# Risk for vertebral osteoporosis in postmenopausal women with alterations of the mandible

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**Abstract**

**Background**. Previous studies have suggested that a thin or eroded cortex of the mandible detected on dental panoramic radiographs is associated with low vertebral bone mineral density (BMD) or osteoporosis. However, those studies did not estimate the multivariate-adjusted risk for low vertebral BMD or osteoporosis associated with alterations of the mandible.

**Methods.** BMD of the lumbar vertebrae (L2–L4) was compared among quartiles of cortical width and among three cortical shape categories in 450 postmenopausal women (mean age, 57.2 years), adjusted for potential confounders. The odds ratios for low BMD or osteoporosis according to cortical width and shape were also calculated. **Results.** Significant associations were found between cortical width and shape and vertebral BMD. The odds ratio for low vertebral BMD associated with the second, third, and lowermost quartiles of cortical width was 1.71 (95% CI, 0.96–3.05), 2.30 (95% CI, 1.29–4.11), and 5.43 (95% CI, 2.16–10.71), respectively, compared to the uppermost quartile. The odds ratios for osteoporosis according to cortical width category were similar to those for low BMD. The odds ratio for low BMD associated with mildly to moderately and severely eroded cortices was 3.85 (95% CI, 2.37–6.25) and 7.84 (95% CI, 2.57–23.90), respectively, compared to normal cortex. The odds ratio for osteoporosis associated with mildly to moderately and severely eroded cortices was 4.73 (95% CI, 2.54–8.80) and 14.73 (95% CI, 6.14–35.47), respectively.

**Conclusions.** Postmenopausal women with alterations of the mandible may have an increased risk for low vertebral BMD or osteoporosis.

***Keywords****:* Osteoporosis; Bone; Menopause; Women; Mandible

## Introduction

A clinically diagnosed vertebral fracture is a risk factor for subsequent long-term morbidity and mortality in elderly women[1,2]. The prevalence of vertebral fractures increases rapidly after the age of 65 years in Japanese and Caucasian women[3]. Vertebral fractures are the most common complication of osteoporosis; however, they are frequently asymptomatic and undetected[4,5]. Since bone mineral density (BMD) is one of the indicators predicting osteoporotic fractures, postmenopausal women with undetected low skeletal BMD should be referred for BMD testing. However, it is likely that a large segment of postmenopausal women with undetected low BMD will not have BMD testing if they do not have a deep concern of osteoporosis.

Postmenopausal women have many opportunities to visit dental clinics for oral care or treatment. A large number of dental panoramic radiographs (approximately 10 million in Japan and 17 million in the United States) are taken annually for the diagnosis and treatment of dental diseases, such as dental caries and periodontal disease[6,7], but not for the diagnosis of non-dental diseases in general dental practice. It would be very beneficial for postmenopausal women with undetected low BMD if the dentists can identify them by incidental finding on dental panoramic radiographs and refer them to medical professionals for BMD testing prior to the incidence of osteoporotic fractures. Some investigators have suggested that a thin or eroded inferior cortex of the mandible detected on dental panoramic radiographs, an indicator of alterations of the mandible, is useful for identifying postmenopausal women with undetected low skeletal BMD or

osteoporosis[8–21]. However, the possible confounding variables, such as age and body weight, were not adjusted sufficiently in those analyses. It is not clear whether postmenopausal women with alterations of the mandible have an increased risk for vertebral low BMD or osteoporosis after adjusting for potential confounding variables. Therefore, this study estimated the multivariate-adjusted risk for low vertebral BMD or osteoporosis in postmenopausal women with alterations of the mandible.

## Methods

### *Participants*

Between 1996 and 2006, 932 women visited our clinic for BMD assessment. Of these, 141 women were patients from the dental clinic in our hospital, 703 were from the gynecology clinic, 62 were from internal medicine, and 26 were from surgery. At the BMD assessment, all the women were asked to give informed consent to a dental panoramic radiographic examination for oral care; 138 women refused the panoramic examination. Of these, 42 were pre- or peri-menopausal women. Of the remaining 752 postmenopausal women who had not menstruated for at least 1 year, 450 postmenopausal women aged 32–84 years (mean ± SD, 57.2 ± 8.1) with no previous diagnosis of vertebral fractures were recruited for this study. Postmenopausal women whose precise medical history was not confirmed by hospital records or a questionnaire were excluded from this study. Other exclusion criteria were tobacco use (only 6.6%), metabolic bone diseases (hyperparathyroidism, hypoparathyroidism, Paget's disease, osteomalacia, renal osteodystrophy, and osteogenesis imperfecta), cancers with bone metastasis, diabetes, major renal impairment, the use of medications that affect bone metabolism other than

