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Risk of osteoporosis in elderly individuals attending a dental clinic

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Objective: Osteoporosis has become a critical public health problem with the rapidly aging population in Japan. It is necessary for dentists to know their patients' status because it influences dental treatment. The purpose of this study was to predict the risk of osteoporosis in elderly patients visiting a dental clinic by assessing mandibular cortical morphology on panoramic radiographs. **Method:** Three-hundred and thirty patients were divided into three classes based on the morphology of their mandibular cortex on panoramic radiographs. Mandibular cortical bone width at the mental foramen was also measured. Bone mineral density (BMD) was determined at the calcaneus using a quantitative ultrasound device. **Results:** The mandibular cortical width decreased significantly from Class 1 (normal cortex), to Class 2 (moderately eroded cortex) and to Class 3 (severely eroded cortex). BMD was negatively correlated with age in both female and male patients. Most (108/186) female patients had a class 3 cortex with a low BMD. Among women, mandibular cortical width was significantly correlated with BMD. Thirty-three percent of the female had received a previous diagnosis of osteoporosis. In contrast, only 13.9% (20/144) of the male had a Class 3 cortex. In men, mandibular cortical width did not significantly correlate with BMD. Only a few of the men had received a previous diagnosis of osteoporosis. The number of remaining teeth did not correlate with low BMD in either sex. **Conclusion:** Our findings reveal that most elderly female patients visiting the dental clinic had a high risk of osteoporosis and a low BMD.

Key words: Bone mineral density, dental clinic, osteoporosis, panoramic radiography

INTRODUCTION

Osteoporosis is a common metabolic bone disease characterised by progressive reduction in bone mass and changes in bone microstructure, leading to increased risk of fracture[1]. In the rapidly aging population in Japan, osteoporosis has become a critical public health problem. According to the 2012 Japanese guidelines for osteoporosis, the condition affects 12.8 million people, with a yearly increase of almost 0.97 million people[2]. However, only 5% of elderly individuals undergo medical examination for osteoporosis, and only about 20% of patients with osteoporosis receive treatment[3].

Dental treatment depends on bone status; low bone mineral density (BMD) can affect bone healing, for example, after tooth extraction, and can influence the success of implant procedures. Dentists should be aware of osteopenia/osteoporosis that is present in the patients they treat. There are reports that tooth loss might be related to mandibular osteopenia[4], and that osteoporosis might contribute to tooth loss in postmenopausal women[5]. Panoramic radiographs are widely used in routine dental examinations, and several studies have proposed their use to identify osteoporosis. Taguchi advocates the use of panoramic radiographs for screening for osteoporosis[3]. Several studies have indicated the diagnostic accuracy of panoramic radiographs in identifying individuals with osteoporosis. Most of these studies examined the accuracy of screening in participants diagnosed with osteoporosis based on dual-energy X-ray absorptiometry (DXA) data. Few studies targeting dental-clinic patients have investigated the probability of osteoporosis in this population.

We quantitatively evaluated the panoramic mandibular cortex morphology and the BMD of the

calcaneus as predictors of osteoporosis. The aim of this study was to estimate the risk of osteoporosis in elderly patients who visited a dental clinic.

MATERIALS AND METHODS

Study participants

We enrolled a total of 842 patients, > 65 years of age, who visited our dental clinic from 1 March 2012 to 31 August 2012. Of those patients, 360 were excluded because panoramic radiographs were not taken or because the mental foramen was not clearly observed. Panoramic radiographs from the remaining 482 patients were analysed and 152 of these patients were excluded because their BMD had not been examined. Consequently, 330 patients were included in the study. All patients provided written informed consent to participate in the study. The protocol was approved by the local research ethics committee of Ohtsuki Association of Healthcare Corporation. The study was conducted in full accordance with ethical principles, including the World Medical Association Declaration of Helsinki.

