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Longitudinal Study of Periodontal Disease and Edentulism With Rates of Bone Loss in Older Women

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Abstract

Background— Previous cross-sectional studies have suggested a link between periodontal disease and osteoporosis. The purpose of the present study is to evaluate the association between changes in bone mineral density (BMD) and clinical signs of periodontal tissue destruction and tooth loss over a 2-year period.

Methods— A total of 398 women (mean age 75.5 years) were randomly selected for an ancillary study of periodontal disease; osteoporosis in association with the presence or absence of teeth was evaluated. Osteoporosis in association with periodontal disease was also evaluated. All subjects were participants at the Pittsburgh Clinical Center for the Study of Osteoporotic Fractures (SOF), a prospective cohort study of women 65 years of age or older designed to determine risk factors for fractures. Oral health examinations, including periodontal probing and attachment loss, were performed at the fourth clinical visit, an average of 6 years after baseline. BMD of the total hip and its subregions was measured using dual energy x-ray absorptiometry at the time of dental examination and 2 years later. Results are expressed as annual percentage change.

Results— A total of 145 (36.4%) women were edentulous and 163 (80.7%) of the dentate women (N = 253) had periodontal disease. Dentate women reported higher education (P <0.001) and a higher calcium intake (P = 0.002). Absolute BMD and percentage change in BMD were similar in dentate and edentulous women. We found no difference in BMD or in absolute or percentage change in BMD between women with or without periodontal disease.

Conclusion— Little evidence exists for an association between edentulousness, periodontal disease, and longitudinal changes in BMD.

Keywords

Bone density; cross-sectional studies; elderly; osteoporosis; periodontal diseases/complications; risk factors; women's health

Osteoporosis is a systemic skeletal disease characterized by low bone mass and micro-architectural deterioration of bone tissue, with a consequent increase in bone fragility and susceptibility to fracture. Osteoporosis is a major public health problem that most often affects postmenopausal women.

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In the United States osteoporosis affects more than 25 million people and predisposes patients to more than 1.3 million fractures annually.[1] Since alveolar bone loss is a clinical feature of periodontal disease, disturbances in bone metabolism and decreases in the bone mineral density (BMD) of the skeleton, especially in the jaws, may be a factor in periodontal disease.[2] Osteoporosis and periodontal disease lead to significant morbidity, mortality, and expense.

The clinical importance of generalized bone loss as a contributor to alveolar bone loss and subsequent tooth loss is unclear. To date, the evidence for an association between tooth loss and bone mineral density (BMD) in the extra-cranial skeleton has been derived from cross-sectional studies and results have been inconclusive.[3] Several large studies conducted in early postmenopausal women failed to find significant associations between tooth status and BMD. Elders et al.[4] found no relationship between the number of missing teeth and either spine BMD or metacarpal thickness. Krall et al.[5] conducted a longitudinal study on associations between tooth loss and bone loss in whole bodies, in the femoral neck, and in the spine. This study included 189 healthy white dentate postmenopausal women who participated in three intervention trials conducted within a 7-year period. Forty-five women (24%) reported having lost one or more teeth. The rates of BMD changes at all three sites (whole body, femoral neck, spine) were independent predictors of tooth loss in the multivariate models supporting a role of systemic bone loss in the development of tooth loss among post-menopausal women.

Bando et al.[6] suggested that sufficient masticatory function with periodontally healthy dentition may inhibit or delay the progress of osteoporotic changes in skeletal bone, or that edentulous women may be more susceptible to osteoporosis. The role of osteoporosis or osteopenia in the etiology of periodontal disease is not fully understood. An observational study supported the possible role of low skeletal BMD or osteoporosis as risk indicators for reduced alveolar crestal height.[2] Rondernos et al.[7] studied the possible association of periodontal disease with femoral BMD in a large sample of U.S. adults (N = 11,655). Their finding indicates that, in the presence of high calculus scores, females with osteoporosis are at an increased risk for attachment loss.

In our earlier report[8] we found no association between BMD and periodontal disease. However, no longitudinal studies have been reported to date. The purpose of the present study was to extend our earlier study[8] and evaluate the association between changes in BMD and clinical signs of periodontal tissue destruction. In addition, we examined the association between edentulism and changes in BMD.

