Clinical Paper
Oral Surgery

Identifying dental panoramic radiograph features for the screening of low bone mass in postmenopausal women

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S. Geary, F. Selvi, S.-K. Chuang, M. August: Identifying dental panoramic radiograph features for the screening of low bone mass in postmenopausal women. Int. J. Oral Maxillofac. Surg. 2015; 44: 395–399. © 2014 International Association of Oral and Maxillofacial Surgeons. Published by Elsevier Ltd. All rights reserved.

Abstract. A retrospective cohort study was performed to evaluate the use of panoramic radiographs as a screening tool for low bone mass in postmenopausal women. Female subjects aged ≥50 years were included. The predictor variables were gonial angle, antegonial angle, mandibular cortical bone integrity, periodontal disease status, and number of remaining teeth. The primary outcome variable was bone mineral density status. Descriptive and logistic regression statistics were computed; $P < 0.05$ was considered significant. The sample was composed of 273 subjects, aged 50–89 years. Visual assessment of mandibular cortical bone integrity demonstrated a statistically significant correlation with low bone mass diagnosis on univariate logistic regression ($P = 0.019$), but lost significance on multivariate analysis with age, body mass index, and number of remaining teeth ($P = 0.6$). A visual estimation of the mandibular cortical bone integrity from panoramic radiographs may be useful for identifying postmenopausal women at high risk for osteoporosis.

Osteoporosis is characterized by loss of bone mineral density (BMD) and deterioration of bone architecture, with consequent susceptibility to fractures, even with minimal force.[1] The World Health Organization (WHO) has established the diagnosis of osteoporosis as a BMD that is −2.5 standard deviations below the young female mean, as measured by dual emission X-ray absorptiometry (DXA).[2] The acceleration of bone mineral degradation during menopause from decreased levels of oestrogen causes postmenopausal women to be especially prone to complications arising from osteoporosis, with approximately one in five women over the age of 50 years in the USA living with osteoporosis.[3] Osteoporotic fractures are a significant source of morbidity and mortality, with common sites involving the wrist, vertebrae, and hip. Hip fractures are associated with a 30% increased mortality rate in the year following injury as a result of complications including deep vein thrombosis and pulmonary embolism.[4] Additionally, one out of every two white women will experience an osteoporotic fracture during her lifetime and one in five will suffer a hip fracture.[5–7] The early detection of osteoporosis is a very important public health goal because interventions such as drug therapy, exercise, and fall-prevention measures can decrease the incidence of fractures.[8]

Dental panoramic radiographs are a routine part of dental care and are often

used in check-ups and treatment planning. Dental radiographs may have great potential as a screening tool for osteoporosis because of their widespread use, practicality, and low cost.[9] Measurements such as gonial angle and visual assessments of mandibular bone health can be extrapolated from a panoramic radiograph. The potential role of panoramic radiography is to use radiographs that are obtained for dental purposes to help identify especially high-risk postmenopausal women who should be referred for a formal diagnosis of osteoporosis.

Multiple studies have examined the mandibular changes resulting from systemic decreases in BMD. One study found that mandibular mineral content is reduced in subjects with osteoporotic fractures,[10] and another demonstrated that mandibular density measured by DXA scan correlates with skeletal BMD.[11] The search for morphological changes demonstrated in panoramic radiographs that correlate with osteoporosis has revealed varying results.[12–18] Devlin and Horner reported a statistically significant relationship between mental index measurements and the diagnosis of reduced BMD.[12] However, they discouraged the use of dental panoramic measurements in diagnosing osteoporosis and instead suggested that such measurements may be useful as part of an osteoporosis risk assessment. Passos et al. recently reported significant correlations between both mandibular cortical bone thickness and the panoramic mandibular index and decreased BMD.[13] While multiple studies have attempted to identify panoramic markers that correlate with decreased BMD, controversy remains regarding the markers that offer the best performance. The aim of the current study was to identify which panoramic markers are useful in screening postmenopausal women for osteopenia/osteoporosis.

