

Diagnostic efficacy of alveolar bone loss of the mandible for identifying postmenopausal women with femoral osteoporosis

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Running title: Alveolar bone loss and femoral osteoporosis

## **Abstract**

**Objectives:** Mandibular cortical width (MCW) detected on panoramic radiographs may be useful for identifying postmenopausal women with osteoporosis. There is little known whether alveolar bone loss (ABL) of the mandible detected on panoramic radiographs is a potentially accurate screening tool for osteoporosis in comparison with MCW. The purpose of this study was to evaluate whether ABL of the mandible on panoramic radiographs is useful for identifying femoral osteoporosis in postmenopausal women in comparison with MCW.

**Methods:** Three hundred and fifty-four Japanese postmenopausal women (mean age  $\pm$  SD, 56.8  $\pm$  7.7) were recruited for this study. Femoral BMD was measured by dual energy x-ray absorptiometry. Panoramic radiographs were obtained to estimate ABL of the mandible and MCW.

**Results:** A multiple regression analysis revealed that femoral BMD was significantly associated with MCW ( $p < 0.001$ ), weight ( $p < 0.001$ ), age ( $p < 0.001$ ), and ABL of the mandible ( $p = 0.029$ ) (adjusted  $r$  square = 0.380). The area under the ROC curve (AUC) for identifying femoral osteoporosis was 0.609 (95% confidence interval [CI], 0.523 to 0.696) for ABL of the mandible and 0.779 (95% CI, 0.713 to 0.844) for MCW, respectively. AUC for ABL of the mandible indicated less accurate.

**Conclusions:** Our results suggest that ABL of the mandible on panoramic radiographs may not be useful for identifying postmenopausal women with femoral osteoporosis in comparison with MCW.

**Key words:** osteoporosis; alveolar bone; mandible; menopause

## **Introduction**

Osteoporotic fractures are a health burden worldwide, resulting in the reduction of physical activity, increased risk of mortality and incremental medical costs. The occurrence of a hip fracture from osteoporosis is associated with an increased risk of death even after prefracture health status is taken into account.<sup>1</sup> Since dual energy x-ray absorptiometry (DXA) is the most reliable way to determine bone mineral density (BMD), which is one of major risk factors for fractures from osteoporosis, the patients with high-risk of osteoporosis should be referred to medical professionals for BMD assessment. However, only a few BMD measurements are obtained among patients, especially postmenopausal women, in high-risk groups because of no symptom prior to fractures.<sup>2</sup> A large segment of postmenopausal women with a high-risk of fractures from osteoporosis still remain undiagnosed.<sup>3</sup>

Most of the elderly have an opportunity to visit dental clinic for the treatment of dental caries or periodontal disease more likely than medical clinic for the diagnosis of osteoporosis prior to fractures. A large number of panoramic radiographs (approximately 10 million annually in Japan) are obtained for the diagnosis and treatment of teeth and jaws in dental clinics. Several studies suggest that mandibular cortical width (MCW) detected on panoramic radiographs may be useful for identifying postmenopausal women with low skeletal BMD or osteoporosis.<sup>4-10</sup> On the other hand, some investigators report that a larger alveolar bone loss (ABL) of the mandible may be associated with lower skeletal BMD or osteoporosis in postmenopausal women<sup>11-15</sup>; however, a statistically significant association between ABL of the mandible and skeletal BMD in these previous studies does not imply that ABL of the mandible may be

a potentially accurate screening tool to detect osteoporosis in postmenopausal women. We cannot still determine whether postmenopausal women with a larger ABL of the mandible and a thicker MCW or those with a smaller ABL of the mandible and a thinner MCW have high-risk of osteoporosis, because there is little known whether ABL of the mandible detected on panoramic radiographs is a potentially accurate screening tool for osteoporosis in comparison with MCW.

Therefore, we evaluated whether ABL of the mandible detected on panoramic radiographs is useful for identifying femoral osteoporosis in postmenopausal women in comparison with MCW.

## **Materials and Methods**

### *Study sample*

Of 676 women who visited our clinic for BMD assessment between 1996 and 2003, 354 postmenopausal women (mean age  $\pm$  SD, 56.8  $\pm$  7.7 years) were recruited for this study. Of these subjects, 115 (33%) had undergone hysterectomy, 26 (7%) had undergone unilateral oophorectomy, 71 (20%) had undergone bilateral oophorectomy, and 79 (22%) currently used estrogen. Women who did not give informed consent for taking panoramic radiographs at skeletal BMD assessment were excluded from the study. Furthermore, excluded from the study were postmenopausal women who had used tobacco or medications that affect bone metabolism except estrogen or who had metabolic bone diseases, diabetes, significant renal impairment, bone-destructive lesions (osteomyelitis or malignant tumor) in the jaw, non-vertebral osteoporotic fractures, and vertebral osteoporotic fracture detected on lateral spine radiographs at skeletal BMD assessment. All subjects gave informed consent before inclusion.

