sum of the values of probing depth measurements and gingival recession or hyperplasia measure-ments. Bleeding on probing was determined by observing whether bleeding was present for more than 10 s after removing the probe from the pocket or sulcus [19]. The presence of plaque was measured at four sites through checking whether biofilm was present on the tooth surface, by using the probe.

All periodontal clinical measurements were obtained by a single examiner, who, at the time of the examination, was unaware of the patients' bone mineral density. Reproducibility was assessed through replication of the periodontal measure-ments: this was done using an experienced periodontist as a reference, on about 10 % of the sample. The intra-examiner k index (±1 mm) for probing depth and recession/hyperplasia measurements were, respectively, 0.80 and 0.89. The inter-examiner k index (±1 mm) showed agreement rates of 0.81 and 0.88 for these measurements, respectively.

Diagnosis of periodontitis

Women were considered to have periodontitis if they presented at least two interproximal sites with clinical attachment loss greater than or equal to 6 mm and at least one interproximal site with probing depth greater than or equal to 5 mm [20].

Evaluation of the bone mineral density

The diagnosis of osteoporosis/osteopenia was based on the densitometry reports, and the criteria were those established by WHO [21]. Osteopenia was defined as a bone mineral density T-score (difference between the measured bone min-eral density and the mean value for young white women in terms of standard deviations [SDs]) of below −1 SD and a minimum of −2.5 SD. Osteoporosis was defined as a bone mineral density T-score of below −2.5 SD. Individuals were considered to be normal when the T-score was above −1 SD in the two segments analyzed (proximal femur and lumbar spine). The individuals with osteopenia were grouped with those with osteoporosis to form an osteopenia/osteoporosis group representing low bone mineral density.

The data from these reports included weight, height, bone mineral density (in grams per square centimeter) and T-scores. Weight and height were used to calculate the body mass index (BMI), which was established by dividing weight (in kilo-grams) by height squared (in meters).

Data analysis

Descriptive analysis was undertaken on the dependent var-iable (periodontitis) and all the covariables that were con-sidered to be of interest, as listed below, through numerical measurements. The main independent variable was catego-rized as osteoporosis/osteopenia or normal. The following covariables were taken into consideration in the analysis: age (<60 or ≥60 years), age at menopause (<48 or ≥48 years), type of menopause (natural or surgical), BMI (<30 or ≥30 kg/m^2), marital status (with or without partner), self-reported racial group (white or non-white), number of children (up to three children or >3 children), schooling level (≤4 or >4 years of school attendance), own income (characterized as yes or no, coming from retirement pension, other pension, formal work, or informal work), family in-come (≤1 or >1 Brazilian minimum monthly salary), phys-ical activity at least once a week (yes or no), smoking (smoker/former smoker or never smoked), alcohol con-sumption (yes or no), use of osteoporosis medication (yes or no), self-reported arterial hypertension (yes or no), and self-reported coronary heart disease (yes or no). Behavioral issues related to oral health included the following factors: use of dental floss at least once a day (yes or no), last visit to dentist (≤2 or >2 years), receipt of guidance on oral hygiene (yes or no), periodic consultation with dentist at least once a year (yes or no), and type of dental care (private or public service). Treatment-related issues included: tooth loss due to caries (yes or no) and tooth loss due to periodontal disease (yes or no). Categorization of continuous variables, when required, was done based on the distribution or cutoff points identified in the literature. Simple frequencies and central trend measurements were obtained, and statistical differen-ces between the case and control groups were evaluated using the X^2 test for categorical variables and t test for continuous variables, with a significance level of 5 %.

The association between osteoporosis/osteopenia and periodontitis was evaluated using odds ratios (ORs) and their respective 95 % confidence intervals. For stratified analysis, covariables, possible confounders, and effect modifiers were selected for modeling. The Mantel–Haenszel homogeneity test was also applied to investigate the existence of possible effect modifiers (alpha 5 %). Potential confounders were selected on both a theoretical and an empirical basis, taking into consideration a relative difference greater than or equal to 20 % among the measurements adjusted using the Mantel–Haenszel method, for each covariable and the crude association measurement [22].