MATERIALS AND METHODS

A total of 398 women (mean age 75.5 years) were randomly selected for an ancillary study of periodontal disease and presence or absence of teeth and osteoporosis. All subjects were participants at the Pittsburgh Clinical Center for the Study of Osteoporotic Fractures (SOF), a prospective study of a cohort of elderly women >65 years of age at baseline, to determine risk factors for fractures.

From September 1986 to October 1988, a total of 2,401 women who were at least 65 years of age or older were recruited for the SOF from the Monongahela Valley near Pittsburgh, Pennsylvania. Age-eligible women were identified on voter registration lists for zip codes within a 25-mile radius of Monessen, Pennsylvania. To be eligible to participate in this ancillary study, women had to be willing to continue participation in the SOF study, to have a dental examination, and to voluntarily sign a University of Pittsburgh Institutional Review Board (IRB)-approved consent form. Exclusion criteria included presence of medical conditions that would preclude conducting an adequate oral examination. All 398 women presenting for SOF

examinations when the dentist examiner was present and who met the above eligibility criteria were eligible for enrollment into the dental study.

BMD Measurement

Bone mineral density (g/cm) of the total hip and its subregions (femoral neck, inter-trochanteric region, trochanter) was measured using dual x-ray absorptiometry.[§] Bone mineral density of the calcaneus was measured[‖] using single-photon absorptiometry at the baseline examination. Details of these measurement methods and densitometry quality control procedures have been published elsewhere.[9]

Periodontal Assessment

The assessment for periodontal destruction was made at three sites on the buccal aspect (mesio-buccal, mid-buccal, disto-buccal) of all natural teeth.[8] Only fully erupted teeth were measured. The loss of attachment was defined both clinically and quantitatively as the distance in millimeters from the cemento-enamel junction (CEJ) to the base of the pocket. Probing depth was the distance from the free gingival margin (FGM) to the base of the sulcus/pocket. A woman was diagnosed with periodontal disease if she had more than 3 mm of attachment loss.[8]

Statistical Analysis

Prior to analysis, all data were screened for accuracy and completeness. Statistical software was used to analyze the data. Descriptive statistics were calculated for all variables including means, standard deviations, ranges, and percentages. Linear regressions were used to compare the rate of bone loss in edentulous versus dentate women. Among dentate women, women with attachment loss (LOA) >4 mm versus women with <4 mm LOA on more than 12 teeth were also compared. We initially adjusted for age. Multivariate adjusted models included variables known to influence bone density and fracture outcomes (age, weight, education, dietary calcium intake, alcohol use, walking for exercise).

RESULTS

Dentate versus edentulous status of 398 women in the study was examined (Table 1). Most (253; 64%) were dentate, and 145 (36%) were edentulous. Dentate women were more likely to report a higher education, greater calcium intake, drinking alcohol, and a dental examination in the last 2 years compared with edentulous women. There were no differences in age, body weight, smoking, hormone use, and physical activity between the two groups. Similar proportions of dentate and edentulous women reported a history of fracture or osteoporosis.

For the most part there was no difference in age-adjusted BMD, absolute rates of bone loss, or percentage rate of bone loss between dentate and edentulous women (Table 2). Further adjustments for age, weight, education, dietary calcium intake, drinking alcohol, and walking for exercise had little effect on these results. The rate of bone loss at the trochanter was somewhat greater among edentulous women (−0.86% per year) compared to dentate women (−0.52% per year).

Periodontal Disease

The majority (202; 80%) of dentate women had some evidence of periodontal disease (Table 3). Women with periodontal disease were slightly older than women without periodontal

[§]QDR-1000 Scanner, Hologic, Inc., Waltham, MA.
[‖]Osteo Analyzers, Siemens-Osteon, Wahiawa, HI.

disease ($P = 0.078$), but all other characteristics were remarkably similar in the two groups. We found no difference in BMD or in absolute or percentage change in BMD between women with and without periodontal disease (Table 4).

We also correlated several other measures of periodontal disease with BMD, including average periodontal attachment loss, number of sites with >6 mm attachment loss, sites with >4 mm attachment loss, and average number of sites with bleeding, calculus, and probing depth. In general there was no association between periodontal disease and rate of bone loss.

DISCUSSION

The overall prevalence of edentulism in this population of older women was higher (36%) compared with the 23% edentulism rate reported for the U.S. population of women ages 70 to 74 years as published in the NHANES III study.[10,11] The higher prevalence observed in our study could have reflected a continued increase in edentulism with advancing age. The women in our study ranged from 73 to 84 years in age. We found little evidence to support an association between osteoporosis and edentulism. BMD and rate of bone loss were similar in these two groups even after adjustments for established correlating factor of edentulism.