Hiroshima University Institutional Human Subjects Committee approved taking dental panoramic radiographs in subjects with informed consent.

*BMD assessment and dental panoramic radiography measures*

BMD at the femoral neck was determined by DXA (DPX-alpha, Lunar Co., Madison, WI, U.S.A.). Height and weight were measured at DXA measurement. The *in vivo* short-term precision error for femoral BMD measurement in our clinic was 2.8%. Osteoporosis was defined as a BMD T-score of -2.5 or less in the femoral neck according to the World Health Organization (WHO) classification.<sup>16</sup> Panoramic radiographs were obtained at the time of DXA measurement with a Panoramax (Asahi Co., Kyoto, Japan) or AZ-3000 (Asahi Co., Kyoto, Japan) at 12 mA and 15 seconds; the kV varied between 70 and 80. Screens of speed group 200 (HG-M, Fuji Photo film Co., Tokyo, Japan) and film (UR-2, Fuji Photo film Co., Tokyo, Japan) were used.

The mandibular total bone height (TBH) and basal bone height (BBH; height from the center of the mental foramen to the inferior border of the mandible) at the site of mental foramen were measured bilaterally using a calipers on panoramic radiographs by one oral radiologist (A.T.) with 17 years of clinical experience according to our previous study (Figure 1).<sup>17</sup> Mean TBH/BBH ratio on both sides was calculated to estimate the degree of ABL of the mandible. Low TBH/BBH ratio indicates high ABL of the mandible. The coefficient of variation due to TBH/BBH measurement error was 2.8% in ten randomly selected panoramic radiographs. Precise number of teeth remaining was also counted on panoramic radiographs.

Measurement of MCW was made bilaterally on the radiographs at the site of mental foramen according to our previous study.<sup>6</sup> 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 inferior border of mental foramen was constructed, along which MCW was measured by a calipers (Figure 2). Mean cortical width on both sides of the jaw was used in this study. The coefficient of variation due to positioning error and operator error in cortical width measure was less than 2%. Intra-observer variation in cortical width measure was 0.1mm, which was similar to inter-observer variation.

#### *Data analysis*

A stepwise multiple linear regression analysis adjusted for age, height, weight, duration of estrogen use (0 for no user), MCW, and history of hysterectomy (yes or no) or oophorectomy (yes or no) was performed to evaluate the association between ABL of the mandible and femoral BMD in these subjects. Femoral BMD was the dependent variable in this regression model. Because of significantly moderate correlations between age and time since menopause ( $r=0.60$ ,  $P<0.001$ ) and ABL of the mandible and number of teeth remaining ( $r=0.57$ ,  $P<0.001$ ), time since menopause and number of teeth remaining were excluded from this model.

Receiver operating characteristics (ROC) curve analysis was used to clarify as to whether postmenopausal women with femoral osteoporosis can be identified accurately by the degree of ABL of the mandible in comparison with MCW. For the test (osteoporosis or non-osteoporosis) that yielded continuous data such as ABL of the mandible and cortical width of the mandible, the cut-off threshold was shifted systematically over the measurement range and the observed pairs of sensitivity and (1-specificity) was established for each of different operating points. Based on these

observed pairs, ROC curve was obtained and the area under the ROC curve (AUC) was calculated.<sup>18</sup> According to an arbitrary guideline,<sup>19</sup> we distinguished between non-informative (AUC=0.5), less accurate (0.5<AUC<0.7), moderately accurate (0.7<AUC<0.9), highly accurate (0.9<AUC<1) and perfect tests (AUC=1). Data analyses were performed using Statistical Package for the Social Sciences (SPSS; version 8.0; SPSS Inc, Chicago, IL). P-values less than 0.05 were considered statistically significance.

## **Results**

Characteristics of study subjects according to femoral BMD category are shown in Table 1. There were statistically significant differences in age ( $p<0.001$ ), height ( $p<0.001$ ), weight ( $p<0.001$ ), time since menopause ( $p<0.001$ ), number of teeth remaining ( $p=0.022$ ), ABL of the mandible ( $p=0.002$ ), and MCW ( $p<0.001$ ) between subjects with and without femoral osteoporosis.