estrogen, bone destructive lesions in the jawbones (such as malignant tumors or osteomyelitis), non-vertebral osteoporotic fractures, and vertebral osteoporotic fractures that were assessed on X-ray at skeletal BMD assessment semiquantitatively[22]. Of the 450 subjects who participated in this study, 105 (23.3%) had used estrogen. One hundred and forty-four subjects had undergone hysterectomy, 37 had undergone unilateral oophorectomy, and 91 had undergone bilateral oophorectomy. The Hiroshima University Institutional Human Subjects Committee approved taking dental panoramic radiographs of the subjects who gave informed consent.

*BMD assessment and dental panoramic radiography measures*

BMD at the lumbar vertebrae (L2–L4) was determined using dual-energy X-ray absorptiometry (DXA, DPX-alpha; Lunar, Madison, WI, U.S.A.). Height and weight were measured at the time of DXA measurement. In our clinic, the *in vivo* short-term precision error of DXA was 1.0% at the lumbar vertebrae. Low BMD was defined as a BMD T score of –1.0 or less. Osteoporosis was defined as a BMD T-score of –2.5 or less according to the World Health Organization (WHO) classification[23].

Dental panoramic radiographs were obtained at the time of DXA measurement with a Panoramax (Asahi, Kyoto, Japan) or AZ-3000 (Asahi) instrument. A screen-film system, which consisted of screens of speed group 200 (HG-M; Fuji Photo Film, Tokyo, Japan) and film (UR-2; Fuji Photo Film), was used for the radiographs in 426 subjects. A digital radiography system (FCR 5000; Fuji Photo Film) was used for the radiographs in 24 subjects. The magnification factor was the same for the two panoramic radiography systems. All the dental panoramic radiographs used in this study were satisfactory for the measurements. Two dental panoramic radiographic measures, mandibular inferior

cortical width and shape (erosion), were considered indicators of alterations of the mandible and estimated by one oral radiologist (A.T.) with 18 years of clinical experience. The number of teeth remaining was also counted on dental panoramic radiographs excluding the third molar.

The mandibular cortical width was measured bilaterally on the radiographs at the site of the mental foramen, as in our previous study[9] (Fig. 1). A line parallel to the long axis of the mandible and tangential to the inferior border of the mandible was drawn. A line perpendicular to this tangent intersecting the inferior border of the mental foramen was constructed, along which the mandibular cortical width was measured using calipers. The mean cortical width on both sides of the mandible was used in this study. The coefficient of variation due to positioning and operator error in the cortical width measure was less than 2%. The intra-observer variation in the cortical width measure was 0.1 mm, which was similar to the interobserver variation[9].

Mandibular cortical shape on the dental panoramic radiograph was determined by observing the mandible distally from the mental foramen bilaterally and was categorized into one of three groups according to the method of Klemetti et al.[8] as follows (Fig. 2).

*Normal cortex*: the endosteal margin of the cortex is even and sharp on both sides.

*Mildly to moderately eroded cortex*: the endosteal margin shows semilunar defects (lacunar resorption) or appears to form endosteal cortical residues.

*Severely eroded cortex*: the cortical layer forms heavy endosteal cortical residues and is clearly porous.

The overall intra- and interobserver agreement was 92 and 82%, respectively[9].

*Data analysis*

Pearson's correlation coefficient was calculated to evaluate the associations between cortical width and shape of the mandible, age, and vertebral BMD. Vertebral BMD was also compared among quartiles of cortical width of the mandible and among three categories of cortical shape of the mandible using analysis of covariance, adjusted for age, height, weight, time since menopause, duration of estrogen use (0 for no use), and history of hysterectomy (yes or no) or oophorectomy (yes or no). A logistic regression analysis adjusted for these confounding variables was used to calculate the odds ratios and 95% confidence interval (CI) of low vertebral BMD or osteoporosis according to the quartile of cortical width and cortical shape category. The data were analyzed using the Statistical Package for the Social Sciences (SPSS; version 8.0; SPSS, Chicago, IL, USA). *P*-values less than 0.05 were considered statistically significant.