Panoramic mandibular index

Digital panoramic radiographs (AUTO III NCM; Asahi Roentgen Ind. Co. Ltd., Kyoto, Japan) were taken at 12 mA and a peak voltage of 60–100 kV, according to the subject's jaw size. Two panoramic radiographic indices, mandibular cortical width and panoramic mandibular index, were measured according to the method of Taguchi *et al.*[6]. A line was drawn parallel to the mandibular cortex and tangential to the inferior border of the mental foramen; the mandibular cortical width was measured along this line using a calliper. The panoramic mandibular index was evaluated by observing the bilateral inferior border of the mandible and was classified into one of three groups: Class 1 (normal cortex); Class 2 (moderately eroded cortex); and Class 3 (severely eroded cortex) (*Figure 1*).

Bone density measurement

The BMD at the calcaneus was measured using ultrasound densitometry (OSTEO Pro Smart; Ito Physiotherapy & Rehabilitation, Tokyo, Japan) in the 330 patients who provided informed consent. This device automatically calculates bone density as a percentage of the young adult mean (YAM) of BMD in Japanese people (20–44 years of age)[2], based on impedance and ultrasound attenuation. According to the diagnostic criteria for primary osteoporosis in Japan, osteoporosis is defined as BMD <70% of YAM and osteopenia is defined as 70–80% of YAM[2].

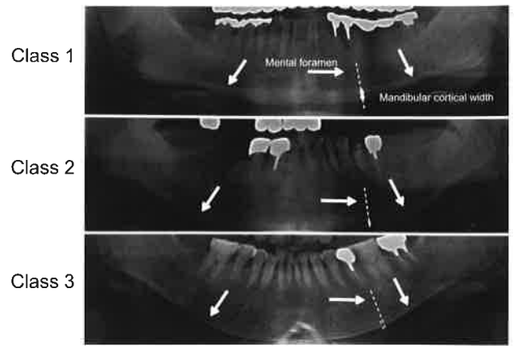

Figure 1. Panoramic mandibular index classification, based on the morphology of the inferior mandibular cortex. Class 1: the endosteal margin of the cortex is even and clear bilaterally. Class 2: the endosteal margin shows semilunar defects (lacunar resorption) and/or endosteal cortical residues are observed on one or both sides. Class 3: the cortical layer forms heavy endosteal cortical residues and is clearly porous.

Intra-observer agreement

The classification and measurements of panoramic radiographs were performed by two general dentists with over 20 years of clinical experience. To quantify interobserver agreement, 100 panoramic radiographs were randomly selected from the sample and analysed by the main observer. Two observers measured the same radiographs to verify interobserver reliability. Observers were not informed of the bone density data from the calcaneus and had no access to information about the patients, such as age and sex. Each observer independently measured mandibular cortical width and judged the panoramic mandibular index based on the mandibular border morphology. For qualitative indices, agreement was calculated as a weighted kappa statistic. The kappa statistic for interobserver agreement was 0.978 and thus interobserver agreement for the panoramic mandibular index had excellent reproducibility. The intraclass correlation coefficient of variation resulting from positioning error and operator error in the mandibular cortical width measurement was 0.958. Interobserver variation for the cortical width measurement was 0.27 mm, which was similar to the intra-observer variation.

Statistical analysis

Data are shown as mean ± standard deviation or as number (per cent). Correlations between the variables studied were established using the Pearson correlation coefficient. The Kruskal–Wallis test was used to assess differences between panoramic mandibular index classes (Classes 1, 2 and 3). Values of $P < 0.05$ were considered significant. Statistical analyses were performed using Statcel 2 (OMS Co., Tokyo, Japan).

RESULTS

The participants included 186 women and 144 men. Among the women, 58.1% had Class 3 cortex, and these individuals had a significantly lower BMD than did those with Class 2 or Class 1 cortices (*Table 1*). Similarly, mandibular cortex width was lower in women with Class 3 cortex than in women with Class 2 or Class 1 cortices. Low BMD (<70% of YAM: osteoporosis) was present in 98 of 108 women in Class 3, in 43 of 55 in Class 2 and in 15 of 23 in Class 1 (*Figure 2*). Few female patients had normal BMD (>80% of YAM). Significant positive correlations were shown between mandibular cortical width and BMD ($r = 0.23$, $P = 0.002$) (*Figure 3*). There was a significant reduction in BMD with increasing age ($r = -0.22$, $P = 0.003$). The number of teeth decreased significantly with age ($r = -0.35$, $P < 0.001$) but not with BMD. Of the women, 32.8% had previously been diagnosed with osteoporosis at a medical hospital. The proportion of female patients who had used anti-resorptive medications to treat osteoporosis increased with mandibular cortical index, and 24.1% of female patients with Class 3 cortex used bisphosphonate-type drugs (*Table 2*).

