

## The correlation between age and mandibular bone quality based on panoramic radiographs

Korelasi antara usia dan kualitas tulang mandibula berdasarkan radiografi panoramik

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### ABSTRACT

**Introduction:** As someone ages, the bone quality may change and may be seen on mandibular bone. The changes in mandibular bone quality may be assessed using a panoramic radiograph. The aim of this study was to describe mandibular bone quality and to know the correlation between age and mandibular bone quality on panoramic radiograph. **Methods:** Cross sectional correlation analysis; the population was panoramic radiograph archives of patients in Dental Radiology Installation RSGM Universitas Padjadjaran within the range of age 13-59 years old when the radiograph was taken so that obtained 48 samples. The mandibular bone quality was obtained with *mandibular alveolar bone resorption index* (MM ratio) method using EzPax-Plus software. **Results:** The highest average number of MM ratio was 2.384 and the lowest was 2.2856. The results showed correlation coefficient between age and MM ratio on right mandible calculated with Spearman's rank ( $r_s$ ) was -0.046 (p-value=0.757) and  $r_s$ =-0.058 (p-value=0.697) between age and MM ratio on left mandible. **Conclusion:** There is no correlation between age and mandibular bone quality on panoramic radiographs in RSGM Unpad based on MM Ratio.

**Keywords:** age, mandibular alveolar bone resorption index (MM ratio), mandibular bone quality, panoramic radiograph

### ABSTRAK

**Pendahuluan:** Seiring bertambahnya usia kualitas tulang dapat berubah, yang terlihat pada tulang mandibula. Perubahan kualitas tulang mandibula dapat dinilai dengan menggunakan radiografi panoramik. Penelitian ini ditujukan untuk mendeskripsikan kualitas tulang mandibula dan mengetahui hubungan usia dengan kualitas tulang mandibula pada radiografi panoramik. **Metode:** Analisis korelasi *cross sectional*; populasi adalah arsip radiografi panoramik pasien di Instalasi Radiologi Gigi RSGM Universitas Padjadjaran dengan rentang usia 13-59 tahun pada saat pengambilan radiografi sehingga diperoleh 48 sampel. Kualitas tulang mandibula diperoleh dengan metode *mandibular alveolar bone resorption index* (MM Ratio) menggunakan software EzPax-Plus. **Hasil:** Rerata jumlah rasio MM tertinggi adalah 2,384 dan terendah adalah 2,2856; menunjukkan koefisien korelasi antara usia dan Rasio MM pada mandibula kanan yang dihitung dengan *rank Spearman* ( $r_s$ ) adalah -0,046 (nilai  $p=0,757$ ) dan  $r_s$ =-0,058 (nilai  $p=0,697$ ) antara usia dan rasio MM pada mandibula kiri. **Simpanan:** Tidak ada hubungan antara usia dengan kualitas tulang mandibula pada radiografi panoramik di RSGM Unpad berdasarkan rasio MM.

**Kata kunci:** usia, indeks resorpsi tulang alveolar mandibula (rasio MM), kualitas tulang mandibula, radiografi panoramik

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### INTRODUCTION

Mandible is the biggest bone that arranges human's skull and the only one that can move. The mandible is particularly formed primarily by intramembranous ossification, while secondary cartilage at its proximal end contributes endochondral components at later stages.<sup>1</sup>

There is no clear consensus on the definition of bone quality, but in general it encompasses multiple aspects of bone physiology, that is degree of mineralization, morphology, and trabecular pattern. The morphology and type of trabecular pattern. Bone quality has been suggested as one of the main factors influencing

implant therapy success. Areas of less bone quality have exhibited higher failure rates and weaker primary stability values.<sup>2</sup>

Changes in bone quality continue to occur as someone aged. The growth and development of human bones starts from the embryo until someone grow up. Heaney said, about 85–90% of final adult bone mass is acquired by the age of 18 years in girls and 20 years in boys.<sup>3</sup> Afterwards, bone mass will continue to be constant until it begins to undergo demineralization process. This loss usually begins after age 30 in females, accelerates greatly around age 45 as levels of estrogens decrease, and

continues up to 30% of the calcium in bones is lost by age 70.<sup>4</sup> A research found while most American women under the age of fifty have normal BMD, by the age of 80 years, 27% are osteopenic and 70% are osteoporotic at the hip, lumbar spine or forearm.<sup>5,6</sup>

Mandibular alveolar bone resorption index (MM ratio) is one method that can be used to measure the quality of mandible bone. Wical and Swoope found this method in 1974. They used mental foramen as the landmark to measure the size of resorption in mandible. The radiographic image of mental foramen is recommended as the reference point to measure the amount of alveolar bone loss because the distance between foramen and mandibular lower edge is relatively constant despite the increasing age or alveolar process resorption above the foramen. From the panoramic radiographs, the ratio between the distance between mandibular lower edge to the mental foramen base and the distance between mandibular lower edge to alveolar highest point is 1:3.<sup>7</sup>