A multiple regression analysis revealed that femoral BMD was significantly associated with MCW ( $p<0.001$ ), weight ( $p<0.001$ ), age ( $p<0.001$ ), and ABL of the mandible ( $p=0.029$ ) (adjusted r square = 0.380) (Table 2). AUC for identifying women with femoral osteoporosis was 0.609 (95% confidence interval [CI], 0.523 to 0.696) for ABL of the mandible and 0.779 (95% CI, 0.713 to 0.844) for MCW, respectively (Figure 3). AUC for MCW was moderately accurate; however, AUC for ABL of the mandible was less accurate (Figure 4,5).

## **Discussion**

This study is the first report as to whether postmenopausal women with femoral

osteoporosis are identified accurately by the degree of ABL of the mandible detected on panoramic radiographs. In this study, a lower femoral BMD was significantly associated with a larger ABL of the mandible detected on panoramic radiographs in Japanese postmenopausal women. This result is in accordance with the results of the previous studies<sup>11-15</sup>; however, area under ROC curve (AUC) for identifying postmenopausal women with femoral osteoporosis by ABL of the mandible was 0.609 (95% CI, 0.523 to 0.696) that indicated less accurate. This implies that postmenopausal women with femoral osteoporosis cannot be identified accurately by ABL of the mandible. Recent study reported that poor periodontal status was significantly associated with low metacarpal BMD (osteopenia or osteoporosis) independent of age and menopausal status in 356 Japanese women; however, AUC in identifying women with low metacarpal BMD by poor periodontal status was 0.67 that indicated less accurate.<sup>20</sup> As well, it is likely that ABL of the mandible may not be a potentially accurate screening tool to detect osteoporosis even if ABL of the mandible is significantly associated with skeletal BMD in some populations.

Compared to ABL of the mandible, AUC for identifying postmenopausal women with femoral osteoporosis by MCW was 0.779 (95% CI, 0.713 to 0.844) that indicated moderately accurate. Devlin and Horner recently reported that AUC for identifying postmenopausal women with low skeletal BMD (at spine, femur or forearm) by MCW was 0.733 (95% CI, 0.618 to 0.830) in 74 Caucasian women aged 43 to 79 years (mean age 62 years).<sup>7</sup> Our result was somewhat similar to that of their study, although they did not evaluate femoral osteoporosis. Gourlay et al. conclude that Osteoporosis Self-Assessment Tool (OST), one of questionnaire-based screening tool for osteoporosis, is the simplest and has the best potential for use in clinical practice.<sup>21</sup> In their study,

AUC for identifying femoral osteoporosis by OST was 0.768 (95% CI, 0.730 to 0.806) in 2539 postmenopausal women aged 45–64 years and 0.762 (95% CI, 0.730 to 0.794) in 1496 postmenopausal women aged 65 years or older, respectively. Our result and theirs suggest that postmenopausal women with femoral osteoporosis may be identified by MCW with sufficient diagnostic efficacy similar to OST index, but not by ABL of the mandible.

This study has limitations. All subjects of this study were not healthy volunteers from the community, but were patients who visited our clinic for BMD assessment. Our subjects, therefore, are not representative of normal Japanese postmenopausal women. This may limit the interpretation of our findings. Iki et al. recently reported that in the healthy Japanese women aged 50 to 79 years, the prevalence rate of osteoporosis according to WHO classification was 11.6% at the femoral neck.<sup>22</sup> We directly cannot compare our subjects with their subjects; however, the prevalence rate of femoral osteoporosis in their study was similar to that (14.7%) in our study.

Second limitation is that we did not estimate oral bone height of both jaws, but of only the mandible. Some investigators traditionally measured alveolar bone loss, the distance from cemento-enamel junction to the alveolar crest, around the remaining teeth of both jaws using intra-oral dental radiographs such as bitewing dental radiographs.<sup>13-15</sup> However, this method limits the subjects because the edentulous subjects or subjects with few teeth will be excluded prior to the study. We may not be able to estimate oral bone height of both jaws in this study; however, bias for sampling the subjects will be at least minimized compared with that in using traditional dental radiographic methods.

In conclusion, a lower femoral neck BMD was significantly associated with a larger ABL of the mandible in Japanese postmenopausal women; however, postmenopausal

women with femoral osteoporosis may not be identified accurately by the degree of ABL of the mandible in comparison with the measurement of cortical width of the mandible on panoramic radiographs.

#### Acknowledgements

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mineral density of the spine, hip and distal forearm in representative samples of the Japanese female population: Japanese Population-Based Osteoporosis (JPOS) Study. *Osteoporos Int* 2001;**12**:529-37.

