The Differences between Panoramic Mandibular Indexes in Young and Older Women on Panoramic Radiograph

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Abstract

Osteoporosis is often misinterpreted as an age-related disease, but this disease can affect anyone, including young people. The physiological decrease in bone mass begins after reaching peak bone mass (PBM) or peak bone density level.

To compare cortical thickness variations between young and older women to obtain data distribution on average panoramic mandibular index (PMI) values.

In the years 2018 and 2019 at the Dental Hospital Faculty of Dentistry Universitas Indonesia, 225 digital panoramic images of female patients aged 31–75 years were evaluated using a cross-sectional research design. The measured variable was the ratio of the average cortical bone thickness using the PMI. Samples were divided by age: subjects aged 31–45 years were used as a reference to the standard PMI value, compared with subjects aged 46–60 years and those aged 61–75 years.

The mean and standard deviations of categories 1, 2, and 3 were 0.30 ± 0.032, 0.28 ± 0.042, and 0.24 ± 0.063, respectively. There was a statistically significant difference between age groups on evaluation of the PMI ($p < 0.05$, ANOVA test).

It can be concluded that the measurements obtained show a gradual decline with age, and there are statistically significant differences between age categories. The three mean measurements correlate with PMI threshold values (<0.3 mm), and categories 2 and 3 (age >45 years) can be categorized as ages at risk of osteoporosis.

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Introduction

Decreased bone mass density is one of the characteristics of bone degeneration, which is a defining aspect of osteoporosis. This metabolic bone disease is characterized by loss of density and quality of bone mineral, which causes increased bone porosity and susceptibility to fractures.[1,2] Aging can be associated with a decrease in several organ systems, including bone.[3] Aging is associated with decreased bone regeneration because of a reduction in the number of osteogenic progenitor cells. In the elderly, bone loss occurs more quickly than bone formation because of the influence of bone resorption by osteoclasts, which exceeds bone deposition by osteoblasts. Therefore, there is an increased risk of osteoporosis.[4]

Osteoporosis is often misinterpreted as an age-related disease, but this disease can affect anyone, including young people. The physiological decrease in bone mass begins after reaching peak bone mass (PBM) or peak bone density level. Reported studies have shown that PBM at the lumbar spine occurs in the late 20s to mid-30s, and PBM at the hip occurs even earlier, at approximately 20 years of age.[5] Bone mass declines gradually and naturally for several years after PBM is reached or after the age of 30.[6] This gradual loss of bone mass is considered to be the primary cause of osteoporosis risk. Therefore, the risk of osteoporosis should not be considered age-restricted. Women have a fourfold higher overall prevalence of osteoporosis compared to men. This study was conducted in women 31–45 years old and 46–75 years old to compare the differences in osteoporosis risk between these

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age categories.

In dentistry, panoramic images are commonly used to obtain diagnostic information and determine treatment plans. Panoramic images can be used as secondary data for early detection of osteoporosis by measuring some variables, such as the mandibular cortical width, number of remaining teeth, and morphology of the inferior cortex using the gonial index (GI), antegonial index (AI), and panoramic mandibular index (PMI).[7-9] Many researchers are interested in detecting early bone density decreases using panoramic radiography. Aside from being effective, it is not expensive, and the technique is familiar among dentists. The PMI was determined by Benson et al. in 1991.[10] This measurement method uses the ratio of the mandibular cortex thickness and the distance between the inferior margin of the foramen mentale and the inferior border of the mandible to assess the shape and width of the cortical mandible linearly. The PMI value of an average healthy person should be >0.3. Because the PMI can be used to compare the mandibular cortex thickness with the average size of a mandible, it can be used for evaluation of bone loss in dentistry.[10,11] Therefore, this index can be used to evaluate bone loss by measuring secondary patient data linearly on panoramic radiography.
Since the cortical variation studies performed in a Texas population by Benson et al. (1991) were published, very little PMI research has been done in Indonesia.[10] The purpose of this study is to compare variations in mandibular cortex thickness between young and older women and obtain data distribution on average PMI values in Jakarta, the capital city of Indonesia.

Materials and methods

Secondary data from 225 digital panoramic images of female patients aged 31–75 years at the Dental Hospital Faculty of Dentistry Universitas Indonesia (UI) from 2018 to 2019 were measured using a cross-sectional research design. The measured variable was average cortical bone thickness obtained by using the PMI. Samples were divided into three groups: data from subjects aged 31–45 years were used as a control to represent the PMI value of an average healthy person, and these data were compared with groups of subjects aged 46–60 years and 61–75 years. The study protocol was approved by the Dental Research Ethics Commission, Faculty of Dentistry, University of Indonesia (Number:02/Ethical Exemption/FKGUI/VII/2019). The subjects were selected based on having the same number of images available (5) and for radiographic quality that could be interpreted well in the regions of the foramen mentale margin and the inferior mandibular cortex margin (region of interest/ROI). All digital radiographs were taken with Veraviewepocs 2D® (J. Morita Corp., Kyoto, Japan) with a high-resolution CCD sensor (32-bit microprocessor). Panoramic exposure was carried out at 10 milliampere-seconds (mAs) for 12–15 seconds at 70–80 kVp. The same radiographer took all radiographs. The process of sampling digital data was completed using I-Dixel imaging software (J. Morita Corp., Kyoto, Japan).