Radiographic assessment may be used to assess mandibular bone quality, to measure the remaining bone and to see bone density. Mandibular bone quality can be assessed using intraoral radiographs, panoramic radiographs, CBCT and dual-energy X-ray absorptiometry.<sup>8</sup>

Panoramic radiograph is an effective method to observe overall condition of mandibular bone. The advantage of using panoramic radiography is that it can show the entire maxilla and mandible, so that more anatomical structures can be seen in a panoramic film than in complete intraoral radiographs.<sup>9</sup>

## METHODS

The method used in this study was cross sectional correlation analysis. The population was panoramic radiograph archives of patients in Dental Radiology Installation RSGM Universitas Padjadjaran within the range of age 13-59 years when the radiograph was taken and total of samples was 48 radiographs. The mandibular bone quality was obtained with MM ratio method using EzPax-Plus software.

Institutional ethical clearance was obtained from Medical Research Ethical Committee of Faculty of Medicine Universitas Padjadjaran. All samples fit with criteria 1) panoramic radiographs from patients both male and female aged 13-59 years old; 2) panoramic radiographs with good quality; 3) mental foramen can be seen clearly on panoramic radiograph; 4) there are no infection, congenital, or malignant lesions on mandibular bone.

The measurement of mandibular bone quality used MM ratio which is the ratio between total height of the mandible and the height of the mandible from the center of the mental foramen to the inferior border of the mandible.<sup>11</sup> The measurement was performed by making a straight line parallel to the long axis of the mandible and tangential to the inferior border of the mandible. Another perpendicular line to this tangent and intersecting the from superior to inferior border of the mandible was constructed. The last straight line was drawn passing the midpoint of mental foramen parallel to the first straight line. Distance from superior to inferior border of mandible was the total height of mandible, which is then divided to the distance between the line at the inferior border of mandible to the line passing the midpoint of mental foramen, resulting an MM ratio. The measurement was done bilaterally, using EzPax-Plus software.

Figure 1 shows a panoramic radiograph of a human mandible. Two horizontal lines are drawn across the mandible. The upper line is parallel to the long axis of the mandible and tangential to the inferior border. The lower line is perpendicular to the upper line and intersects the mandible from superior to inferior border. A third line is drawn passing through the midpoint of the mental foramen, parallel to the upper line. This setup is used to measure the MM ratio, which is the ratio of the distance from the superior border to the inferior border (total height) to the distance from the inferior border to the line passing through the mental foramen midpoint.



**Figure 1** The measurement of mandibular bone quality using MM ratio (Private Documentation on panoramic radiograph in RSGM Unpad).

The obtained study data is presented in tables and graph. Statistical analysis was using SPSS<sup>®</sup> version 23.0. The normality data distribution was tested to MM ratio of left mandible, MM Ratio of right mandible, and age. Also, Spearman's Rank correlation test was performed to find out how strong the correlation between age and mandibular bone quality on panoramic radiographs based on MM ratio. The p-value was used to identify statistical signification.

## RESULTS

Based on the data, there were 48 samples of panoramic radiography. Characteristics of respondents were differentiated over age and gender. Table 1 shows that there was 20 male samples and 28 female samples out of 48 samples. Table 2 shows the distribution of sam-

**Table 1** Sample Distribution Based on Gender.

Gender	Quantity	Percentage (%)
Male	20	41.7
Female	28	58.3
<b>Total</b>	<b>48</b>	<b>100</b>

**Table 2** Sample Distribution Based on Age Group.

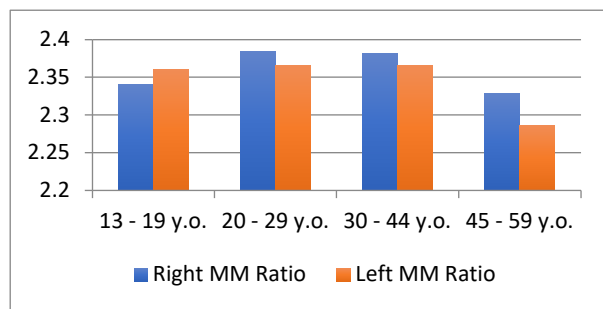
Age (year)	Quantity	Percentage (%)
13-19	9	18.8
20-29	13	27.1
30-44	14	29.2
45-59	12	25.0
<b>Total</b>	<b>48</b>	<b>100</b>