Materials and methods

Study sample

A retrospective cohort study design was used. Clinic records of the department of oral and maxillofacial surgery for the period 2006–2012 were screened to identify female subjects aged 50 years or older. The records were then checked for the presence of both a dental panoramic radiograph and a DXA measurement taken within 3 years of each other. Due to the retrospective nature of this study, it was granted an informed consent exemption in writing by the institutional review board of

the hospital. Since menses status was not taken routinely for subjects, age ≥ 50 years was taken as postmenopausal status. Edentulous subjects, subjects with a previous diagnosis of metabolic bone disease (e.g., Paget's disease of bone, osteogenesis imperfecta), and subjects with bone destructive lesions were excluded from the study. Subjects with uninterpretable panoramic radiographs were also excluded.

Demographic information

Medical information was accessed from each subject's hospital electronic medical record. Information recorded for each subject included age at the time of BMD measurement, ethnicity, and body mass index (BMI).

Radiographic measurements

Panoramic radiographs were recorded digitally within the department of oral and maxillofacial surgery using a Planmeca ProMax Dimax 3 (Planmeca, Roselle, IL, USA). Measurement and interpretation were performed with Planmeca Romexis version 2.4.2.R (2010). Unless uninterpretable, all panoramic radiograph measurements were performed on both the left and right sides.

A single observer (SG), blinded to BMD status, performed the following measurements: (1) Gonial angle, measured by tracing a line tangent to the lower border of the mandible and another line tangent to the posterior border of the ramus on each side. The intersection of these lines formed the gonial angle. This method has been described previously by Dutra et al.[17] (Fig. 1). (2) Antegonial angle, measured by tracing two lines parallel to the lower cortical border at the antegonial region and measuring the angle of their intersection at the deepest point of the antegonial notch. This method has been described previously by Dutra et al.[17] (Fig. 1). (3) Number of teeth, determined by counting the number of

remaining teeth in the mandible and maxilla from the panoramic radiograph. Implants were not counted as teeth.

Additional panoramic parameters were assessed by a single observer (MA), blinded to both age and BMD status: (1) Periodontal status was determined by a visual estimation of the level of bone loss around teeth with the most apparent levels of bone loss. Bone loss was categorized as no bone loss, mild (less than a third of the root exposed), moderate (between a third and two-thirds of the root exposed), and severe (more than two-thirds of the root exposed). In addition, localized versus generalized patterns of bone loss were noted. (2) Mandibular cortical bone integrity was measured by a visual assessment of the inferior cortical bone of the mandible. Loss of mandibular cortical bone integrity, or scalloping, was characterized as no scalloping, mild (less than a third thickness of the inferior cortex), moderate (between a third and two-thirds thickness of the inferior cortex), and severe (more than two-thirds thickness of the inferior cortex) (Fig. 2).

Bone densitometry

All subjects had BMD measurements taken by DXA, the gold standard for diagnosing osteoporosis. Subjects were classified according to the WHO classification as normal (T-score > -1), osteopenic (T-score of -1 to -2.5), or osteoporotic (T-score < -2.5), based on the lowest BMD classification at all available sites. The location and number of skeletal sites with available BMD measurements varied between subjects. The DXA T-score demonstrates a subject's BMD relative to a young, healthy, ethnicity-matched female mean.