## Figure legends

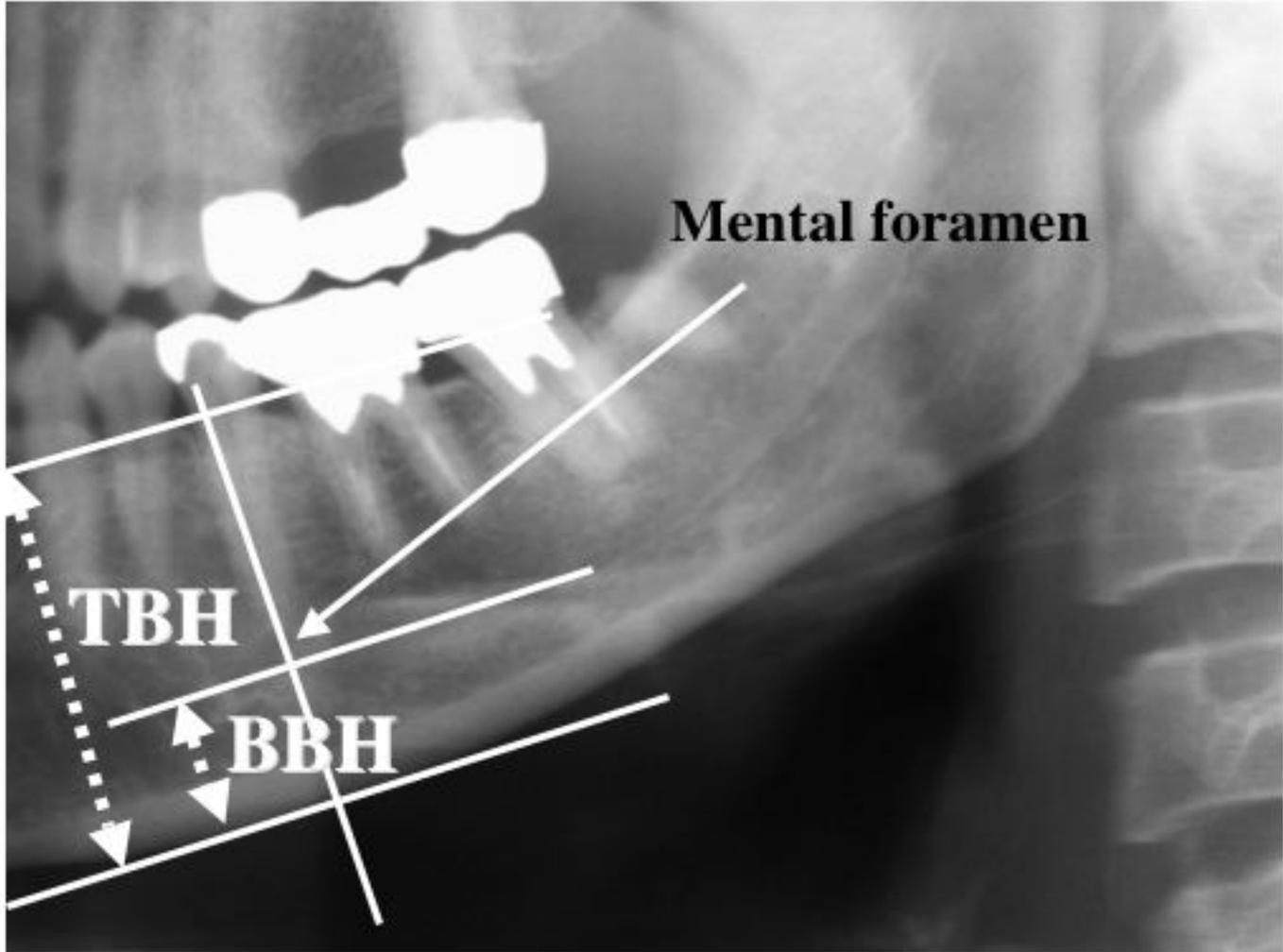
Figure 1. The mandibular total bone height (TBH) and basal bone height (BBH; height from the center of the mental foramen to the inferior border of the mandible) at the site of mental foramen were measured bilaterally. Mean TBH/BBH ratio on both sides was defined as the degree of alveolar bone loss of the mandible.