**Table 3** MM ratio on both gender

Variable	Gender		P value
	Male	Female	
<b>Right MM Ratio</b>			
Average	2.333	2.382	0.412
Std. Deviation	0.225	0.186	
<b>Left MM Ratio</b>			
Average	2.274	2.395	0.041
Std. Deviation	0.207	0.187	

**Table 4** The MM ratio on each age group

Variable	Age (year)				P value*
	13-19	20-29	30-44	45-59	
<b>Right MM ratio</b>					
Average	2.341	2.384	2.382	2.329	0.880
Median	2.351	2.303	2.388	2.310	
Range	2.000-2.588	2.116-2.810	2.073-2.605	1.917-2.705	
<b>Left MM ratio</b>					
Average	2.360	2.366	2.366	2.286	0.729
Median	2.417	2.300	2.406	2.334	
Range	2.008-2.757	2.110-2.759	2.073-2.605	1.870-2.647	

**Figure 2** Average MM ratio on each age group

ple into several age groups. The highest is 14 samples aged 30-44 years old.

Table 3 shows there was no significant difference between male and female MM ratio on right mandible ( $p > 0.05$ ), otherwise there was a significant difference on the left mandible ( $p < 0.05$ ). Female had a higher MM ratio on left mandible than male.

Table 4 shows there was no significant difference between MM ratio on both sides of mandible ( $p > 0.05$ ), with details p-value of MM ratio on right mandible was 0.880 dan 0.729 on left mandible.

**Table 5** The normality of data distribution test on the whole variable results

Variable	Average	Std. Deviation	Median	Range	P-Value*
Right MM ratio	2.362	0.202	2.354	1.917-2.810	0.939
Left MM ratio	2.345	0.02	2.347	1.870-2.759	0.605
Age (year)	32.85	13.17	30.50	14-58	0.004

\*Based on Saphiro-Wilk test ( $n < 50$ ),  $p$ -value  $< 0.05$  which means data distribution was abnormal.

**Table 6** The correlation between age and MM ratio

Correlation	Correlation Coefficient ( $r_s$ )*	P-Value
Age with Right MM Ratio	-0.046	0.757
Age with Left MM Ratio	-0.058	0.697

\* $r_s$  = Spearman's rank correlation coefficient

There was a change in the mean value of MM ratio of each age group although the difference is insignificant shown in Fig. 2. MM ratio on both sides of mandible increased from 13-19 years old age group to 20-29 years old age group, and decreased in 45-59 years old age group.

The average of MM ratio on right mandible was higher than MM ratio on left mandible shown in Table 5 even the difference was not so big. Samples involved in this study were 48 samples, so the data distribution normality test was using Saphiro-Wilk's test. Based on data distribution normality test results, the data distribution of MM ratio on both sides of mandible was normal because  $p$ -value  $> 0.05$  while data distribution for age was abnormal because  $p$ -value  $< 0.05$  so this study used non-parametric correlation test.

Spearman's rank correlation analysis was used to find out the correlation between age and mandibular bone quality on panoramic radiographs based on MM ratio. The hypothesis null was there is no correlation between age and mandibular bone quality.

Table 6 shows that between the mandibular bone quality and age on the panoramic radiograph based on MM ratio on the right mandible. So the temporary conclusion of this study there was no correlation between age and mandibular bone quality.

## DISCUSSION

This research used MM ratio method to assess mandibular bone quality on panoramic radiographs. This method was found by Wical and Swoope which estimated the actual height of mandible that has undergone resorption. The study resulted a ratio between the total height of mandible and the distance from mandibular inferior border to inferior border of mental foramen and ratio between the total height of mandible and the distance from mandibular inferior border to superior border of mental foramen. The measurement technique used in this study based on the latest technique adapted Wical and Swoope's technique that is compared the total height of mandible to the distance from mandibular inferior border to the midpoint of mental foramen.<sup>11</sup>

Bone size shows gender difference that are considered to occur due to sex steroid activity in bone and is generally larger in males than in females. The larger bone width in men results from greater periosteal expansion during puberty and early adulthood in men, whereas girls predominantly increase their cortical thickness by limit-

ing endocortical expansion.<sup>12</sup> Furthermore, difference on bone size can be explained by sex difference in muscle mass which start to appear at the time of puberty. Muscle mass is androgen-dependent and greater muscle mass can exert greater mechanical action on bone, thus resulting in increased bone size and bone mass.<sup>13</sup> Growth spurt also plays an important role in this case. At puberty, the secretion of hormones known as sex hormone causes a dramatic effect on bone growth. The sex hormones include estrogens and androgens such as testosterone. These hormones are responsible for increased osteoblast activity and synthesis of bone extracellular matrix and the sudden growth spurt that occurs during the teenage years. Estrogens, in both sexes, shut down growth at epiphyseal plates. Lengthwise growth of bones typically ends earlier in females than in males due to their higher levels of estrogens.<sup>4</sup> Different things are seen in table 3, where MM ratio on female, both right and left mandible, have a higher average when compared with male MM ratio. Difference in the results of this study, probably due to the number of male and female samples included in this study are different.