Statistical analysis

Data analysis was performed using SAS software version 9.3 (SAS Institute, Cary,

Fig. 1. Measurement of the gonial and antegonial angle from a panoramic radiograph.
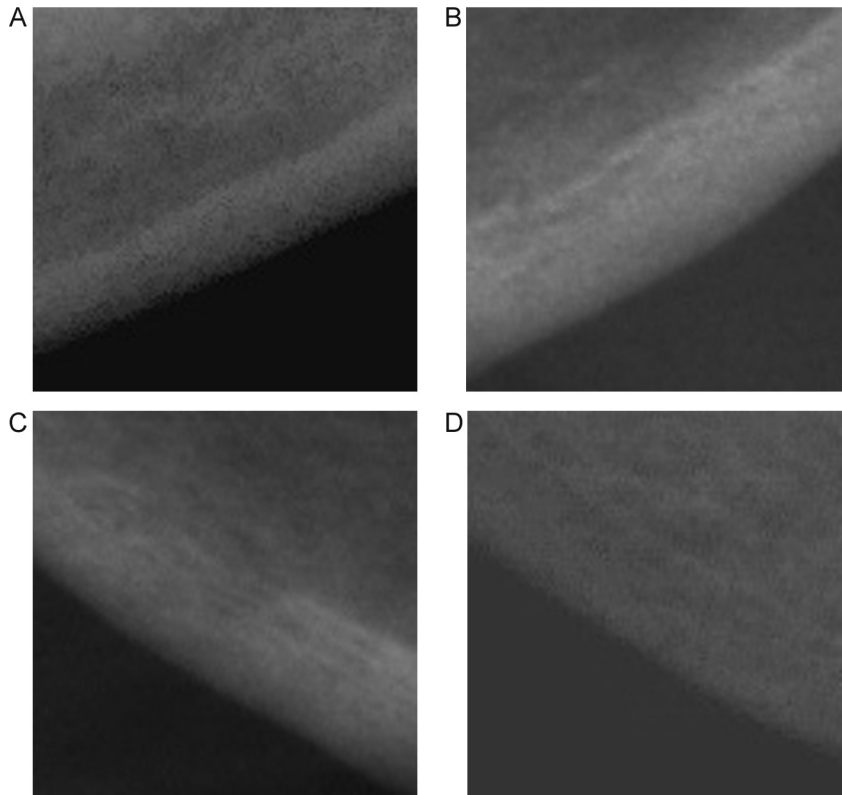
Fig. 2. Mandibular cortical bone integrity assessment. Detail of the superior aspect of the cortical bone of the mandible, anterior to the antegonial notch. (A) No scalloping. (B) Mild scalloping. (C) Moderate scalloping. (D) Severe scalloping.

Table 1. Demographics of the study sample.

Characteristic	*n*	%
Age, years		
50–59	102	37.4
60–69	98	35.9
70–79	47	17.2
80+	26	9.5
Bone status		
Healthy	74	27.1
Osteopenia	139	50.9
Osteoporosis	60	22.0
Ethnicity[a]		
Caucasian	241	88.6
African American	19	7.0
Asian	6	2.2
Hispanic	6	2.2
Total	273	100

[a] One subject did not have a reported ethnicity.

NC, USA). Descriptive and logistic regression statistics were computed to analyse the relationship between the predictor variables and decreased BMD. *P*-values of <0.05 were considered significant. Each variable was analysed for correlation with osteoporotic status in a logistic regression model. The dependent variable was BMD status, with subjects classified as either healthy or osteoporotic/osteopenic. Variables that demonstrated significance in a univariate logistic regression model were run in a multivariate logistic regression model. A logistic regression model was chosen to evaluate the panoramic markers because the issue at hand was identifying the ability to screen for a categorical result (osteoporosis/osteopenia) and not a given marker's correlation with bone density in general.

Results

The initial screening of female subjects aged ≥50 years between 2006 and 2012 yielded 4511 subjects. Two hundred and eighty-four subjects had both dental panoramic radiographs and DXA measurements taken within 3 years of each other. After excluding uninterpretable radiographs, the final study sample comprised 273 subjects. Table 1 summarizes the demographics of the study sample. The mean age of the sample was 64.0 ± 9.3 years. The average BMD *T*-score was −1.59 ± 1.11; 27.1% of the subjects were healthy (BMD *T*-score > −1), 50.9% were osteopenic (BMD *T*-score between −1 and −2.5), and 22.0% were osteoporotic (BMD *T*-score < −2.5).