For logistic regression analysis, the presence of effect-modifying covariables was observed using the maximum likelihood ratio test ($p < 0.05$). For variables in which the presence of modifying effects had not been empirically identified, the role of confounding variables was assessed using the backward procedure in unconditional logistic regression analysis, assuming therefore that such variables produced a change of least 20 % in the association measurement. Classic confounders, covariables recognized as confounding factors established in the literature on the theme, were also retained in the model.

Effects from the use of osteoporosis medications and from tooth loss, on the association between osteoporosis/osteopenia and periodontitis, were evaluated using exploratory subgroup analysis. Two additional models were then constructed from this.

The goodness-of-fit of the final model was determined by means of the Hosmer–Lemeshow test and the discriminatory ability of the model, according to the area under the receiver operating characteristic (ROC) curve. Data analyses were performed using the STATA software, version 9.0, and the assessment model fit was evaluated using SPSS, version 10.0.

Results

Out of 986 women who sought an evaluation of their oral health status between June 2008 and September 2011, in accordance with the eligibility criteria, 465 were excluded from the sample because they presented with diabetes (126), thyroid disorders (32), less than four teeth (200), age under 50 years (63), cessation of menstrual cycle less than 1 year earlier (19), or periodontal treatment performed less than 6 months earlier (25).

The final sample for this study consisted of 521 postmenopausal women, of whom 94 were cases and 427 were controls. The participants had a mean age of 60.8 years (±7.4 years) and a median of 59 years, with a range from 50 to 80 years. The occurrence of periodontitis was 18 %.

The participants' general characteristics, according to the presence or absence of periodontitis (case and control

groups, respectively), are shown in Table 1. The case and control groups were relatively homogeneous with regard to most features. Statistically significant differences were observed with regard to family income ($p = 0.01$), use of osteoporosis medication ($p = 0.01$), and presence of osteoporosis/osteopenia ($p = 0.02$). The case group had lower frequencies of women with family income of less than one minimum monthly salary (7.4 vs 16.9 %) and of women who were on osteoporosis treatment (13.8 vs 25.8 %) than seen in the control group. On the other hand, osteoporosis/osteopenia was observed in almost 83.0 % of the cases, but in only 70.7 % of the controls.

With regard to factors relating to oral health (Table 2), greater proportions of the women with periodontitis reported that the last visit to a dentist was more than over 2 years earlier (48.9 vs 34.7 %; $p = 0.01$); that they had not received any guidance on oral hygiene (61.7 vs 42.9 %; $p = 0.001$); and that their frequency of periodic consultation with dentist at least once a year was lower (69.1 vs 51.5 %; $p = 0.002$). When inquired about the reasons for tooth loss, 21.3 % of the cases mentioned the presence of periodontal disease as a cause, and tooth mobility was the identifying characteristic of the disease.

In relation to periodontal clinical parameters, worse conditions were observed in the case group than in the control group, with statistically significant mean differences, with the exception only for the number of teeth (Table 3). In the unadjusted association analysis, among the women with osteoporosis/osteopenia, the chance of having periodontitis was twice as high as among those with normal bone mineral density (OR$_{unadjusted}$=2.02; 95 % CI [1.13–3.59]; $p = 0.017$). In the stratified analysis, no interaction effects or potential confounders were detected.

The logistic regression analysis confirmed that there was no interaction or confounding in relation to the covariables analyzed. Nonetheless, *smoking habit*, *age*, *family income*, and *last visit to dentist* were kept in the final model on the basis of theoretical considerations. Adjustment for these variables produced a slight increase in the magnitude of the association, thus reaffirming that osteoporosis/osteopenia had an independent effect on periodontitis (OR$_{adjusted}$= 2.24; 95 % CI [1.24–4.06]; $p = 0.01$; Table 4).