**Results**

One hundred and eighty (40%) subjects had a normal BMD, 172 (38.2%) subjects had osteopenia (BMD T score of –2.5 to –1.0) at the lumbar vertebrae, and 98 (21.7%) subjects had vertebral osteoporosis (Table 1). Two hundred and fourteen (47.6%) subjects had an eroded cortex of the mandible. When the cortical width of the mandible was divided into quartiles, the ranges of cortical width in the uppermost, second, third, and lowermost quartiles were from 6.92 to 4.66, 4.65 to 4.08, 4.07 to 3.46, and 3.45 to 1.37 mm, respectively. Since a magnification factor was about 1.2, the actual ranges of cortical width in the uppermost, second, third, and lowermost quartiles were considered from 5.77 to 3.88, 3.87 to 3.40, 3.39 to 2.88, and 2.87 to 1.14 mm, respectively.

Age was significantly correlated with cortical width of the mandible ($r = –0.32$, $P < 0.001$) and cortical shape of the mandible ($r = 0.48$, $P < 0.001$). Vertebral BMD was also significantly correlated with cortical width of the mandible ($r = 0.44$, $P < 0.001$) and cortical shape of the mandible ($r = –0.47$, $P < 0.001$). The analysis of covariance adjusted for confounding variables revealed a significant association between the quartile of cortical width of the mandible and vertebral BMD ($P < 0.001$) (Table 2). Subjects belonging to the lowermost quartile of cortical width had a significantly lower vertebral BMD than those belonging to the uppermost ($P < 0.001$), second ($P < 0.001$), or third ($P = 0.027$) quartiles of cortical width. Furthermore, there was a significant association between the cortical shape of the mandible and vertebral BMD ($P < 0.001$). Subjects with a severely eroded cortex had a significantly lower vertebral BMD than those with a mildly to moderately eroded cortex ($P = 0.001$) or normal cortex ($P < 0.001$). Further adjustment for dentition status (number of teeth remaining) did not change these associations between the quartile of cortical width of the mandible and vertebral BMD or between cortical shape of the mandible and vertebral BMD.

The odds ratios of low vertebral BMD associated with the second, third, and lowermost quartiles of cortical width of the mandible were 1.71 (95% CI, 0.96–3.05), 2.30 (95% CI, 1.29–4.11), and 5.43 (95% CI, 2.16–10.71), respectively, compared to the uppermost quartile (Table 3). The odds ratios of vertebral osteoporosis associated with the second, third, and lowermost quartiles of cortical width of the mandible were 0.79 (95% CI, 0.30–2.12), 2.95 (95% CI, 1.27–6.87), and 6.04 (95% CI, 2.68–13.58), respectively, compared to the uppermost quartile. The odds ratios of low vertebral BMD associated with mildly to moderately and severely eroded cortices compared to the normal cortex were 3.85 (95% CI, 2.37–6.25) and 7.84 (95% CI, 2.57–23.90),

respectively. The odds ratios of vertebral osteoporosis associated with mildly to moderately and severely eroded cortices compared to the normal cortex were 4.73 (95% CI, 2.54–8.80) and 14.73 (95% CI, 6.14–35.47), respectively.

The odds ratio of vertebral osteoporosis for 33 subjects with both the lowermost quartile of cortical width and a severely eroded cortex was 22.77 (95% CI, 7.88–65.78) compared to 160 subjects with a normally shaped cortex belonging to both the uppermost and second quartiles of cortical width.

**Discussion**

Postmenopausal women with a thinner cortical width had an increased risk for low vertebral BMD or osteoporosis in this study after adjusting for possible confounding variables. In particular, women belonging to the lowermost quartile of cortical width of the mandible had a significantly lower vertebral BMD than those belonging to the other quartiles of cortical width. This implies that a thin cortex determined visually by dentists based on their clinical experience can be used as an indicator for identifying postmenopausal women with a low BMD or osteoporosis. In fact, about 80% of postmenopausal women who were selected visually using a “thin” cortex alone, as determined by the dentists, had a low skeletal BMD in our recent study[20].

