The Relationship between Mandibular Cortical width and Age in Elderly Indonesian Women

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Abstract

As the elderly population increases, so does the incidence of osteoporosis in the world. According to the International Osteoporosis Foundation, one in four women over the age of 50 is at risk of osteoporosis, leading to fracture. In its early stage, osteoporosis has no specific symptoms and is often ignored as a result. Currently, dual-energy x-ray absorptiometry is considered the gold standard for osteoporosis detection, but it is expensive in Indonesia, and its availability is limited. Thus, a new, alternative early detection tool for osteoporosis risk is being developed by measuring the mandibular cortical width (MCW) on panoramic radiographs.

To compare between the mean of MCW in women aged 31-45 years and 46-75 years.

This study utilizes 270 digital panoramic radiographs of women aged 31-75 years from the Dental Hospital, Universitas Indonesia. MCW was measured using radiography software with 2x magnification of the region of interest.

Average and standard deviation in women aged 31-45 years are 3.40±0.42 mm; 46-60 years 3.18±0.47 mm; and 61-75 years 2.76±0.66 mm. The mean of MCW between each age group is statistically different ($p<0.05$) and decreases with age.

The mean of MCW in women aged 31-45 years is significantly different from women aged 46-75.

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Introduction

As we grow older, the aging process begins to occur in the human body's connective tissues, one of which is bone. Bone is continuously undergoing remodeling, in which old bone is metabolized by osteoclasts and replaced with new bone formation by osteoblasts. During aging, this remodeling process becomes unbalanced, with more resorption occurring than bone formation. This condition causes a change and decrease in bone microstructure composition that results in a reduction of bone mineral density (BMD) and triggers osteopenia, which can then lead to osteoporosis.[1,2] The incidence of osteoporosis increases with an aging population. Osteoporosis is often called a "silent disease" because it does not cause particular symptoms and is often ignored as a result.[3] Detection of the disease is possible through the calculation of BMD using gold standard equipment, dual-energy x-ray absorptiometry (**DXA**). Still, its availability is limited and very expensive in Indonesia. One of the main factors for osteoporosis is only being detected at an advanced stage because it is not diagnosed early enough. Azhari et al. found that the mandible bone density will increase from 10 years old and remain unchanged until 35 years old.4 Whereas the diagnosis of osteoporosis at an advanced stage would create the cost of treating fractures resulting from osteoporosis is substantial and can entail a decrease in quality of life. IOF states that 1 in 3 women aged 50-80 years' experience a fracture due to osteoporosis, especially hip fracture. The rate of mortality from osteoporosis is 40%, close to that of coronary heart disease.[5]

Early detection devices, to which all levels of society have access, are needed. In the field of dentistry, panoramic radiography is often used to detect diseases or dental abnormalities. Several measurement indexes from panoramic radiographs can be used to identify the risk of osteoporosis, namely: mandibular cortical width (MCW), panoramic mandibular index (PMI), and mandibular cortical index (MCI).[6,7] The MCW

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index was first introduced by Taguchi et al. in 1996,[8] and measures the decrease in the inferior cortical width of the mandible below the mental foramen region, along a line that passes through the middle of the mental foramen, and that is perpendicular to the tangent of the mandibular lower border. The MCW is one of the most commonly studied radiomorphometric indices in panoramic radiographs. Mandibular cortical bone is used for the purposes of osteoporosis identification because it is here that the process of degradation most closely resembles bone mineral loss in the hip bone. Specifically, the mandibular cortex has a reasonably wide area and is affected by changes in age, development, and physiology, and is more easily examined compared to the trabecular bone.[9,10]

Previous studies by Nissia et al. and Kanya et al. (2017) suggest conducting further research on MCW by considering gender variables and increasing the number of samples, which drove the current study.7,11 Both studies were unable to find an association between mandibular cortical width and mandibular bone osteoporosis. In this study, female samples were used because the prevalence of osteoporosis in women is four times higher than it is in men.11 Women have lower peak bone mass (PBM) and BMD than men and experience changes in the hormone estrogen, which in adolescence is used to maintain bone minerals. At around 40 years of age, women experience menopause, during which time estrogen production decreases, and bone resorption increases as a result.[12,13] This study aimed to determine the mean MCW of women aged 31-75 years and identify the significance of the mean difference in MCW between groups of women aged 31-45 years and those aged 46-60 years and 61-75 years. This research will enrich our existing knowledge of MCW and its relation to increasing age.