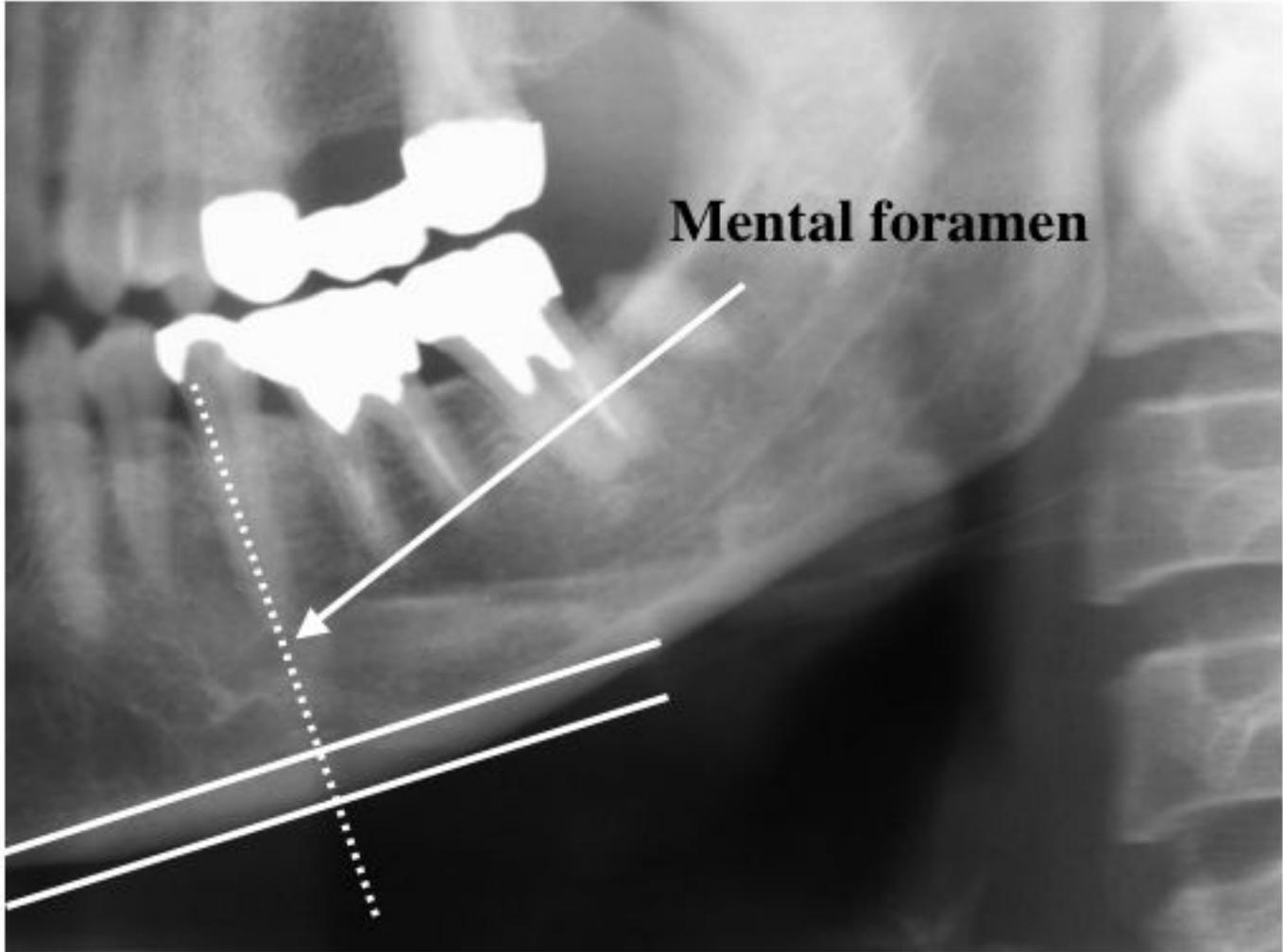
Figure 2. A line parallel to the long axis of the mandible and tangential to the inferior border of the mandible was drawn. A line (dotted line) perpendicular to this tangent intersecting inferior border of mental foramen was constructed, along which mandibular cortical width (MCW) was measured. The distance between two parallel solid lines is MCW.