Postmenopausal women with an eroded cortex also had an increased risk for low vertebral BMD or osteoporosis after adjusting for confounding variables. Especially, the odds ratio for vertebral osteoporosis was 14 times greater in subjects with a severely eroded cortex compared to those with a normal cortex. Furthermore, the odds ratio for vertebral osteoporosis was 23 times greater in subjects with both a thinner (lowermost

quartile) and severely eroded cortex compared to those with both a normal and thicker (uppermost and second quartiles) cortex. These women at risk for vertebral osteoporosis should be referred for BMD testing before osteoporotic vertebral fractures occur.

Age was significantly correlated with the cortical width of the mandible ($r = –0.32$, $P < 0.001$) in this study. Vertebral BMD was also significantly correlated with cortical width of the mandible ($r = 0.44$, $P < 0.001$). Devlin and Horner recently reported that subject age was significantly correlated with cortical width of the mandible below the mental foramen ($r = –0.26$, $P = 0.024$) in 74 British postmenopausal women aged 43–79 years (mean age, 62 years)[12]. In their study, the cortical width of the mandible was significantly correlated with the BMD T-score recorded at the lumbar vertebrae (L1–L4) ($r = 0.52$, $P < 0.01$). Their results were in accord with our results. It is possible that the crude threshold of cortical width for identifying low vertebral BMD or osteoporosis in Japanese postmenopausal women cannot be used directly for British postmenopausal women because of the difference in the size of the mandible. However, the percentage based on the mean cortical width of the mandible in postmenopausal women with a normal vertebral BMD may be used in both Japanese and British women for identifying low vertebral BMD or osteoporosis because a similar correlation was observed between cortical width and vertebral BMD in both races. Devlin and Horner found that the mean cortical width (3.96 mm) in British postmenopausal women with a low BMD (T score of –1.0 or less) was about 84% of the mean cortical width (4.73 mm) in those with a normal BMD[12]. In our study, the mean cortical width (3.75 mm) in Japanese postmenopausal women with a low BMD was also about 84% of the mean cortical width (4.45 mm) in those with a normal BMD. Two recent British studies suggest that a diagnostic threshold for cortical width of 3 mm (or less) is the most appropriate threshold for referral for bone

densitometry in postmenopausal and perimenopausal women[12,13]. Considering the use of percent mean cortical width, a diagnostic threshold of 2.8 mm (or less), which was within the lowermost quartile in our study, is suggested as an appropriate threshold for BMD testing in Japanese women.

Cortical thinning and erosion of the mandible were regarded as indicators of alterations of the mandible in this study. These changes reflect the increase in widened Haversian canals with resorption surfaces in the cortex[24]. In the skeleton, trabecular bone is more sensitive to osteoporotic changes than cortical bone; however, it is not clear whether a similar change is observed in the trabecular part of the mandible. Jonasson et al. reported a significant correlation between the forearm BMD and the coarseness of trabeculation ($r = 0.62$, $P < 0.001$) in 80 women with a mean age of 47 years (range, 20–78 years)[25]. White et al. also reported that changes in radiographic trabecular structure, represented by the node-to-terminus strut, in the mandibular incisor region were predictive of hip fracture in 598 elderly women[26]. Conversely, Choel et al. indicated that the infra-alveolar trabecular BMD measured using DXA was more sensitive to the local dental status than to the systemic status[27]. Klemetti et al. failed to find a significant association between trabecular BMD determined using quantitative computed tomography and skeletal BMD (lumbar spine and femoral neck) determined using DXA in 74 totally or nearly edentulous menopausal women[28]. Southard et al. also found no significant association between alveolar trabecular bone architecture in the premolar to molar region of the mandible, represented by fractal dimension, and skeletal BMD (lumbar spine, total hip, and total wrist) determined using DXA in 37 dentate healthy Caucasian women aged 20–78 years[29]. Since the trabecular bone architecture of the mandible is markedly different in the incisor, premolar, and molar regions[30] and is easily

influenced by dental infections, which contribute to both osteolytic and osteosclerotic changes, we regarded cortical width and the shape of the mandible as indicators of alterations of the mandible in this study.