Among the men, 20 of 144 had Class 3 mandibular cortex, which was associated with lower mandibular cortex width than Class 1 or Class 2 cortices, as for the women (*Table 1*). Men with Class 3 cortex had lower BMD than did men with Class 2 or Class 1 cortices, but the difference was not significant. A high proportion of patients with Class 3 cortex had low BMD (8/20; 40.0%) compared with those with Class 1 cortex (18/51; 35.2%) or Class 2 cortex (21/73; 28.8%). Although BMD significantly decreased with age ($r = -0.09$, $P < 0.001$), mandibular cortical width did not correlate with BMD (*Figure 4*). Only 2.1% of male patients had been previously diagnosed with osteoporosis at a medical hospital. Similarly, few male patients had used anti-resorptive medications (*Table 2*).

DISCUSSION

Currently, a definitive diagnosis of osteoporosis is generally made with DXA evaluation. However, people rarely visit medical clinics seeking DXA because osteoporosis often has no symptoms until a patient experiences bone fracture. Therefore, public screening for osteoporosis is needed. BMD information is often necessary for dental treatment. We surveyed patients who regularly visited a dental clinic to estimate their likelihood of osteoporosis.

Our study indicated that 58.1% of female patients and 13.8% of male patients over 65 years of age had a Class 3 cortex. Women with Class 3 cortex had a significantly lower BMD than did women with Class 2 or Class 1 cortices, suggesting a high risk of osteoporosis. One study in Japan reported that 45.8% of women with Class 3 cortex had osteoporosis, based on BMD of the lumbar spine[7]. When we defined Class 3 cortex and BMD < 70% of YAM as a high risk of osteoporosis, we found that 52.7% (98/186) of female patients and 5.6% (8/144) of male patients had a high risk of osteoporosis. Mandibular cortex classification is highly accurate for screening: clinical trials have

Table 1 Associations between panoramic mandibular indices and age, number of teeth, mandibular cortical width and bone mineral density (BMD) in female (a) and male (b) patients

(a) Female

	Class 1 ($n = 23$)		Class 2 ($n = 55$)		Class 3 ($n = 108$)		Statistical significance		
	Mean	SD	Mean	SD	Mean	SD	Class 1 *vs.* Class 2	Class 2 *vs.* Class 3	Class 1 *vs.* Class 3
Age (years)	73.7	6.9	72.2	5.5	72.6	5.4	NS	NS	NS
Number of teeth	19.9	7.5	19.5	9.0	18.9	8.3	NS	NS	NS
Mandibular cortical width (mm)	4.7	0.9	3.9	0.9	2.9	0.9	**	**	**
Bone mineral density (% YAM)	61.6	13.0	62.0	7.8	56.5	8.6	NS	**	*

(b) Male

	Class 1 ($n = 51$)		Class 2 ($n = 73$)		Class 3 ($n = 20$)		Statistical significance		
	Mean	SD	Mean	SD	Mean	SD	Class 1 *vs.* Class 2	Class 2 *vs.* Class 3	Class 1 *vs.* Class 3
Age (years)	72.6	5.3	72.4	5.3	72.6	5.8	NS	NS	NS
Number of teeth	19.3	8.5	18.3	8.7	17.3	9.3	NS	NS	NS
Mandibular cortical width (mm)	4.5	0.9	4.2	0.8	3.5	1.2	*	**	**
Bone mineral density (% YAM)	78.8	20.2	78.0	16.2	71.4	16.8	NS	NS	NS

% YAM, bone density calculated as a percentage of the young adult mean BMD in Japanese people 20–44 years of age; NS, not significant.
*$P < 0.05$, **$P < 0.01$.

found that 95% of women with Class 3 cortex received a definitive diagnosis of osteoporosis[3]. However, in the present study, only 2.1% (3/144) of male patients and 32.8% (61/186) of female patients had ever received a definitive diagnosis of osteoporosis. The percentage of female patients who had used anti-resorptive medications for osteoporosis was low and only one-quarter of female patients with Class 3 cortex used bisphosphonate-related drugs. Few male patients used such drugs. Thus, most women who visit dental clinics have the potential for osteoporosis and could be encouraged to visit a physician for further diagnostic analyses, such as DXA testing.