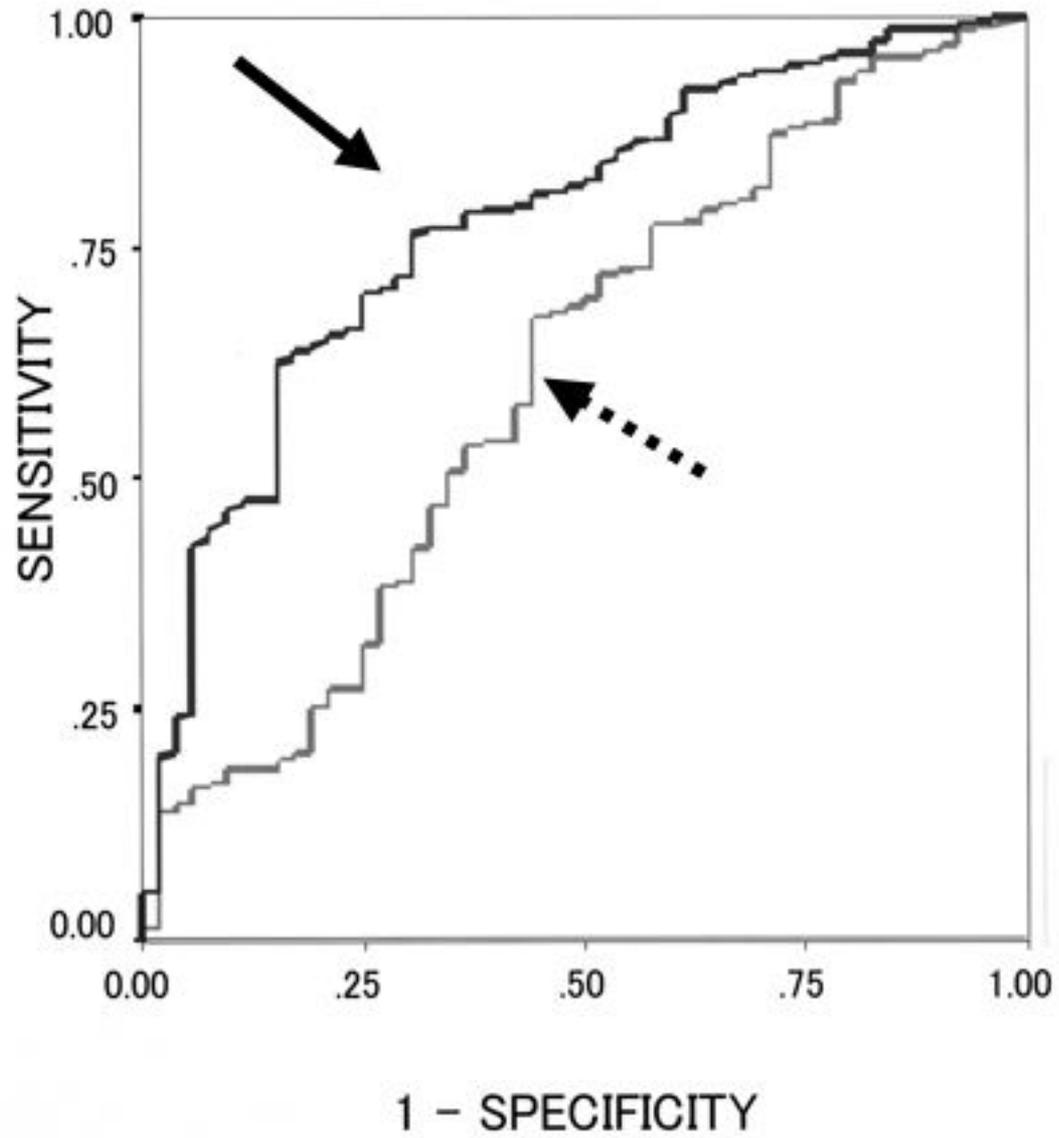
Figure 3. Receiver operating characteristics curve for identifying postmenopausal women with femoral osteoporosis by alveolar bone loss (ABL) of the mandible (arrow of dotted line) and mandibular cortical width (MCW) (arrow of solid line)