When the use of osteoporosis medication was taken into consideration in exploratory subgroup analysis (Table 5), it was observed that the association increased and remained statistically significant (OR$_{adjusted}$=2.51; 95 % CI [1.33–4.72]; $p = 0.004$) among nonusers. However, for the group of users, the magnitude of the association was reduced (OR$_{adjusted}$=1.17; 95 % CI [0.19–7.36]; $p = 0.87$), thereby losing statistical significance. In the model obtained for tooth loss, the association increased and remained statistically significant (OR$_{adjusted}$=2.50; 95 % CI [1.18–5.27]; $p = 0.016$) among the women with at least 10 teeth. However,

Table 1 General characteristics of the case group (with periodontitis) and control group (without periodontitis) (*n*=521)

Characteristics	Cases *n*=94	Controls *n*=427	*p**
Age (years)			
<60 years	50 (53.2)	212 (49.6)	0.53
≥60 years	44 (46.8)	215 (50.4)	
Mean ± SD	60.6±7.3	60.9±7.4	
Range	50–80	50–87	
Age at menopause (years)			
≥48 years	61 (64.9)	246 (57.6)	0.19
<48 years	33 (35.1)	181 (42.4)	
Mean ± SD	48.0±5.1	47.1±5.9	
Range	34–60	30–61	
Type of menopause			
Natural	73 (77.7)	291 (68.1)	
Surgical	21 (22.3)	136 (31.9)	0.09
BMI (kg/m^2)			
<30	83 (88.3)	365 (85.5)	0.48
≥30	11 (11.7)	62 (14.5)	
Mean ± SD	25.2±4.2	25.3±4.2	
Range	18–39	15–42	
Marital status			
With partner	43 (45.7)	223 (52.2)	0.26
Without partner	51 (54.3)	204 (47.8)	
Racial group			
White	15 (16.0)	68 (15.9)	0.99
Non-white	79 (84.0)	359 (84.1)	
Number of children			
No child or ≤3 children	38 (40.4)	190 (44.5)	
>3 children	56 (59.6)	237 (55.5)	0.47
Own income			
Yes	69 (73.4)	325 (76.1)	
No	25 (26.6)	102 (23.9)	0.58
Family income			
<1 minimum monthly salary	7 (7.4)	72 (16.9)	
1 to 3 minimum monthly salaries	76 (80.9)	331 (77.5)	
>3 minimum monthly salaries	11 (11.7)	24 (5.6)	0.01
Schooling level (years)			
>4 years	20 (21.3)	75 (17.6)	
≥4 years	74 (78.7)	352 (82.4)	0.40
Smoking habit			
Nonsmoker	57 (60.6)	277 (64.9)	
Smoker/former smoker	37 (39.4)	150 (35.1)	0.44
Alcohol consumption			
No	77 (81.9)	353 (82.7)	
Yes	17 (18.1)	74 (17.3)	0.86
Practice of physical activity			
No	34 (36.2)	178 (41.7)	
Yes	60 (63.8)	249 (58.3)	0.32
Osteoporosis treatment			
No	81 (86.2)	317 (74.2)	

Table 1 (continued)

Characteristics	Cases *n*=94	Controls *n*=427	*p**
Yes	13 (13.8)	110 (25.8)	0.01
Hypertension			
No	34 (36.2)	195 (45.7)	
Yes	60 (63.8)	232 (54.3)	0.12
Heart disease			
No	88 (93.6)	406 (95.1)	
Yes	6 (6.4)	21 (4.9)	0.56
Osteoporosis/osteopenia			
No	16 (17.0)	125 (29.3)	
Yes	78 (83.0)	302 (70.7)	0.02

Feira de Santana, Bahia, Brazil, 2011

**p* value: significance level ≤0.05

there was a reduction and loss of significance concerning the effect of osteoporosis/osteopenia on periodontitis for the group of women with less than 10 teeth (OR$_{adjusted}$=1.63; 95 % CI [0.64–4.66]; *p*=0.28).