Table 2 shows a comparison of the demographics and panoramic markers between the healthy and low BMD groups. The results of the logistic regression analysis of the panoramic markers are given in Table 3. Of the predictor variables examined, mandibular cortical bone integrity (*P* = 0.019), age (*P* < 0.0001), and BMI (*P* < 0.0001) showed significant correlations with a BMD diagnosis of osteoporosis.

Table 2. Comparison of demographics and panoramic markers between healthy and low bone mass groups.

	Healthy, mean (SD) [range]	Low BMD, mean (SD) [range]
Characteristics		
Number	74	199
Age, years	60.2 (8.1) [50–82]	65.4 (9.3) [50–90]
Height, m	1.6 (0.07) [1.5–1.8]	1.6 (0.07) [1.4–1.8]
Weight, kg	81.8 (16.4) [47.6–133.4]	66.2 (14.9) [38.1–137.9]
BMI, kg/m^2	30.3 (6.1) [19.2–50.2]	30.3 (6.1) [19.2–50.2]
Indices		
Gonial angle	127.7 (6.4) [109.9–148.7]	128.3 (6.6) [111.2–149.6]
Antegonial angle	165.8 (6.9) [148.1–180.0]	164.7 (7.6) [128.4–180.0]
Number of teeth	22.4 (6.0) [1–32]	23.7 (5.7) [1–32]
	Healthy, *n* (%)	Low BMD, *n* (%)
Mandibular cortical bone integrity		
0	8 (47.1)	9 (52.9)
1	35 (29.2)	85 (70.8)
2	27 (25.5)	79 (74.5)
3	4 (13.3)	26 (86.7)
Periodontal disease status		
0	2 (2.7)	1 (0.5)
1	22 (29.7)	57 (28.6)
2	41 (55.4)	107 (53.8)
3	9 (12.2)	34 (17.1)

SD, standard deviation; BMD, bone mineral density; BMI, body mass index.

Table 3. Logistic regression model.

Panoramic marker	OR (95% CI)	*P*-value
Average gonial angle	1.014 (0.973–1.057)	0.5
Average antegonial angle	0.979 (0.943–1.017)	0.3
Mandibular cortical bone integrity	1.542 (1.074–2.214)	0.019
Number of teeth	1.037 (0.991–1.084)	0.1
Age	1.075 (1.038–1.114)	<0.0001
BMI	0.877 (0.833–0.923)	<0.0001
Ethnicity		0.3

OR, odds ratio; CI, confidence interval; BMI, body mass index.

Table 4. Multivariate logistic regression model featuring mandibular cortical bone integrity, age, BMI, and number of teeth.

Parameter	OR (95% CI)	*P*-value
Mandibular cortical bone integrity	1.132 (0.717–1.786)	0.6
Number of teeth	1.075 (1.017–1.137)	0.01
Age	1.093 (1.046–1.141)	<0.0001
BMI	0.867 (0.819–0.918)	<0.0001

BMI, body mass index; OR, odds ratio; CI, confidence interval.

In the multivariate logistic regression analysis, shown in Table 4, mandibular cortical bone integrity did not demonstrate significance ($P = 0.6$), while age and BMI remained significant ($P < 0.0001$).

Discussion

The aim of the current study was to identify markers in existing panoramic radiographs that warrant referral for BMD measurement in postmenopausal women. The early detection of osteoporosis can lead to interventions that prevent the morbidity and mortality associated with osteoporotic fractures. Panoramic studies are commonly obtained as a dental screening tool in a variety of practice settings. The radiographic markers are quickly and easily measured. While linear measurements from radiographs have demonstrated promise in previous studies, these measurements often required strict controls for magnification and the use of callipers, making their widespread usage impractical. The panoramic markers chosen for this study (visual assessments and angular measurements) can be employed easily.

