The average value of mandible measurements in panoramic radiographs: a comparison of 14–35 and 50–70 year old subjects

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Abstract. To obtain the mandibular parameter values using panoramic radiographs as basic data related to age estimation in 14–35 and 50–70 year old subjects. Measurement of mandibular parameters on digital panoramic radiographs of 200 subjects aged 14–35 and 50–70. The mandibular parameter measurement values are not statistically significant, but they tend to change according to age. Measurement of mandibular parameters in panoramic radiographs cannot be used as basic data for age estimation in 14–35 year old and 50–70 year old subjects.

1. Introduction
Radiographs provide a view of bone that is not visible to the naked eye. In the mandible, which is one of the regions of interest in dentistry, many potential landmarks give diagnostic information about growth and development related to such things as age, sex, and race. This diagnostic information is needed in various fields of dentistry, such as orthodontics, pedodontics, and forensics. In the literature, many studies have reported on the parameters of growth and development, including in the mandible. Nevertheless, studies conducted with Indonesian subjects are still limited.

Forensics is one of the areas that use information on age-related growth and development parameters. Geographically, Indonesia has great potential for natural disasters, such as earthquakes, floods, volcanic eruptions, and landslides, as well as disasters caused by humans, such as accidents on the land, on sea, and in the air, as well as fires, bombings, and unrest that cause damage, loss of property, and relatively heavy human casualties, including injury or death [1]. In some instances, it is possible to determine the identities of the death casualties, while other times it is not; therefore, identification procedures are required. In such cases, age estimation can be a useful tool, due to the increasing physical growth and development of the human body; any changes can be attributed to an individual’s age. In addition to using age estimation to identify individuals that have died, it can also be used to determine the age of individuals who are still alive in order to know whether a person is a child or an adult, if the judicial process requires such information and/or a person’s birth certificate is not available or its authenticity is doubtful [2]. The mandible has a role in the estimation of age because it is the largest and strongest bone in the skull and it often remains intact, even after death. The compact bone in the mandible helps it maintains its shape, and it retains that shape more often than other bones [3]. In adolescence, the growth of the jaw bone is related to puberty pubertas [4]. Until the third decade of life, morphology and dental changes can contribute to estimating a person’s age; however, after the third decade, changes related to age are nearly imperceptible [3]. In old age,
changes in the mandible occur, especially with tooth loss, and when the alveolar bone is absorbed resulting in decreasing bone height [5].

In the estimation of the age, radiography is one of the least invasive methods that can be used on individuals, whether they are living or dead [3]. A panoramic radiograph is a radiograph that has been widely used to obtain a comprehensive overview of the complex maxillofacial, and it is routinely used in clinical settings to observe the structure of the mandible bilaterally [6]. Nowadays, digital panoramic radiography is widely used. The advantage of this technique is that the measurements can be performed digitally and the settings in the image can be adjusted in order to provide an accurate method for measuring the mandible [3, 7]. Panoramic radiographs can be used to measure the parameters of the mandible, including the ramus height, the gonial angle, the bigonial width, the maximum inter-ramus distance, the minimum inter-ramus distance, the condylar-ramus height, the ramus-coronoid height, and the mentalis index. The measurement of the mandible parameters as the principle method for age estimation is used in forensic identification as well as in a variety of fields in dentistry. In orthodontics, mandibular parameter measurements can play a role in monitoring the growth patterns of individuals for orthodontic assessment [8].

The average value of the measurement parameters of the mandible vary in different populations. This makes it possible to determine the variations between the average values of the existing measurements with the average value of the measurement parameters of the mandible in an Indonesia population. Moreover in Indonesia, a study of the mandible using panoramic radiographs was conducted by Wardhani, but this study was limited to one parameter only, specifically the gonial angle on male subjects [9]. Therefore, this present study was conducted to obtain the mandibular parameter values using panoramic radiographs as basic age estimation data in 14–35 and 50–70 year old patients at Rumah Sakit Khusus Gigi dan Mulut, Faculty of Dentistry, University of Indonesia. The 14–35 year old patients were used to represent teenagers and adulthood, while the 50–70 year old patients were used to represent old age. This study aimed to provide basic age estimation data related to mandibular parameter measurements in order to contribute adding information to various fields of dentistry.