As shown in Table 4, the highest and lowest average of MM ratio on right mandible and left mandible. In accordance with existing theory, the age of 20 is the age when a person reaches the peak of bone mass, while the lowest value is at age 56 according to Curtis et al., which states that peak bone mass is achieved as a person grows older and as age increases will decrease around the fifth decade.<sup>14</sup>

Figure 2 shows an increase in the average value of the MM ratio in both sides of mandible of the 13-19 years old age group to the 20-29 years old age group. Peak bone mass occurs at age 18 for women and 20 years for men. The achievement of peak bone mass is triggered by increased sex of steroids, such as estrogen in women and androgens in men during puberty.<sup>4</sup> Puberty is the important period for achieving peak bone mass and this is influenced by increased levels of GH and IGF-1. GH will stimulate prechondrocytes in the growth plate followed by a clonal expansion and stimulating osteoblasts. The IGF-1 is the most abundant growth factor stored in bone and produced by osteoblast cells, also participates in regulating bone turnover.<sup>15</sup>

Figure 2 also shown a decreased in average of MM ratio on both sides of mandible from 20-29 years old age group to the older age group. This point is in line with the Heaney's research charts which shows since the early age of 20 years the bone mass is described to increase and decrease very little around the age of 30 years. Significant decrease in bone mass occurs at age 50, because at this age, estrogen levels in the body will begin to decrease, especially when a woman reaches menopause. During the first 5-8 years post-menopause in women,

bone density will decrease 40-50% of bone mass while in men bone mass decreases 1% annually after the age of 50 years.<sup>16,17</sup>

As shown on Table 5, the average score of MM ratio on the right mandible was 2.362 and on the left mandible was 2.345. This is not significantly different from the ratio of the total height of the mandible to the distance from the inferior border of the mandible to the superior border of mental foramen from the Wical and Swoope's research results that was 2.34:1.<sup>18</sup> Nevertheless, a significant difference seen when the total height of mandible compared with the distance from the inferior border of mandible to the inferior border of mental foramen, which was as big as 2.90:1. This significant difference could happened because the study conducted by Wical and Swoope used conventional panoramic radiographs, while they did not have contrast as good as in digital panoramic radiographs causing the image of the mental foramen not to be clearly visible, so that there can be errors in determining the superior and inferior borders of the mental foramen.<sup>19</sup>

Although there were differences between age groups, statistical tests using Spearman's correlation method showed no association between age and mandibular bone quality on panoramic radiograph based on MM ratio. Spearman's rank coefficient ( $r_s$ ) on right mandible was -0.046 and p-value = 0.757 and MM ratio on left mandible was -0.058 and p-value = 0.697. These results mean that the correlation is very low or bad ( $r_s < 0.1$ ) and the difference is considered insignificant ( $p > 0.05$ ) so that  $H_0$  is accepted. It means, the results of Spearman's rank correlation test showed there was no correlation between age with mandibular bone quality both in right mandible and left mandible.

The sample in this study used panoramic radiograph archive of patients who did not experience tooth loss, and this condition can also be the reason there is no significant difference in MM ratio of each age group. When the tooth is loaded, it will induce a mechanical stimulation, strains, in the bone immediately adjacent to the tooth. The loading of more distant teeth, the action of the masticatory muscles and the reaction forces at the temporomandibular joints will give rise to bending moments in the mandible. These bending moments will also give rise to strains in the bone adjacent to the tooth in question. A steady-state condition is assumed to prevail, which means that the sum of these strains will represent the strain stimulus needed to maintain bone mass as proposed by Qin, et al.<sup>20</sup> Furthermore, it is well known that the jaws undergo a continuous alveolar ridge atrophy after extraction of teeth and the use of full dentures.<sup>21</sup>

This study has data limitation for panoramic radiographs, because panoramic radiographs used in this study, since the archives taken as samples were not accom-

panied by information on factors that could affect mandibular bone quality such as drug use, systemic disease, smoking and alcohol consumption, chewing habits, occlusion trauma, and others. These factors should be considered because it can affect the results obtained.

Based on data analysis and discussion above, it can be concluded that there is no correlation between age and mandibular bone quality on panoramic radiographs in RSGM Unpad based on mandibular alveolar bone resorption index (MM ratio).

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