The measurements for this process began with adjusting magnification to 100%, and balancing the contrast and brightness to have a clear image of the ROI. Cortical width at the mental foremen region was assessed according to the technique described by Benson et al[10] in which the mental foremen is identified and a line traced perpendicular to the tangent to the lower border of the mandible and through the center of the mental foremen. The researchers then measured the mandible's cortical thickness and the distance of the foramen mentale inferior border from the mandible inferior border. After that, the ratio of the cortical thickness and the measurement between the inferior border of the foramen mentale and the inferior border of the mandible was calculated. Measurements were taken bilaterally, and the average of the two PMI results were calculated as the final PMI value (Figure 1).

Figure 1. Measurement of Panoramic Mandibular Index on panoramic images.

Before the data were analyzed, intra- and inter-observer reliabilities were evaluated. The

Bland-Altman test was used to compare two measurements on each sample. Each radiograph was measured twice by two observers at different times, preceded by the calibration process. The Bland-Altman test aims to determine the reliability of the data used and whether the measurement or calculation remains consistent, even when different people measure it at different times. The minimum sample used in this reliability test is ¼ of the total samples tested. In this study, the researchers tested 70 samples.

Statistical analysis

All statistical analyses were performed using SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, NY USA). The data normality test was done using the Kolmogorov-Smirnov test because the number of samples in the study was greater than 50. Based on this test, the ratio of mandibular cortical thickness in each age category had a normal data distribution. The association among age groups was assessed by a one-way analysis of variance (ANOVA) test, and the significance level was set at $p < 0.05$.

Results

The description of the 428 subjects is shown in Table 1. The number of samples in each category is the same and sufficient for each category. Sample selections were chosen based on the clearest images of the ROI.

	Ages (years old)	Frequency (%)
Category 1	31–45	75 (33.3%)
Category 2	46–60	75 (33.3%)
Category 3	61–75	75 (33.3%)
Total		225 (100%)

Table 1. Description of subjects.

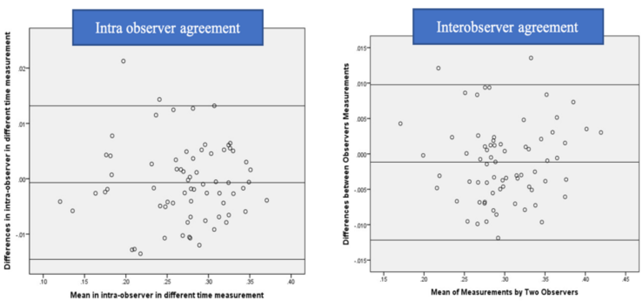

Figure 2. Scatter plots for Bland-Altman tests of intra- and inter-observers.

The results of the Bland-Altman t-test indicate that the tested data have a p-value above 0.05. Therefore, it can be concluded that the tested data have no significant differences between intra- and inter-observer tests and show a high level of reliability for data analysis. The Bland-Altman intra-observer test revealed the mean and standard deviation to be -0.001 ± 0.007. The upper and lower limits of the observers' agreements were 0.01 and -0.01. For the inter-observer test, the mean and standard deviation was -0.001 ± 0.005. The upper and lower limits of the observers' agreements were 0.01 and -0.01. Figure 2 shows that the distribution of all data is scattered around the mean difference and is still within range of the limit of the agreement. The scatter plot diagram (Figure 2) shows that the measurements made by the first and second researchers do not have significant differences, so the data obtained can be relied upon for research trials.

The ANOVA analysis results in Table 2 show that the PMI values had statistically significant differences in the three age groups with a p-value <0.05). To analyze the differences among age groups, category one was used to represent an average healthy person's PMI value, and comparisons were made with groups 2 and 3. The ANOVA post hoc test was measured. The results of these calculations are presented in Figure 3.

Panoramic Mandibular Index	Mean ± SD	*p-value*
Category 1	0.30 ± 0.032	< 0.05
Category 2	0.28 ± 0.042	
Category 3	0.24 ± 0.063	

Table 2. Relationship between PMI (Panoramic Mandibular Index) ratio and age according to ANOVA test.

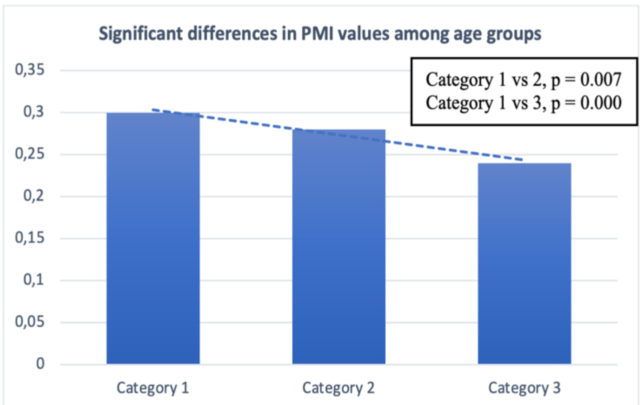

Figure 3. Results of statistically significant differences in PMI values among age groups.