This study has limitations. Our subjects were not healthy volunteers from the community, but were patients who visited our clinic for BMD assessment. Therefore, the subjects are not representative of normal Japanese postmenopausal women. Iki et al. recently reported that in healthy Japanese women aged 50–79 years, the prevalence of osteoporosis according to the WHO classification was 38.0% at the lumbar vertebrae[31]. We cannot compare our subjects aged 32–84 years with their subjects directly; however, the prevalence of osteoporosis at the lumbar vertebrae (21.7%) was lower than that in their study. The relative younger mean age (57.2 years) might contribute to the lower prevalence of vertebral osteoporosis. These results may limit the interpretation of our findings. Dentition status might influence alterations of the mandible due to the change in masticatory function[32]. This might also contribute to vertebral osteoporosis via the change of nutritional intake[33]. However, further adjustment for dentition status (number of teeth remaining) did not change the associations among the mandibular cortical parameters and vertebral BMD in this study. Since a number of subjects with tobacco use was small (6.6%) in 752 postmenopausal women who had not menstruated for at least 1 year and the history of their tobacco use varied (current use, former use or no precise history of use), postmenopausal women with tobacco use was excluded from this study.

In conclusion, after adjusting for potentially confounding variables, the odds ratio for low vertebral BMD or osteoporosis associated with the lowermost quartile of cortical width of the mandible was 5.43 (95% CI, 2.16–10.71) and 6.04 (95% CI, 2.68–13.58), respectively, compared to the uppermost quartile. The odds ratio for low vertebral BMD

or osteoporosis associated with a severely eroded cortex was 7.84 (95% CI, 2.57–23.90) and 14.73 (95% CI, 6.14–35.47), respectively, compared to the normal cortex. Postmenopausal women with a thinner or eroded cortex of the mandible detected on dental panoramic radiographs had an increased risk for low vertebral BMD or osteoporosis. Our results suggest that dentists should refer asymptomatic postmenopausal women with alterations of the mandible to medical professionals for bone densitometry.

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**Figure legends**

Figure 1. A line parallel to the long axis of the mandible and tangential to the inferior border of the mandible was drawn. A line (dotted line) perpendicular to this tangent intersecting the inferior border of mental foramen was constructed, along which mandibular cortical width (the distance between the two parallel solid lines) was measured.

Figure 2. Classification of mandibular inferior cortical shape observed distally from the mental foramen on dental panoramic radiographs: (A) normal cortex, (B) mildly to

moderately eroded cortex, and (C) severely eroded cortex. A small letter “m” shows the mental foramen.