Materials and methods

This study uses a numerical descriptive cross-sectional method with a sample of 270 good-quality digital panoramic radiographs taken from female patients aged 31-75 years at the dental hospital of the Faculty of Dentistry, Universitas Indonesia. Samples were collected using non-randomized sampling according to inclusion criteria. The study was conducted by taking secondary data samples according to inclusion and exclusion criteria. The specified inclusion criteria included panoramic radiographs of female patients aged 31-75 years. A computer equipped with I-Dixel Morita© radiograph software was used, and other tools include data forms, stationery, and statistical analysis software. There were two variables in this study: an independent variable in the form of age groups, of which there were three: 31-45 years, 46-60 years, and 61-75 years; and a dependent variable, which was the value of the mandibular cortical width (MCW). The measurement of MCW, starting with lines from the mental foramen, was carried out as follows:

1. Lines parallel to the long axis of the mandible and tangent to the lower border of the mandible were made.
2. A second straight line was made from the middle of the mental foramen to the mandible's inferior border, perpendicular to the first line on step one.
3. A third line parallel to the first line was made on the inner surface of the endosteum.
4. The first line is on the step one distance to the third line in the mandible's cortical portion is the value of MCW. The measurement of MCW (in mm) was taken using digital calipers on the left and right sides, then averaged (Figure 1.)

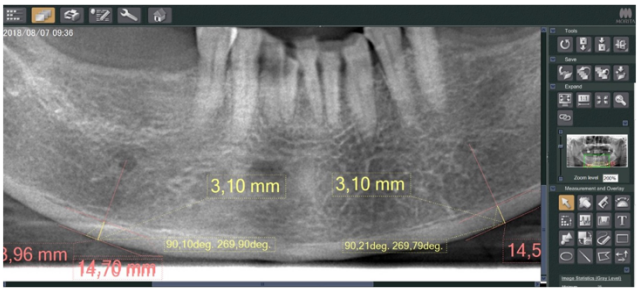

Figure 1. The mandibular cortical width measurement.

Intraobserver and interobserver reliability was measured based on 33% of the digital panoramic radiograph samples. Intraobserver reliability was measured to determine the appropriateness of the same observer's judgment with different observation times. Interobserver reliability was performed to determine reliability between observers. In intraobserver measurements, the t-test reliability test showed that the researchers' measurements

of panoramic radiographs had an acceptable level of reliability, which was observed to be p> 0.05.

Statistical Analyses

Data processing using statistical analysis software began with a reliability test using a t-test and Bland Altman. It then proceeded with a normality test and a one-way ANOVA numerical statistical analysis test.

Results

A description of the samples is shown in Table 1. Samples were equally distributed in each category. The result of intra- and interobserver measurement in MCW using a t-test is shown in Table 2. The mean difference and standard deviation of intra- and interobserver measurements were 0.0045 ± 0.0543 and 0.0048 ± 0.08191, respectively. Based on the Bland Altman test, the limit of agreement (**LoA**) ranges of intra- and interobserver measurements were from 0.111 to -0.102 and from 0.1636 to -0.1539. Distribution of most of the data scattered around the mean difference, but it is still in the LoA range. Bland Altman's plot shows that the measurement has good reliability (Figures 2, 3).

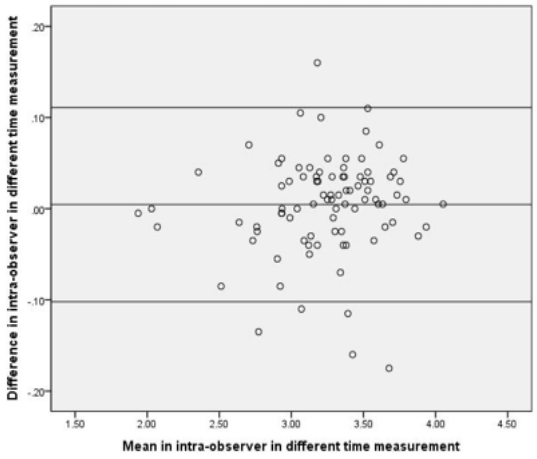

Figure 2. Bland Altman's *scatter* intraobserver plot measurement.

After the reliability test, the Kolmogorov-Smirnov normality test was carried out because the sample > 50. Based on the normality of test results, it was found that the distribution of MCW data in the 31-45 years, 46-60 years, and 61-75 years age groups were normal, with a p-value ≥ 0.05. Therefore, a one-way ANOVA parametric comparative test was performed. There are significant differences in the value of MCW between the three age groups (p <0.05, ANOVA test). To identify the differences between age groups, a Tamhanes posthoc test was carried out because the homogeneity test was p <0.05. Figure 4 shows that the mean value of MCW decreases in each age category.