Table 2 Characteristics relating to oral health in the case group (with periodontitis) and control group (without periodontitis) (*n*=521)

Characteristics	Cases *n*=94	Controls *n*=427	*p**
Use of dental floss least once a day			
Yes	30 (31.9)	144 (33.7)	
No	64 (68.1)	283 (66.3)	0.74
Last visit to dentist			
≤2 years	48 (51.1)	279 (65.3)	
>2 years	46 (48.9)	148 (34.7)	0.01
Guidance on oral hygiene			
Yes	36 (38.3)	244 (57.1)	
No	58 (61.7)	183 (42.9)	0.001
Periodic consultation with dentist at least once a year			
No	65 (69.1)	220 (51.5)	
Yes	29 (30.9)	207 (48.5)	0.002
Dental care type			
Private service	69 (73.4)	298 (69.8)	
Public service	25 (26.6)	129 (30.2)	0.49
Tooth loss due to caries[a]			
No	9 (9.6)	30 (7.0)	
Yes	85 (90.4)	396 (93)	0.40
Tooth loss due to periodontal disease[a]			
No	74 (78.7)	394 (92.5)	
Yes	20 (21.3)	32 (7.5)	<0.01

Feira de Santana, Bahia, Brazil, 2011

**p* value: significance level ≤0.05

[a] One subject had a full set of teeth and did not show tooth loss

Table 3 Distribution (in percent) of clinical periodontal conditions between the case and control groups (n=521)

Clinical parameters	Periodontal disease		p*
	Yes N=94	No N=427	
Bleeding on probing index (%)			
Mean ± SD	36.7±19.6	15.2±14.6	<0.01
Median	37.8	10.7	
Range	2.2–97.2	0–87.5	
Plaque index (%)			
Mean ± SD	35.9±28.8	26.0±22.4	0.01
Median	32.1	20	
Range	0–100.0	0–100.0	
Teeth with probing depth ≥4 mm (%)			
Mean ± SD	42.3±26.0	6.4±3.6	<0.01
Median	39.2	5.2	
Range	0–100	0–78.6	
Teeth with clinical attachment level ≥5 mm (%)			
Mean ± SD	66.8±24.0	25.3±8.4	<0.01
Median	64.2	22.7	
Range	12.0–100.0	0–100.0	
Probing depth (mm)			
Mean ± SD	2.8±0.6	2.0±0.4	<0.01
Median	2.7	2	
Range	1.6–5.1	1.2–3.5	
Clinical attachment level (mm)			
Mean ± SD	4.0±1.2	2.6±0.7	<0.01
Median	3.7	2.4	
Range	2.3–8.4	1.2–5.8	
Teeth present (n)			
Mean ± SD	13.2±5.8	12.9±6.3	0.73
Median	13	12	
Range	4–27	4–28	
≥10 teeth	65 (69.1)	255 (59.7)	
<10 teeth	29 (30.9)	172 (40.3)	0.08

Feira de Santana, Bahia, Brazil, 2011

*p value: significance level ≤0.05

Table 4 Odds ratio (OR) and 95 % confidence interval (95 % CI) for the association between osteoporosis/osteopenia and periodontal disease among postmenopausal women (n=521)

Models	OR	95 % CI	p*
Unadjusted	2.02	1.13–3.59	0.02
Adjusted[a]	2.24	1.24–4.06	0.01

Feira de Santana, Bahia, Brazil, 2011

*p value: significance level ≤0.05

[a] Adjusted for age, smoking habit, last visit to dentist, and family income

According to the Hosmer–Lemeshow goodness-of-fit test, the adjusted model for the association between osteoporosis/osteopenia and periodontitis showed good calibration for the sample analyzed (chi-square=1.45; p=0.96). Moreover, in evaluating the model, an area of 0.62 under the ROC curve was observed, thus showing fair discriminatory capacity, i.e., the model was able to identify about 62 % of the subjects with and without the disease, between all possible pairs.