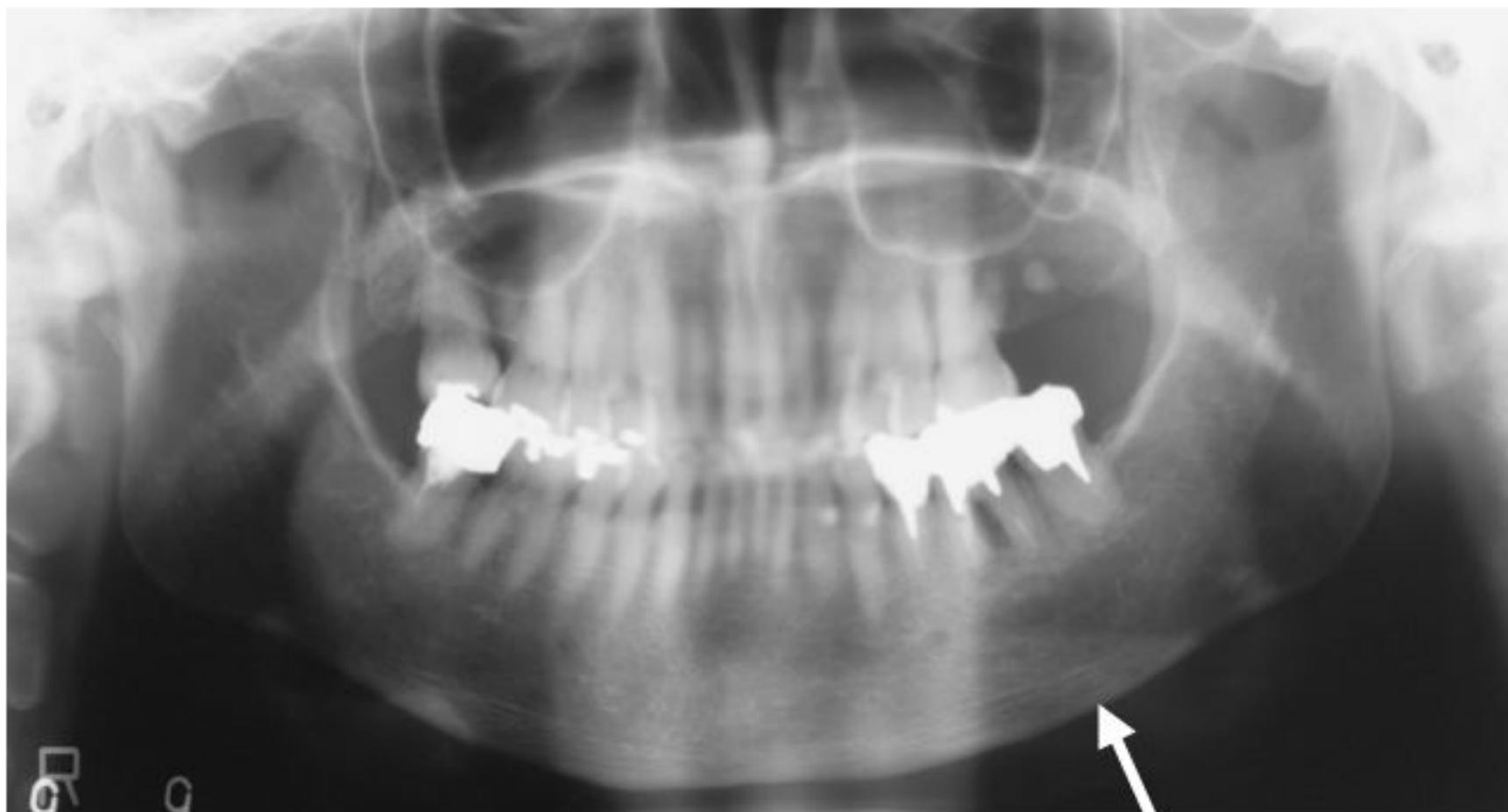
Figure 4. In panoramic radiograph of 59-year-old postmenopausal women with femoral osteoporosis, alveolar bone loss of the mandible is very small, but cortical width of the mandible (white arrow) is extremely thin.

Figure 5. In panoramic radiograph of 57-year-old postmenopausal women with normal femoral bone mineral density, alveolar bone loss of the mandible is severe, but cortical width of the mandible (white arrow) is relatively thick.