Tooth loss has been observed to be related to bone density in the oral cavity. When interpreting results in various anatomic regions, it is necessary to remember that tooth loss is highly influenced not only by periodontal disease, but also by the local practices of the dental community, as well as other factors related to oral health.

The majority (80%) of dentate women had some evidence of periodontal disease ($P = 0.078$). We found no statistically significant associations between periodontal disease variables (average periodontal attachment loss, average number of sites with bleeding, and average number of sites with calculus) and BMD at trochanter, inter-trochanter, and femoral neck either cross-sectionally or longitudinally. This was true even after controlling variables for age, weight, and other important correlating factors. A possible explanation of our lack of an association between periodontal disease and BMD may be because our population was chronologically older and was missing a large number of teeth. We have no information on the individual reasons for missing teeth. This edentulousness could be due to periodontal disease that occurred earlier in the individual's life.

Historical events such as tooth loss can alter the interpretation of the current status of periodontal disease. Loss of several periodontally involved teeth can result in an improvement of periodontal summary scores, such as average loss of attachment. Compared to the other NHANES III studies,[10,11] average attachment loss for the U.S. population was reported to be 2.1 mm, while data for our population showed an average attachment loss of 2.49 mm. The major strengths of this current study are its large sample size, drawn randomly from a large population of community-dwelling women, and well-controlled measurement of variables.

Limitations

Interpretations of the present study may be limited since periodontal measures of bone such as subtraction radiography or Shei bone score measurement were not available. In addition, masked dental examiners were only able to record a single assessment of periodontal measurements.

CONCLUSION

In conclusion, there was little evidence of an association between edentulousness, clinical periodontal disease, and longitudinal changes in BMD in this population of older women.

Future studies may be needed to longitudinally correlate periodontal disease and BMD over the same period.

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Table 1

Characteristics of Dentate and Edentulous Postmenopausal Women (N = 398) (values are mean [SD] or number [%])

Characteristic	Dentate (N = 253)	Edentulous (N = 145)	*P* Value
Age (years)	75.9 (4.12)	78.8 (4.40)	0.741
Height (cm)	158.0 (5.45)	157.3 (6.01)	0.239
Weight (kg)	68.5 (12.69)	67.85 (11.82)	0.587
Body mass index (kg/m^2)	27.4 (4.80)	27.4 (4.55)	0.935
Age at menopause (years)	47.2 (6.5)	46.8 (5.6)	0.523
Smoking (N, %)			
Past	75 (29.64)	47 (32.64)	
Current	11 (4.35)	7 (4.86)	0.503
Education (N, %)			
>12 years	145 (57.31)	103 (71.03)	
>16 years	91 (35.97)	12 (8.28)	<0.001
Dietary calcium intake (mg/day)	500.82 (1.81)	411.13 (1.93)	0.002
Calcium supplement use (N, %)	103 (40.71)	49 (33.79)	0.172
Alcohol drinking (N, %)	97 (38.49)	43 (29.66)	0.076
Walking for exercise (N, %)	111 (43.9)	46 (31.7)	0.017
Diabetes (N, %)	17 (6.72)	8 (5.52)	0.634
Osteoporosis (N, %)	25 (10.00)	12 (8.39)	0.599
History of fracture after age 50 (N, %)	114 (45.1)	67 (46.2)	0.825
Maternal history of fracture (N, %)	53 (25.85)	23 (21.30)	0.371
Thiozide use (N, %)	14 (17.00)	22 (15.17)	0.636
Estrogen use (N, %)			
Past	46 (18.47)	24 (16.78)	
Current	18 (7.23)	8 (5.59)	0.423
Glucocorticoid use (N, %)	20 (7.91)	13 (8.97)	0.712
Dental examination (N, %)			
Less than 6 months	177 (69.86)	12 (8.28)	
1 year ago	44 (17.39)	18 (12.41)	
2 years ago	12 (4.74)	23 (15.86)	
>2 years ago	20 (7.91)	92 (63.45)	<0.001