The gonial angle and antegonial angle were not significantly different between the healthy and low bone mass groups (Tables 2 and 3), and their use as a screening tool appears unhelpful. Our findings are in contrast to those of a previous study which demonstrated a statistical difference in the antegonial angle in a population of edentulous women with low bone mass compared to healthy controls, even when adjusted for age.[17] The authors demonstrated no difference in the gonial angle among these subjects. It is possible that edentulous patients experience more significant remodelling at the antegonial region during periods of bone loss compared to dentate patients. Previous studies have similarly demonstrated that dental status influences mandibular bone remodeling.[19,20] The healthy and low bone mass groups in the current study had a wide range of remaining teeth (1–32 teeth for both groups), and this variability may have reduced the ability to detect a correlation between antegonial angle and decreased bone mass. A previous study reported a significant relationship between a decreased number of remaining molar teeth and osteoporosis, and concluded that osteoporotic patients are more likely to lose teeth.[21] Our study failed to demonstrate a statistical correlation between tooth loss and decreased BMD.

Visual assessment of the mandibular cortical bone integrity demonstrated the highest correlation with a diagnosis of low bone mass of all the panoramic markers examined in this study, $P = 0.019$ (Table 3). Previous studies have also reported this observation.[17,22] The proportion of subjects with an assessment of the cortical bone as normal was 47.1% for healthy subjects and 52.9% for those with low BMD; however, an assessment of mild scalloping of the cortical bone increased the proportion of low BMD subjects to 70.8%, while that of healthy subjects decreased to 29.2% (Table 2). Increasingly severe scalloping (from moderate to severe) of the cortex produced modest increases in the proportion of low bone mass subjects, 74.5% and 86.7% (Table 2). These findings suggest that even mild scalloping of the inferior mandibular cortex on panoramic film may indicate a loss of BMD. This correlation, however, was not found to be statistically significant in a multivariate logistic regression model with age, BMI, and number of remaining teeth also considered. This loss of statistical significance could be explained by the fact that the healthy group was younger than the low bone mass group (60.15 vs. 65.44 years, respectively). While age appears to influence mandibular cortical bone, the use of visual assessment of the cortex from a panoramic radiograph may still be useful as part of an osteoporosis risk assessment.

The current study has several limitations. Since BMD and panoramic measurements were taken within a window period of each other, instead of at the same point in time, the correlations found in this study may be an underestimation of the true correlation. Another limitation was the lack of available medical data for the subjects in the sample. For example, smoking history is a well-established osteoporosis risk factor. Information about the duration and amount of smoking was inconsistently available in this sample. In addition, menstruation history was not routinely documented. Subjects with premature or surgically induced menopause were not identified. Information regarding hormone replacement therapy, dietary history, and exercise history would also be relevant. Additionally, our study sample was composed primarily of white female subjects treated at an oral surgery clinic in an urban setting, so the results of this study may not apply to populations with different demographics.

Future studies to assess panoramic radiograph markers of osteoporosis should include a prospective design, in which baseline panoramic measurements are made prior to menopause. If panoramic markers truly correlate with decreasing BMD, these markers should change over time in the individual as their BMD decreases.

In conclusion, given the significance of mandibular cortical bone integrity on univariate analysis and the biological plausibility, it may be useful as a risk assessment tool and to recommend a BMD evaluation. The remaining markers, including gonial angle, antegonial angle, number of remaining teeth, and periodontal disease status are not recommended as screening tools for osteoporosis in postmenopausal women.

and Research Fund and Harvard Medical School Scholars in Medicine Office.

Competing interests

The authors report no conflicts of interest.

Ethical approval

Ethical approval was given by Massachusetts General Hospital Institutional Review Board (reference number 2012P000658).

Patient consent

Not required; waved by Massachusetts General Hospital Institutional Review Board.