Discussion

The results of this study showed that there was a statistically significant difference between age groups in the evaluation of PMI values ($p < 0.05$, ANOVA test). The mean and standard deviations obtained in all measurement data show a gradual decline with age. These results are in line with previous studies conducted by Bozdag et al. (2015), which concluded that the ratio of the PMI index gradually decreases. The age group of 18–40 years is 0.42, the age group of 41–55 years is 0.375, the age group of 56–69 years is 0.34, and the age group ≥70 years is 0.30.[12] Other researchers have shown that the decrease in PMI values for people older than 60 years is 0.27 in osteoporosis subjects and 0.32 in non-osteoporosis subjects.[13] The cut-off point of PMI values suggested by Benson et al. as a threshold for subjects at risk of osteoporosis is >0.3.[10] In this study, we used the threshold recommended by Benson et al., and the range of PMI values for the three groups was from 0.24 ± 0.063 to 0.30 ± 0.032, with average results starting to decrease in category 2 (46–60 years old). Therefore, this study showed that at the age of 45 years, the average value of PMI begins to decrease, and the risk of osteoporosis begins. This study is in line with the research of Benson et al., which showed a PMI range from 0.266 to 0.352, with yields beginning to decrease (<0.30) at the age of 50 years.[10] Bathla et al. (2015) also published research with subjects aged 30–65 years, and the range of PMI values was 0.286 ± 0.007 to 0.381 ± 0.019 with similar conclusions of a decrease in the average PMI starting in the age group above 50–55 years.[14] This finding is similar to research conducted in Indonesia that showed a decrease in cortical thickness with increasing age.[15]

Related to the cut-off point of the average PMI value, a study by Devi et al. found a different value in Indians at 0.25. This number is lower than the result of the study conducted by Benson et al.[10] It can be concluded that a cut-off point assessment for PMI may be different in each region. In this study, category 1 (31–45 years) was considered representative of the PMI value for an average healthy person. Based on the results obtained in this study, the average PMI value for category 1 is 0.3. This is similar to Benson's findings with a threshold value of <0.3, which is considered at risk for osteoporosis. However, these conclusions must be further tested to obtain a definitive diagnosis of osteoporosis.

Several factors can account for the difference in mean values of PMI data for age groups 1 (31–45 years), 2 (46–60 years), and 3 (61–75 years) obtained in this study and the PMI threshold values in various countries, such as the influence of age-related metabolism decreases. This condition positively affects the process of bone remodeling. As is well known, the process of human bone remodeling is influenced by several factors. Minerals such as fluoride, magnesium, and calcium are needed for the growth of bones and for the remodeling process that affects the changes in bone density in cases of deficiency. Vitamins, especially A, C, D, K, and B12, are also needed. Finally, the secretion of sex hormones can cause significant effects on bone growth, as they are responsible for increasing osteoblast activity for bone formation.[16] In addition to the three factors that have been mentioned, a healthy lifestyle can affect bone growth because activities such as weight-bearing exercise can stimulate osteoblasts, assist in the development of thicker, stronger bones, and slow down the loss of bone mass.

Increasing age can be a significant factor in bone density reduction. Research done by Sianipar et al. proved that age is a factor associated with bone density.[17] Bone density decreases after PBM beginning at 30 years of age, and bone resorption takes place faster than bone formation. Bone resorption is influenced by an increase in fat formation in old age, resulting in an increase in visceral fat mass in the abdomen. Bone density can be affected by the presence of visceral fat because of increased production of proinflammatory cytokines, which can increase bone resorption. These factors may have contributed to the results of this study, which shows a decrease in density in groups of increasing age.

Another factor that can affect the results of mean and PMI threshold values are calcium and vitamin D levels in people of different regions/countries. Siti Setiati (2008) studied subjects at the Cipto Mangunkusumo Hospital (RSCM) in Jakarta regarding the status of vitamin D prevalence of older women in Indonesia. Her research revealed a prevalence of vitamin D deficiency in Indonesia of 35.1%, which is relatively high.[18] Some factors that affect the prevalence are the lack of vitamin D intake in Indonesian society and minimal exposure to sunlight, even though Indonesia is a country crossed by the equator.[18] This condition occurs because women in Indonesia consider sunlight to be damaging to the skin, which results in avoidance of sun exposure.[12]

In subjects aged 46–75 years (categories 2 and 3), the relevance of Benson's PMI threshold value (<0.3) was confirmed as an indicator for subjects at risk of osteoporosis. One limitation of this study was that further investigation regarding systemic diseases in the subjects was not done to determine whether other factors may have contributed to the decrease in PMI values. This step should be taken with diagnostic tools to confirm osteoporosis.

Conclusions

It can be concluded that PMI measurements show a gradual decline with age, and there are statistically significant differences between age groups. The three means correlate with PMI threshold values (<0.3). Age groups 2 and 3 (>45 years) can be categorized as at risk for osteoporosis. Therefore, increased early awareness of bone health should be encouraged.

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Declaration of Interest

The authors declare no potential conflicts of interest concerning the research, authorship, and publication of this article.

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