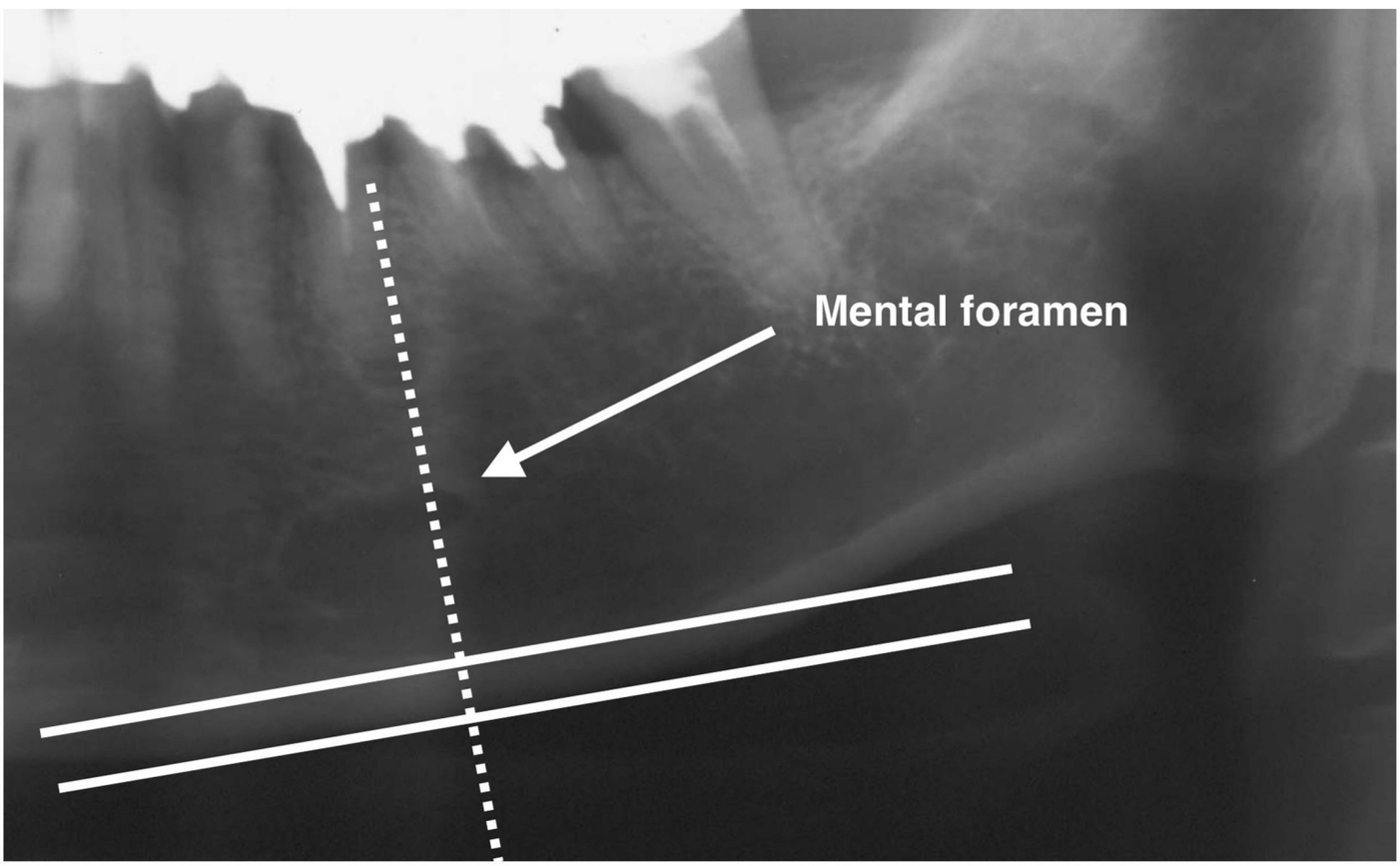
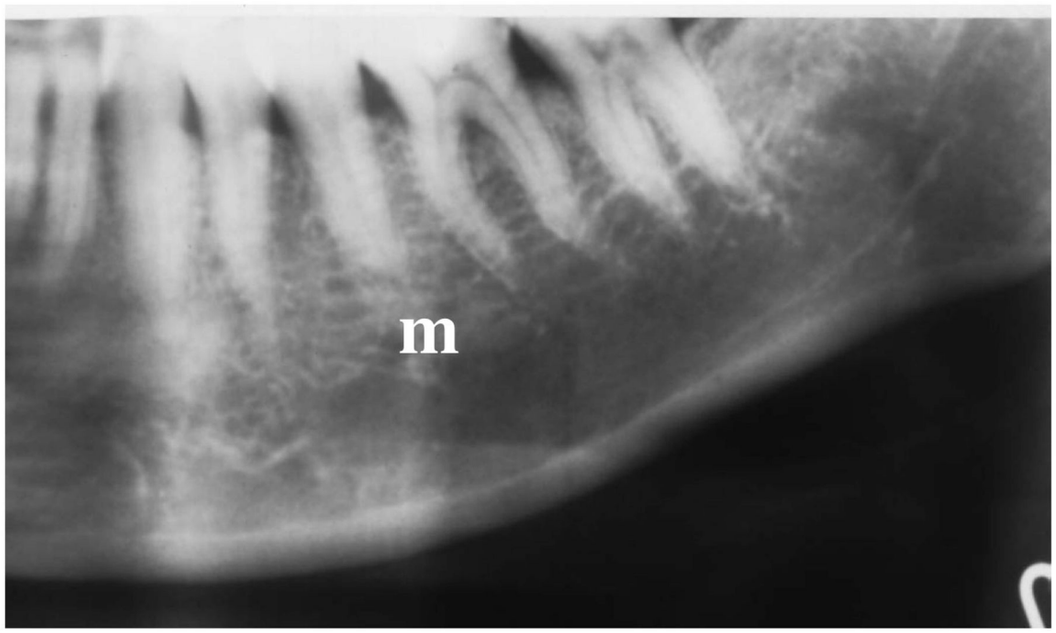