Discussion

The findings showed that osteoporosis/osteopenia influenced the progression of periodontitis, since women with osteoporosis/osteopenia were twice as likely to have periodontitis as were those with normal bone mineral density, even after adjustment for potential confounders. These positive findings are consistent with other studies [3, 4, 15–17, 23]. This also supports the hypothesis that estrogen deficiency, which is common at the menopause and is reflected in reduction of individuals' bone mineral density, can also contribute towards coinduction of RANK-RANKL-OPG imbalance at the level of the periodontal structures through stimulating increased levels of serum inflammatory mediators (IL-1, IL-6, and TNF), thereby promoting clinical attachment loss and alveolar bone reduction [2, 24].

Additional evidence that provides support for the biological plausibility of the influence of osteoporosis/osteopenia on the progression of periodontitis came from Golub et al. They initially conducted experimental studies on animal models and subsequently evaluated postmenopausal women with osteopenia, with regard to the effect of antimicrobial drugs such as doxycycline for reducing local bone loss (periodontitis) and systemic bone loss, through inhibition of pro-inflammatory and resorptive cytokines [25, 26]. However, it needs to be borne in mind that these biological mechanisms are not yet fully known. Evidence showing that the systemic inflammatory response has an impact at oral level has also been strengthened through studies [27, 28].

Given the evidence that hormone therapy and calcium supplementation can control bone loss and reduce the risk of fractures [29, 30], the present study explored the effect of use of osteoporosis medication on this association. Subgroup analysis on this factor revealed that, in particular among the women who were nonusers of osteoporosis medication, the influence of osteoporosis/osteopenia was higher still and remained statistically significant.

However, among the participants who reported the use of osteoporosis medication, a reduction in the association measurement was observed, although this was not statistically significant. Hence, further analysis on the possible protective effect of this medication on this population is required.

Table 5 Odds ratio (OR) and 95 % confidence interval (95 % CI) for the association between osteoporosis/osteopenia and periodontal disease among postmenopausal women, stratified according to use of osteoporosis medication and teeth remaining (n=521)

Models	Use of osteoporosis medication					
	No (n=398)			Yes (n=123)		
	OR	95 % CI	p*	OR	95 % CI	p*
Unadjusted	2.34	1.25–4.35	0.007	1.30	0.27–6.30	0.75
Adjusted[a]	2.51	1.33–4.72	0.004	1.17	0.19–7.36	0.87
Models	Teeth remaining					
	<10 teeth (n=201)			≥10 teeth (n=320)		
	OR	95 % CI	p*	OR	95 % CI	p*
Unadjusted	1.57	0.60–4.09	0.355	2.29	1.11–4.73	0.025
Adjusted[a]	1.73	0.64–4.66	0.276	2.50	1.18–5.27	0.016

Feira de Santana, Bahia, Brazil, 2011

*p value: significance level ≤0.05

[a] Adjusted for age, smoking habit, last visit to dentist, and family income

Only a few studies have evaluated the role of these medications on periodontal condition [15, 31–36]. Smaller probing depth measurements and clinical attachment level measurements [31, 33] as well as greater tooth retention [15, 36] have been observed among users of osteoporosis medication.

Unexpectedly, regarding the distribution of socioeconomic factors, it was observed that there was a higher frequency of higher income women among the cases of periodontitis. One possible explanation for this finding may be that the low-income elderly population is more affected by tooth loss as a result of inadequate dental care received over these individuals' lifetimes, in which tooth removal has been seen to be a more viable option [37, 38]. In the present study, the controls presented lower income levels and fewer remaining teeth. This greater tooth loss may have underestimated the frequency of periodontitis in the sample [39], thus serving as a potential source of bias, since identification of this disease is dependent upon the number of teeth.