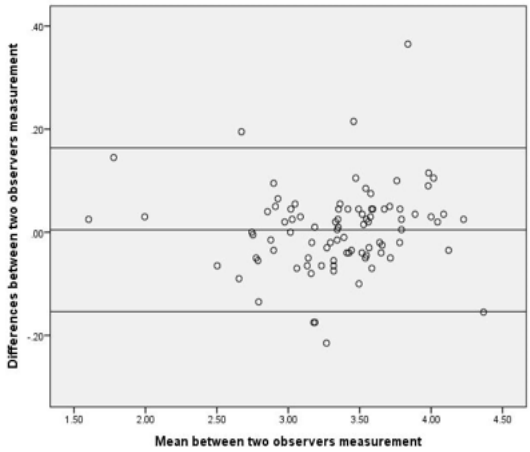

Figure 3. Bland Altman's scatter interobserver plot measurement.

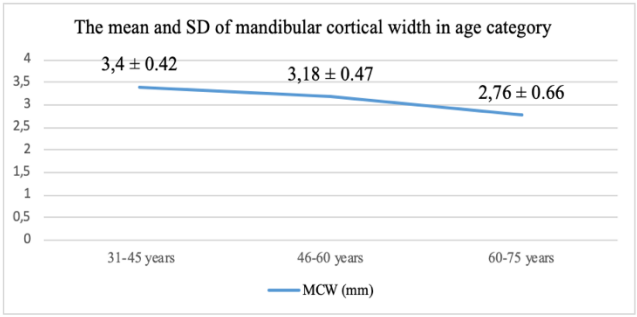

Figure 4. Mean mandibular cortical width (MCW) values in the age group 31-45 years, 46-60 years, and 61-75 years.

Category	Age	Distribution (%)
I	31-45 years	90 (33%)
II	46-60 years	90 (33%)
III	61-75 years	90 (33%)

Table 1. The distribution of samples in each category.

	first measurement	second measurement	P-value *t-test*
	mean±SD	mean±SD	
Mandibular cortical width (MCW) in intraobserver	3.24 ± 0.39	3.237 ± 0.39	0.43
Mandibular cortical width (MCW) interobserver	3.34 ± 0.48	3.33 ± 0.48	0.57

Table 2. The results of intra-and interobserver measurement in MCW using a t-test.

Category	Age's category (years)	Mean±SD	*p-value*
I	31-45	3.40±0.42	<0.001
II	46-60	3.18±0.47	
III	61-75	2.76±0.66	

Table 3. The significant relationship between mandibular cortical width and age using ANOVA test.

Discussion

The measurement of MCW values based on the Kolmogorov-Smirnov normality test showed that the data distribution was normal. Next, an MCW analysis was performed based on each age group. This study found that the mean and standard deviation of MCW at the age of 31-45 years was 3.40 ± 0.42 mm; age 46-60 years at 3.18 ± 0.47 mm; and aged 61-75 years by 2.76 ± 0.66 mm. Therefore, the MCW decreases with age, an observation that is in keeping with previous research findings.[8-10,14] The comparative analysis of data using the one-way ANOVA test revealed significant differences between the three age groups; the Tamhanes post-hoc test also yielded results indicating that the MCW of each age group is significantly different. Both tests showed that the MCW of the 31-45 year age group was significantly different from that of the age groups at risk of osteoporosis (46-60 and 61-75 years). These results indicate that every period of 15 years has a significant impact on women's cortical mandible. At the age of 30, bone has reached maximum strength and density, or "peak bone mass," which will decrease slowly and then more quickly as estrogen hormone production decreases.[1] Around the ages of 45-50 years or during menopause,[15,16] reduction in bone quantity and quality can be observed to be radiographically higher by around 15% per decade, especially one year after menopause continue slowly during the postmenopausal phase.[17] At the age of 60, osteoporosis is more often detected. However, fractures generally occur at the age of 75.[18] In this study, a comparison was made between the first age group, 31-45 years, in which bones have just reached PBM, and two age groups at risk of osteoporosis: the 46-60 year age group, in which symptoms may be radiographically observed but are not yet clinically visible; and the 61-75 year age group, in which clinical features of osteoporosis have manifested. Results addressed the shortcomings of previous studies by Nissia et al. and Kanya et al., contrary to which research was conducted considering gender factors, a larger sample size, and age division.[7,11] Results were also supported by the study by Alapati et al., which states that gender has a significant effect on MCW, the t-test for which showed significant differences (p <0.001).[19]