Figure 1

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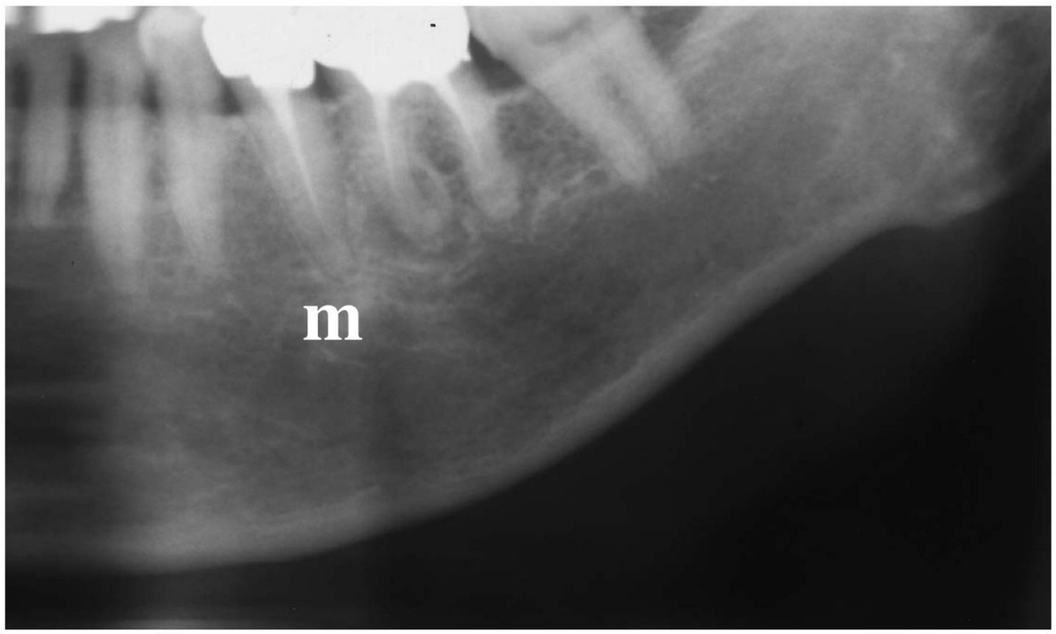


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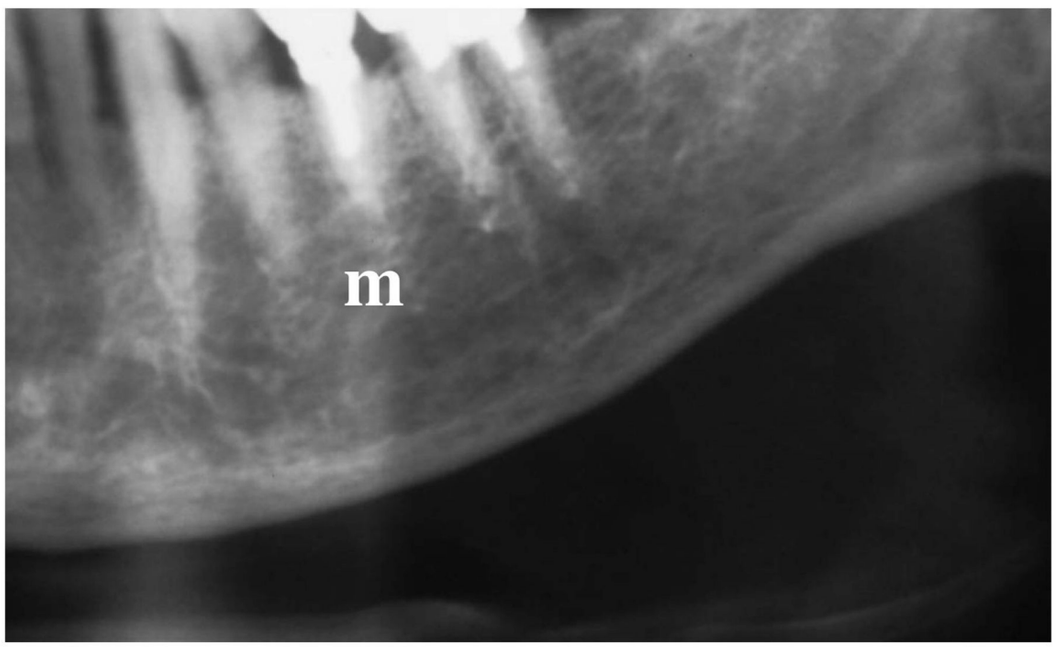