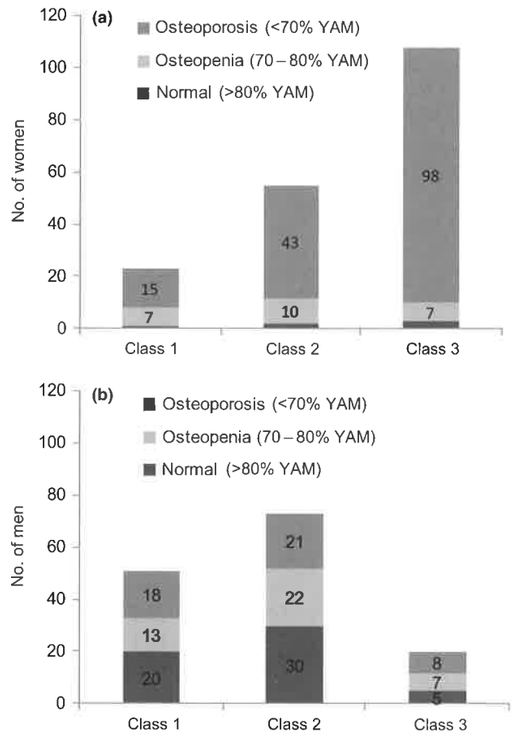

Figure 2. Stacked bar chart indicating the number of patients identified with low bone mineral density (BMD). (a) Women. (b) Men. YAM, young adult mean BMD in Japanese people 20–44 years of age.

Most data published on BMD have been restricted to women. It is obvious that osteoporosis should be more prevalent in women than in men because secretion of oestrogen affects bone metabolism. There are many unique features of male osteoporosis. Men have less microstructural damage with aging and ongoing bone apposition throughout life with increased bone strength[8]. Even as men age, periosteal apposition of new bone can occur, which may lead to greater bone stability and high BMD[9]. Thus, different bone-metabolism rates in men compared with women affect the mandibular cortex indices and BMD and might not give clear results.

This study used two panoramic radiographic indices, according to the criteria of Taguchi *et al.*[6]. A systematic review and meta-analysis revealed that the mandibular cortical width and panoramic mandibular index are, overall, useful tools that can potentially be used by dentists to screen for low BMD[1]. The advantage of these indices is that they are easy-to-use, low-cost tools, which dental practitioners can employ to detect early signs of osteopenia and osteoporosis. We found a significant, positive correlation between the mandibular cortex width and BMD in female patients. Thin Class 3 mandibular cortex on panoramic radiographs indicates a high risk of osteoporosis[6]. Our findings suggest that patients with a thin mandibular cortex plus low BMD have a high risk of osteoporosis.

Table 2 Number of patients who used anti-resorptive medications

Group	Class 1 *n* (%)	Class 2 *n* (%)	Class 3 *n* (%)
Female	2 (8.7)	8 (14.5)	26 (24.1)
Male	1 (2.0)	1 (1.4)	0 (0.0)

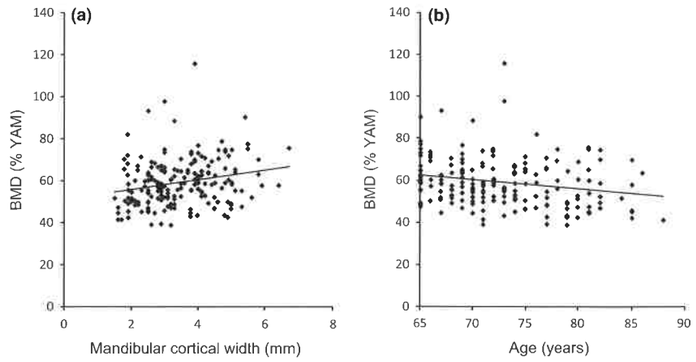

Figure 3. (a) Scatter plot and Pearson's correlations between mandibular cortical width (mm) and bone mineral density (BMD) (% YAM) in women. (b) Scatter plot and Pearson's correlations between age (years) and BMD (% YAM) in women. % YAM, bone density calculated as a percentage of the young adult mean BMD in Japanese people 20–44 years of age.