Studies have shown that there is an association between osteoporosis/osteopenia and periodontitis through evaluation of tooth loss [14, 15]. In the present study, there were no statistically significant differences between the case and control groups (13.2±5.8 vs 12.9±6.3) or between subjects with and without osteoporosis/osteopenia (data not shown), in relation to the number of present teeth, although a trend toward fewer remaining teeth in the controls was observed. In order to explore the effect of tooth loss, the association was further stratified according to the number of present teeth (<10 teeth or ≥10 teeth). In the group of women with 10 or more remaining teeth, the influence of osteoporosis/ osteopenia on the progression of periodontitis was higher still and remained statistically significant, while in the stratum with less than 10 remaining teeth, there was a reduction in this influence, although without statistical significance. It is likely that the lack of association between osteoporosis/osteopenia and periodontitis that has been found in some studies is due to noncompliance with a minimum number of remaining teeth in the subjects, especially when strict criteria are used to define disease severity, since periodontitis is site-specific.

The lack of statistical significance in some of the stratified subgroup analyses explored above should be interpreted with caution. The lack of statistical power for detecting real differences between individuals may be explained by the small number of participants in each substrate.

The variables smoking habit, age, family income, and last visit to dentist were included in the final adjusted model based on theoretical groundings. Studies have emphasized that smokers are more likely to have periodontitis [40] and have highlighted that this habit has the effect of reducing bone mineral density [41]. With regard to age, higher prevalence of periodontal disease and osteoporosis has been detected with increasing age [39, 42]. Some studies that have associated osteoporosis and periodontitis have also adjusted their magnitude measurements for dental care and socioeconomic status [15, 43].

Another methodological precaution in the present study was the choice of appropriate criteria for classifying exposure and outcome. The diagnostic criteria adopted for periodontitis were used because they allowed the evaluation of certain aspects of the disease related to the age of the women in this study (≥50 years). It is expected that in such individuals, the gingival margin will be found more apically, in relation to the cement–enamel junction as a natural consequence of passive tooth eruption and of trauma to the gingival tissue caused by brushing and tooth wear over these

individuals' lifetimes [44]. This would minimize the numbers of false positives from spurious associations. It should be noted that for this evaluation, the examiner was unaware of the diagnosis of osteoporosis/osteopenia and had previously undergone training in order to ensure reliability of reproduction of the clinical periodontal measurements.

Regarding the exposure criterion, the dual-energy X-ray absorptiometry technique was used in this study as it is the gold standard for diagnosing osteoporosis/osteopenia, in accordance with the World Health Organization criteria. This technique has been adopted by most studies that have evaluated this association, although a few studies have made use of other criteria because of the difficulty in obtaining public access to these more sophisticated tests.

Despite the positive findings of the influence of osteoporosis/osteopenia on the progression of periodontitis in the present study, some limitations should be taken into consideration. One of these relates to the participant's self-reporting of their use of osteoporosis medication, although the interviewers were trained to achieve reliability in the answers, by asking for the name of the medication, in order to confirm whether hormone therapy or calcium supplementation was used. Regarding the type of medication, although most studies have only assessed the effect of hormone therapy on this association, calcium supplementation has been prescribed by many experts to control the outcomes from osteoporosis. This has been investigated by some dental researchers through a randomized clinical trial that demonstrated that this medication has some beneficial effects for reducing tooth loss [45].

Another limitation of the present study relates to the possibility that the sample used may not have been representative of the population of women in this age group. Although the health clinic chosen for conducting this study covers most of the population of the city and surrounding municipalities who seek bone densitometry examinations, the particular exclusion criteria used may have limited the ability to generalize the findings to other populations. However, the employed analytical approach suffices for risk indication. Finally, it should be noted that although the results reported here include early evidence for this important association, future prospective studies with monitoring of biomarkers should be encouraged in order to better evaluate this hypothesis and better clarify the biological mechanisms involved.

Conclusions

Postmenopausal women with osteoporosis/osteopenia had a greater chance of presenting periodontitis than did those with normal bone mineral density, especially the nonusers of osteoporosis medication and those with more teeth in the oral cavity, showing that osteoporosis/osteopenia has had an influence on the progression of periodontitis.

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