Table 2

Age-Adjusted BMD and Annualized Percent Change by Edentulous Status

	Dentate (N = 253)	Edentulous (N = 145)	*P* Value
BMD (g/cm^2)			
Total hip	0.74 (0.01)	0.73 (0.01)	0.528
Femoral neck	0.63 (0.01)	0.63 (0.01)	0.729
Intertrochanter	0.87 (0.01)	0.86 (0.01)	0.661
Trochanter	0.57 (0.01)	0.56 (0.01)	0.401
Absolute rate of BMD change (mg/cm^2/year)			
Total hip	−4.31 (0.55)	−5.07 (0.73)	0.408
Femoral neck	−3.18 (0.57)	−3.03 (0.75)	0.871
Intertrochanter	−4.92 (0.71)	−5.88 (0.94)	0.415
Trochanter	−2.96 (0.54)	−4.60 (0.71)	0.068
Rate of BMD change (%/year)			
Total hip	−0.60 (0.08)	−0.72 (0.10)	0.343
Femoral neck	−0.50 (0.09)	−0.49 (0.12)	0.958
Intertrochanter	−0.59 (0.08)	−0.72 (0.11)	0.325
Trochanter	−0.52 (0.10)	−0.86 (0.13)	0.045

Table 3

Characteristics of Dentate Women With and Without Periodontal Disease (N = 202)*

Characteristic	Periodontal Disease (>4 mm LOA)		
	Yes (N = 163)	No (N = 39)	*P* Value
Age (years)	76.39 (4.25)	75.08 (3.67)	0.078
Height (cm)	157.65 (5.11)	158.43 (5.88)	0.407
Weight (kg)	68.01 (12.40)	69.33 (9.83)	0.539
BMI (kg/m^2)	27.37 (4.87)	27.71 (4.19)	0.690
Age at menopause (years)	47.83 (6.03)	46.02 (7.99)	0.118
Current smoking (N, %)	9 (5.52)	0 (0.0)	0.211
Education (N, %)			
>12 years	97 (59.5)	21 (53.9)	0.330
>16 years	54 (33.1)	16 (41.0)	
Dietary calcium intake (mg/day)	484.91 (1.81)	498.66 (1.78)	0.796
Alcohol drinking (N, %)	61 (37.65)	14 (35.90)	0.839
Walking for exercise (N, %)	71 (43.6)	15 (38.5)	0.563
Diabetes (N, %)	9 (5.52)	1 (2.56)	0.691
Osteoporosis (N, %)	15 (9.38)	5 (12.82)	0.521
History of fracture after age 50 (N, %)	70 (42.9)	19 (48.7)	0.514
Maternal history of fracture (N, %)	32 (24.81)	14 (41.18)	0.059
NSAID use (N, %)	38 (23.31)	9 (23.08)	0.975
Current hormone replacement therapy (N, %)	13 (7.98)	0 (0.0)	0.077
Glucocorticoid use (N, %)	13 (7.98)	3 (7.69)	1.000
Dental exam (N, %)			
Less than 6 months	119 (73.0)	31 (79.5)	0.564
1 year ago	30 (18.4)	4 (10.3)	
2 years ago	6 (3.7)	1 (2.6)	
>2 years ago	8 (4.9)	8 (4.9)	

* Data were not available for 51 subjects.

Table 4

Age-Adjusted BMD and Annualized Percent Change in BMD of Dentate Subjects by Periodontal Status (N = 202)*

	Periodontal Disease		
	Yes (N = 163)	**No (N = 39)**	***P* Value**
BMD (g/cm^2)			
Total hip	0.74 (0.01)	0.74 (0.02)	0.991
Femoral neck	0.63 (0.01)	0.63 (0.02)	0.839
Intertrochanter	0.87 (0.01)	0.87 (0.02)	0.928
Trochanter	0.56 (0.01)	0.57 (0.02)	0.931
Absolute rate of BMD change (mg/cm^2/year)			
Total hip	−4.17 (0.70)	−3.94 (1.44)	0.888
Femoral neck	−2.76 (0.70)	−3.08 (1.43)	0.844
Intertrochanter	−4.48 (0.91)	−4.50 (1.87)	0.994
Trochanter	−2.76 (0.68)	−3.45 (1.40)	0.657
Rate of BMD change (%/year)			
Total hip	−0.54 (0.10)	−0.59 (0.20)	0.906
Femoral neck	−0.42 (0.11)	−0.50 (0.23)	0.756
Intertrochanter	−0.53 (0.11)	−0.65 (0.25)	0.837
Trochanter	−0.47 (0.12)	−0.58 (0.22)	0.504

* Data were not available for 51 subjects.