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Figure 2

Table 1. Characteristics of 450 study subjects

| | Mean +/- SD or number of subjects (% subjects) |
|---|---|
| Age (years) | 57.2 +/- 8.1 |
| Height (cm) | 153.4 +/- 5.7 |
| Weight (kg) | 51.8 +/- 7.5 |
| Time since menopause (years) | 9.6 +/- 7.6 |
| Mandibular cortical width (mm) | 4.0 +/- 1.0 |
| Number of teeth remaining | 22.1 +/- 7.3 |
| Mandibular cortical shape | |
| Normal cortex | 236 (52.4%) |
| Mildly to moderately eroded cortex | 175 (38.9%) |
| Severely eroded cortex | 39 (8.7%) |
| Diagnosis based on BMD of the lumbar vertebrae | |
| Normal | 180 (40.0%) |
| Osteopenia | 172 (38.2%) |
| Osteoporosis | 98 (21.7%) |

BMD: bone mineral density

Table 2. Vertebral bone mineral density according to mandibular cortical width and cortical shape categories

| | Number of subjects | Vertebral bone mineral density ($g/cm^2$) | P-value † |
|---|---|---|---|
| Cortical width* | | | |
| Uppermost quartile | 112 | 1.019 +/- 0.013 | < 0.001 |
| Second quartile | 111 | 0.975 +/- 0.013 | |
| Third quartile | 114 | 0.946 +/- 0.013 | |
| Lowermost quartile | 113 | 0.891 +/- 0.014 | |
| Cortical shape* | | | |
| Normal | 239 | 1.008 +/- 0.010 | < 0.001 |
| Mildly to moderately eroded | 175 | 0.919 +/- 0.011 | |
| Severely eroded | 39 | 0.826 +/- 0.023 | |

The results were shown as mean +/- SEM.

* Means are significant different from each other after Bonferroni adjustment for multiple comparisons; cortical width (uppermost quartile vs. third quartile: P<0.001, uppermost quartile vs. lowermost quartile: P<0.001, second quartile vs. lowermost quartile: P<0.001, third quartile vs. lowermost quartile: P=0.027) and cortical shape (normal cortex vs. mild to moderately eroded cortex: P<0.001, normal cortex vs. severely eroded cortex: P<0.001, mildly to moderately eroded cortex vs. severely eroded cortex: P=0.001).

† From the analysis of covariance, adjusted for age, height, weight, time since menopause, duration of estrogen use (0 for none-user), and history of hysterectomy (yes or no) or oophorectomy (yes or no)

Table 3. Unadjusted and multivariate-adjusted odds ratio and 95% confidence interval of low vertebral bone mineral density (BMD) or osteoporosis according to mandibular cortical width and shape categories

| | BMD T score of -1.0 or less (Low BMD) | | BMD T score of -2.5 or less (Osteoporosis) | |
|---|---|---|---|---|
| | Unadjusted | Adjusted | Unadjusted | Adjusted |
| Cortical width | | | | |
| Uppermost quartile | 1.00 | 1.00 | 1.00 | 1.00 |
| Second quartile | 1.95 (1.15 – 3.33) | 1.71 (0.96 – 3.05) | 1.01 (0.40 – 2.53) | 0.79 (0.30 – 2.12) |
| Third quartile | 2.55 (1.49 – 4.36) | 2.30 (1.29 – 4.11) | 3.01 (1.38 – 6.59) | 2.95 (1.27 – 6.87) |
| Lowermost quartile | 7.86 (4.19 – 14.75) | 5.43 (2.16 – 10.71) | 8.70 (4.12 – 18.36) | 6.04 (2.68 – 13.58) |
| Cortical shape | | | | |
| Normal | 1.00 | 1.00 | 1.00 | 1.00 |
| Mildly to moderately eroded | 4.90 (3.14 – 7.64) | 3.85 (2.37 – 6.25) | 6.22 (3.46 – 11.18) | 4.73 (2.54 –8.80) |
| Severely eroded | 11.45 (3.95 – 33.19) | 7.84 (2.57 – 23.90) | 20.61 (9.15 – 46.43) | 14.73 (6.14 – 35.47) |

The multivariate model includes age, height, weight, time since menopause, duration of estrogen use (0 for none-user), and history of hysterectomy (yes or no) or oophorectomy (yes or no).