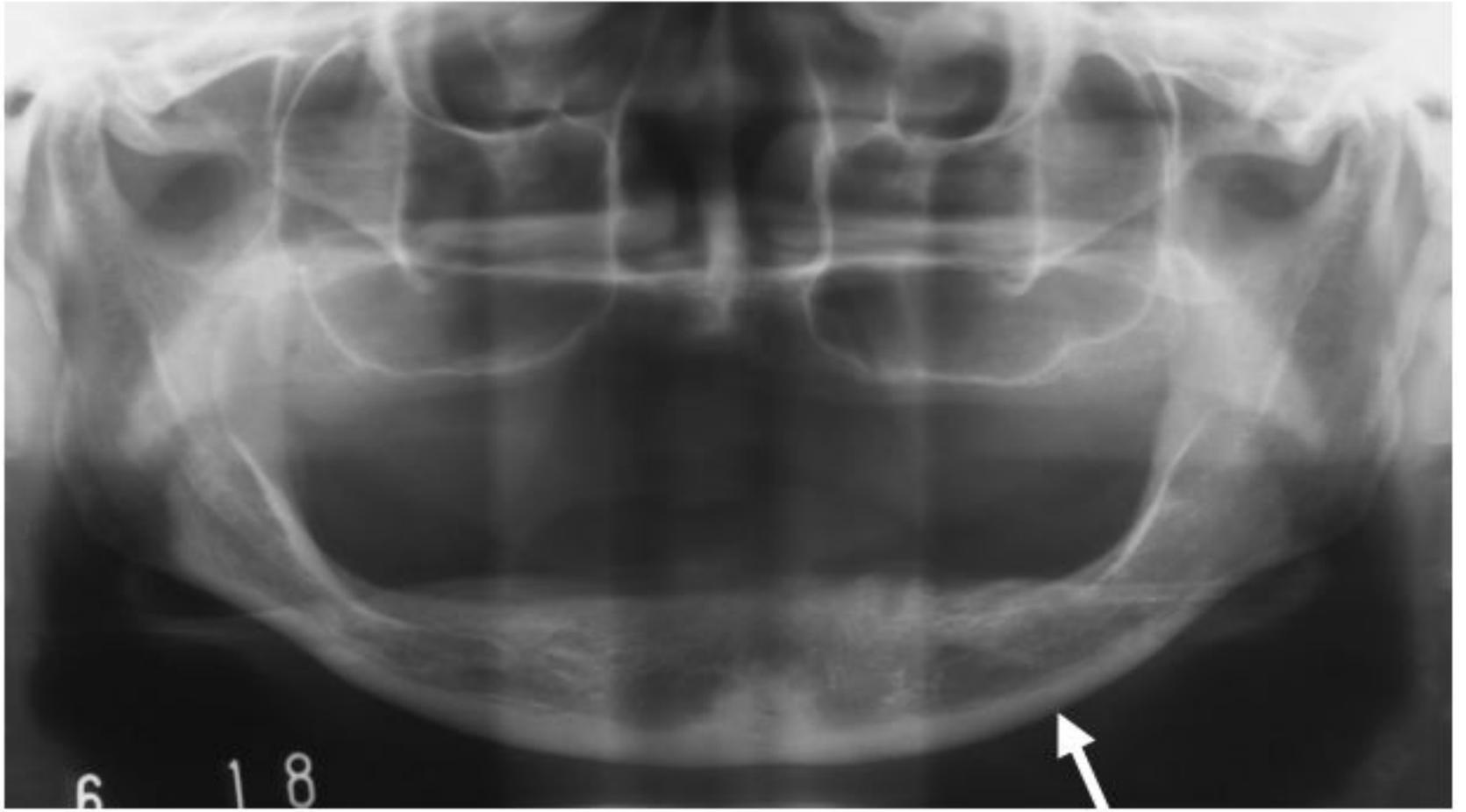


Table 1. Characteristics of 354 study subjects according to femoral bone mineral density (BMD) category

|   | Normal BMD or Osteopenia<br>(BMD T score more than -2.5) | Osteoporosis<br>(BMD T score of -2.5 or less) |
|---|--|---|
| Number of subjects                              | 302  | 52  |
| Age (years)                                     | 55.6 +/- 7.0   | 64.3 +/- 7.2                                  |
| Height (cm)                                     | 153.9 +/- 5.2  | 149.2 +/- 5.8                                 |
| Weight (kg)                                     | 52.3 +/- 7.2   | 47.1 +/- 5.2                                  |
| Time since menopause                            | 8.4 +/- 7.2  | 14.9 +/- 7.3                                  |
| Number of teeth remaining                       | 22.5 +/- 7.2   | 20.0 +/- 8.3                                  |
| Alveolar bone loss of the mandible <sup>a</sup> | 2.19 +/- 0.28  | 2.06 +/- 0.37                                 |
| Mandibular cortical width (mm)                  | 4.1 +/- 0.9  | 3.2 +/- 0.9                                   |
| Hysterectomy                                    | 101 (33.4%)  | 14 (26.9%)                                    |
| Oophorectomy                                    | 84 (27.8%)   | 13 (25.0%)                                    |
| Estrogen use                                    | <b>68 (22.5%)</b>  | <b>11 (21.1%)</b>                             |

Results are shown as mean +/- SD or number of subjects (% subjects).

<sup>a</sup> Alveolar bone loss of the mandible is the ratio of the radiographic mandibular total bone height to mandibular basal bone height.

Table 2. Stepwise multiple linear regression analysis for predicting femoral bone mineral density

|   | parameter estimates | standard error | t-statistics | p-value |
|---|---------------------|----------------|--------------|---------|
| Intercept                                       | 0.449               | 0.077          | 5.858        | <0.001  |
| Mandibular cortical width (mm)                  | 0.044               | 0.006          | 7.801        | <0.001  |
| Weight (kg)                                     | 0.004               | 0.001          | 5.890        | <0.001  |
| Age (years)                                     | -0.003              | 0.001          | -4.716       | <0.001  |
| Alveolar bone loss of the mandible <sup>a</sup> | 0.038               | 0.018          | 2.197        | 0.029   |

<sup>a</sup> Alveolar bone loss of the mandible is the ratio of the radiographic mandibular total bone height to mandibular basal bone height.