Digital panoramic radiographs were interpreted using i-Dixel Morita© software. Measurements of the mandibular cortical bone below the mental foramen area were performed either on the left or right side. Both were averaged because MCW values on both sides may differ due to differences in occlusal forces.[10] Based on Taguchi et al., an MCW cut-off <3 mm is at risk of osteoporosis and needs to be referred for further examination by DEXA measurements.[20] Based on Kim et al.'s study, in Korean female subjects, the appropriate MCW cut-off is 2.2 mm, and if it is <2.5 mm, further osteoporosis evaluation should be performed.[21] Based on Mansour et al., Saudi female subjects were assigned MCW cut-off points of 4.5 mm.[13] MCW cut-offs vary in each region, as the condition is influenced by the different calcium, genetic, and lifestyle factors of each.[15] Research data shows that the average MCW of the 61-75 year age group is 2.76 mm, whereas it is based on cut-off points (3 mm), which are already classified as osteoporosis risk groups.[8] Therefore, further research is needed on MCW to support MCW cut-off.

In addition, an intra- and interobserver reliability test was performed. The t-test was conducted first to verify for systematic error in the intraobserver measurement. The p-value was 0.434 (> 0.05), which showed no significant difference in the mean MCW. Reliability tests continued with the Bland Altman test, the results of which were obtained in the form of a difference plot (Figure 2) with a picture of the distribution of most of the data scattered around the mean of difference and within the range of agreement (LoA) between 0.111 to -0.102. It can be concluded that intraobserver measurement has good reliability. In inter-observer measurements, similar tests were used. T-test results obtained a p-value of 0.577 (> 0.05), showing no significant differences between the first and second researchers' measurements. Bland Altman's test results in the form of difference plots (Figure 3)

illustrate the distribution of most of the data scattered around the mean of difference and are in the LoA range between 0.1636 to -0.1539. Both reliability tests for both intraobserver and interobserver show the validity and quality of measurements to be used for data analysis.

Osteoporosis has been known to be caused by an imbalance in the remodeling process. The interaction of genetic and environmental factors also is suggested in causing osteoporosis. Interleukin-8 (IL-8) as an inflammatory marker has been found to play a role in bone resorption. Recent studies found that the −251 A / T polymorphism of IL-8 is significantly associated with osteoporosis in Indonesian sample population.22 The contribution of environmental factors had been found in several studies. Researchers had found an association of mandibular bone osteoporosis with calcium intake (p=0.00), physical activity (p=0.00), multivitamin intake (p=0.01)23, and level of education (p=0.018).24 However, there was no significant relationship between mandibular bone osteoporosis and oral health-related quality of life on the cross-sectional study. 24 Finally, osteoporosis is a multifactorial disease, which means it is challenging to determine osteoporosis from the cause that appears in older people. Therefore, early detection of osteoporosis is essential. Dentists can reduce the number of osteoporosis by using the MCW value on panoramic radiographs.

The strength of this research was the use of digital radiographs, which yielded highly accurate results. This study also uses a more significant number of samples than previous studies by Nissia et al.7 and Kanya et al.11 Furthermore, subjects were grouped to a limited extent by radiographs divided into three age groups, which showed significant differences. This study's limitation is that the determination of incomplete inclusion criteria is not detailed based on race, menopause status, and drug consumption status, all of which can affect BMD. Further research that considers these factors is needed to produce more detailed data and serve as a baseline for the average value of mandibular cortical width (MCW) as an early detection tool for osteoporosis risk.

It is recommended that further research be accompanied by measurements using the DEXA tool to determine the MCW cut-off point for Indonesian people to be immediately used for early detection of osteoporosis risk in Indonesia.

Conclusions

The results of the average mandibular cortical width (MCW) of the 31-45 year age group were compared with those of the age groups at risk of osteoporosis, 46-60 years and 61-75 years, and were found to be statistically significantly different. From the mean of MCW, it can be said that MCW is correlated with age. The younger the person, the lower the MCW value.