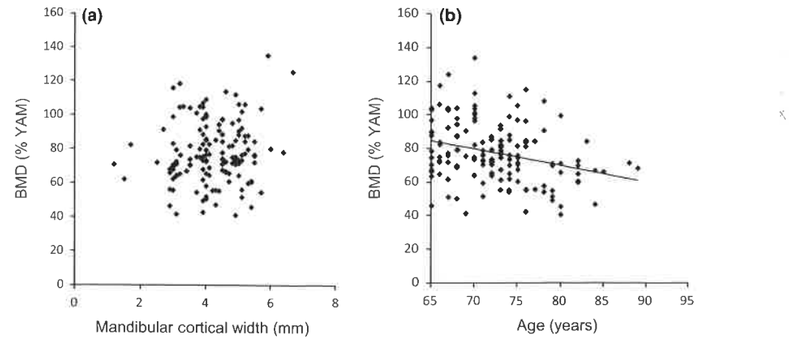

Figure 4. (a) Scatter plot and Pearson's correlations between mandibular cortical width (mm) and bone mineral density (BMD) (% YAM) in men. (b) Scatter plot and Pearson's correlations between age (years) and BMD (% YAM) in men. % YAM, bone density calculated as a percentage of the young adult mean BMD in Japanese people 20–44 years of age.

It has been reported that the thickness of mandibular cortical bone decreases with age[10]. The mandibular cortical width of Korean women, 60–69 years of age, showed a steep decline[11]. However, we found no significant correlation between mandibular cortical width and age in either men or women, and the presence of osteoporosis did not depend on age. There was no significant correlation between the number of existing teeth and the mandibular width in either men or women. Additionally, the number of occlusal stops between upper and lower teeth (Eichner's classification) in the patients was also not associated with the panoramic mandibular index (data not shown). These findings are in contrast to those of Kribbs[12] and Taguchi *et al.*[4], who reported greater tooth loss among women with diagnosed osteoporosis. Osteoporosis decreases bone density of the alveolar bone as well as of the vertebral bone. There is a significant correlation between the height of the mandibular edentulous ridge and the severity of osteoporosis[13]. However, tooth loss may be primarily determined by other factors, such as dental caries and periodontal disease, which result in inflammation in the alveolar bone and reduction of the bone mass supporting the teeth. Thus, it is unlikely that bone loss resulting from osteoporosis leads directly to tooth loss. Another report indicated that osteoporotic bone fracture is not an important predictor of tooth loss and residual alveolar ridge resorption[14]. A recent study of Gray *et al.* demonstrated no statistical correlation between tooth loss and decreased BMD[15]. Tooth loss might not be related to the risk of osteoporosis.

We used quantitative ultrasound (QUS), rather than vertebral DXA measurement, to determine patients' bone density. Generally, the diagnosis and clinical management of osteoporosis are based on the standard method of measuring bone mineral density using DXA. QUS provides information about bone density and bone quality; measurements at the calcaneus have a close relationship with vertebral bone DXA. Heelbone density measured using QUS has significant correlations with mandibular cortical width and shape[16]. Our data agreed with previous findings and indicated that QUS measurement of BMD is a surrogate for DXA examination.

CONCLUSIONS

We quantitatively evaluated panoramic mandibular cortex morphology and BMD of the calcaneus to estimate the risk of osteoporosis in elderly patients who routinely visited a dental clinic. This study revealed that older female patients had an increased risk of osteoporosis with low BMD, while older male patients did not. There was also a significant correlation between BMD and mandibular cortical width or age. However, tooth loss may not be related to osteoporosis in these patients. Assessment of the mandible on a panoramic radiograph can be useful for general dentists to predict the risk of osteoporosis.

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Conflict of interest

All authors declare no potential conflicts of interest with respect to the research, authorship and publication of this article.

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