References

1. Consensus Development Conference: diagnosis, prophylaxis, and treatment of osteoporosis. *Am J Med* 1993;**94**:646–50.
2. World Health Organization. Assessment of fracture risk and its application to screening for postmenopausal osteoporosis. Report of a WHO Study Group. *World Health Organ Tech Rep Ser* 1994;**843**:1–129.
3. Management of osteoporosis in postmenopausal women: 2010 position statement of The North American Menopause Society. *Menopause* 2010;**17**:25–54.
4. Parker MJ, Anand JK. What is the true mortality of hip fractures. *Public Health* 1991;**105**:443–6.
5. Johnson CC, Cummings SR, Dawson-Hughes B, Lindsay R, Melton LJ, Slemenda CW. *Physician's guide to prevention and treatment of osteoporosis*. Washington, DC: National Osteoporosis Foundation; 1998
6. Oden A, Dawson A, Dere W, Johnell O, Jonsson B, Kanis JA. Lifetime risk of hip fractures is underestimated. *Osteoporos Int* 1998;**8**:599–603.
7. Melton III LJ. Epidemiology of hip fractures: implications of the exponential increase with age. *Bone* 1996;**18**(3 Suppl.): 121S–5S.
8. Cheung AM, Feig DS, Kapral M, Diaz-Granados N, Dodin S, Canadian Task Force on Preventive Health Care. Prevention of osteoporosis and osteoporotic fractures in postmenopausal women: recommendation statement from the Canadian task force on preventive health care. *CMAJ* 2004;**170**: 1665–7.
9. White SC. Oral radiographic predictors of osteoporosis. *Dentomaxillofac Radiol* 2002;**31**: 84–92.
10. Von Wowern N, Klausen B, Kollerup G. Osteoporosis: a risk factor in periodontal disease. *J Peridontol* 1994;**65**:1134–8.
11. Horner K, Devlin H, Alsop CW, Hodgkinson IM, Adams JE. Mandibular bone mineral density as a predictor of skeletal osteoporosis. *Br J Radiol* 1996;**69**:1019–25.
12. Devlin H, Horner K. Mandibular radiomorphometric indices in the diagnosis of reduced skeletal bone mineral density. *Osteoporos Int* 2002;**13**:373–8.
13. Passos JS, Filho IS, Sarmento VA, Sampaio DS, Goncalves FP, Coelho JM, et al. Women with low bone mineral density and dental panoramic radiography. *Menopause* 2012;**19**: 704–9.
14. Bollen AM, Hujoel PP, Hollender LG. Case–control study on self-reported osteoporotic fractures and mandibular cortical bone. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2000;**90**:518–24.
15. Law AN, Bollen AM, Chen SK. Detecting osteoporosis using dental radiographs: a comparison between four methods. *J Am Dent Assoc* 1996;**127**:1734–42.
16. Taguchi A, Sanada M, Krall EA, Nakamoto T, Ohtsuka M, Suei Y, et al. Relationship between dental panoramic radiographic findings and biochemical markers of bone turnover. *J Bone Miner Res* 2003;**18**:1689–94.
17. Dutra V, Devlin H, Susin C, Yang J, Horner K, Fernandes A. Mandibular morphological changes in low bone mass edentulous females: evaluation of panoramic radiographs. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2006;**102**:663–8.
18. Hastar E, Yilmaz HH, Orhan H. Evaluation of mental index, mandibular cortical index and panoramic mandibular index on dental panoramic radiographs in the elderly. *Eur J Dent* 2011;**5**:60–7.
19. Dutra V, Yang J, Devlin H, Susin C. Radiomorphometric indices and their relation to gender, age, and dental status. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2005;**99**:479–84.
20. Dutra V, Yang J, Devlin H, Susin C. Mandibular bone remodeling in adults: evaluation of panoramic radiographs. *Dentomaxillofac Radiol* 2004;**33**:323–8.
21. Darcey J, Horner K, Walsh T, Southern H, Marjanovic EJ, Devlin H. Tooth loss and osteoporosis: to assess the association between osteoporosis status and tooth number. *Br Dent J* 2013;**214**:10.
22. Lee K, Taguchi A, Ishii K, Suei Y, Fujita M, Nakamoto T, et al. Visual assessment of the mandibular cortex on panoramic radiographs to identify postmenopausal women with low bone mineral densities. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2005;**100**: 226–31.

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