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Declaration of Interest

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

References

1. Demontiero O, Vidal C, Duque G. Aging and bone loss: New insights for the clinician. Therapeutic Advances in Musculoskeletal Disease. 2012; 4(2):61–76.
2. Ramkumar S, Malathi R. Detection of osteoporosis and osteopenia using bone densitometer - Simulation study. Materials Today: Proceedings. 2018; 5(1):1024–36.
3. Kiswanjaya B, Yoshihara A, Miyazaki H. Mandibular inferior cortex erosion as a sign of elevated total serum calcium in elderly people: A 9-year follow-up study. Dentomaxillofacial Radiology 2014; 43(3):20130341.
4. Azhari, Oscandar F, Fariska I. Normal Value of cortical and mandibular trabecular bone density using Cone Beam Computed tomography (CBCT). Journal of International Dental and Medical Research. 2019; 12(1):160-4.
5. Calciolari E, Donos N, Park JC, Petrie A, Mardas N. Panoramic measures for oral bone mass in detecting osteoporosis: A systematic review and meta-analysis. Journal of Dental Research. 2015; 94(3):17S-27S.
6. Anthamatten A, Parish A. Clinical update on osteoporosis. Journal of Midwifery & Women's Health. 2019; 31(1):71–5.
7. Ananda N, Kiswanjaya B, Sulistyani LD, Iskandar HB. The Average Mandibular Cortical Bone Width of Patients at Risk of Osteoporosis. Journal of International Dental and Medical Research. 2017; 10(Special issue):652-6.
8. Taguchi A, Suei Y, Ohtsuka M, Otani K, Tanimoto K, Ohtaki M. Usefulness of panoramic radiography in the diagnosis of postmenopausal osteoporosis in women. Width and morphology of inferior cortex of the mandible. Dentomaxillofacial Radiology. 1996; 25(5):263–7.

9. Leite AF, Figueiredo PT de S, Guia CM, Melo NS, de Paula AP. Correlations between seven panoramic radiomorphometric indices and bone mineral density in postmenopausal women. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology. 2010; 109(3):449–56.
10. Tounta TS. Diagnosis of osteoporosis in dental patients. Journal of Frailty, Sarcopenia, and Falls. 2017; 2(2):21–7.
11. Kanya AP, Kiswanjaya B, Makes BN, Iskandar HHB. Estimating sex in an Indonesian Population Using the mean value of eight mandibular parameters in panoramic images. Journal of International Dental and Medical Research. 2017; 10(special issue):417-22.
12. Cawthon PM. Gender differences in osteoporosis and fractures. Clinical Orthopaedics and Related Research. 2011; 469(7):1900–5.
13. Bandela V, Munagapati B, Reddy Karnati RK, Venkata GRS, Nidudhur SR. Osteoporosis: Its prosthodontic considerations – A review. Journal of Clinical and Diagnostic Research. 2015; 9(12):ZE01–4.
14. Mansour S, Alghamdi AST, Javed F, Marzouk H, Khan EA. Panoramic radiomorphometric indices as reliable parameters in predicting osteoporosis. American Journal of the Medical Sciences. 2013; 346(6):473–8.
15. Compston JE, McClung MR, Leslie WD. Osteoporosis. The Lancet. 2019; 393(10169):364–76.
16. Dasarathy J, Labrador H. Bone Health in Women. Primary Care - Clinics in Office Practice. 2018; 45(4):643–57.
17. Kruger MJ, Nell TA. Bone mineral density in people living with HIV: A narrative review of the literature. AIDS Research and Therapy. 2017; 14(1):1–17.
18. Makhdoom A, Rahopoto MQ, Siddiqui KA, Qureshi GA. Detection of osteoporosis by dual-energy X-ray absorptiometry. Pakistan Journal of Medical Sciences. 2014; 30(6):1265–70.
19. Alapati S, Reddy R, Tatapudi R, Kotha R, Bodu N, Chennoju S. Identifying risk groups for osteoporosis by digital panoramic radiography. Contemporary Clinical Dentistry. 2015; 6(6):253.
20. Taguchi A. Panoramic radiographs for identifying individuals with undetected osteoporosis. Japanese Dental Science Review. 2009; 45(2):109–20.
21. Kim OS, Shin MH, Song IH, Lim IG, Yoon SJ, Kim OJ, et al. Digital panoramic radiographs are useful for diagnosis of osteoporosis in Korean postmenopausal women. Gerodontology. 2016; 33(2):185–92.
22. Sukmawaty TI, Nicoline, Gani AZ, Joenoes H, Djamal NZ, Auerkari EI. Association of IL-8-251 A/T Polymorphism and Osteoporosis in Postmenopausal Indonesian Women. Journal of International Dental and Medical Research. 2020; 13(4):1527-30.
23. Ernawati MG, Kusdhany LS, Agustin D, Iskandar HHB, Rahardjo TB. A mandibular bone density index for prediction of jaw bone osteoporosis in Men. Journal of International Dental and Medical Research. 2017; 10(Special Issue):612-8.
24. Madarina A, Kusdhany LS, Mahiddin FG. Mandibular bone osteoporosis and oral health-related quality of life in the elderly. Journal of International Dental and Medical Research. 2017; 10(special issue):423-8.