2. Materials and Methods
This descriptive analytic research study used a cross-sectional approach. The study sample consisted of digital panoramic radiographs from the medical records of dental patients at the Teaching Dental Hospital, Faculty of Dentistry, University of Indonesia. The sample consisted of 100 digital panoramic radiographs of patients aged 14–35 years and 100 digital panoramic radiographs of patients aged 50–70 years. The inclusion criteria included both men and women ranging in age from 14 to 35 and from 50 to 70 with good quality panoramic radiographs. Patients with abnormalities of growth and development of the jaw, systemic disease that affects the mandible and mandibular fractures were not included in this study.

This study began with the selection of digital panoramic radiographs that were in accordance with the inclusion criteria. Digital panoramic radiographs were then transferred into AutoCAD 2016 software. Furthermore, the following mandibular parameters were measured: the ramus height, the gonial angle, the bigonial width, the maximum ramus breadth, the minimum ramus breadth, the ramus-condylar height, the ramus-coronoid height, and the mentalis index. The measurement of the mandible parameters was performed twice at different times and by two observers. After the measurement was completed, an intra-observer reliability test and an inter-observer reliability test were performed. In this present study, the intra-observer and inter-observer reliability tests were performed using the Technical Error of Measurements (TEM) method based on the formula presented by Dahlberg [10]. When performing the measurements, a smaller value represented a better accuracy for the TEM observation. After the reliability test was performed, the data was processed statistically. In order to obtain more accurate analysis results, the age range was divided into four categories: 14–24 years, 25–35 years, 50–59 years and 60–70 years. The normality test was done using the Kolmogorov-Smirnov test for a study sample greater than 50 subjects. The data has a normal distribution when the
statistically significant value is greater than 0.05 (p > 0.05). After determining the normal distribution of the data, statistical analysis was performed using parametric tests, such as the independent t-test. The data that did not have a normal distribution was statistically analyzed using non-parametric tests, such as the Mann-Whitney U test. The data are not statistically significant when the value is greater than 0.05 (p > 0.05).

3. Results and Discussion

3.1 Results

Figure 1. Mandible parametric measurements using a panoramic radiograph. Ramus height (purple), gonial angle (orange), bigonial width (dark blue), maximum inter-ramus distance (green), minimum inter-ramus distance (yellow), ramus-condyle height (pink), ramus-coronoid height (light blue), and the mental index (red)

After the intra-observer and inter-observer reliability tests were conducted using Dahlberg’s TEM-based formula, a TEM overall value of less than 1 mm was obtained. As noted by Gore, the acceptable measurement tolerances for teeth and bones, based on the Dahlberg formula, is 1 mm. This indicates that the value is still within the limits of the tolerance measurements.

The Kolmogorov-Smirnov test results showed that the gonial angle, the bigonial width, the maximum ramus breadth, and the minimum ramus breadth had a statistical significance value of 0.05, so they were included in the normal distribution data. Meanwhile, the ramus height, the ramus-condylar height, the ramus-coronoid height, and the mentalis index were found to have a statistical significance value less than 0.05, so the distribution of that data is not normal.

Table 1. Mean, deviation, and interval of the gonial angle and the bigonial width

| Age Group | Gonial Angle (mm) | Bigonial Width (mm) |
|-----------|------------------|---------------------|
|           | Mean (SD)        | IK 95%              | Mean (SD)        | IK 95%              |
| 14–24     | 123.53 (7.130)   | 121.48–125.58       | 223.78 (16.094)  | 219.15–228.40       |
| 25–35     | 123.59 (8.139)   | 121.30–125.88       | 223.80 (12.592)  | 220.26–227.35       |
| 50–59     | 124.02 (6.406)   | 122.20–125.84       | 224.83 (14.149)  | 220.81–228.85       |
| 60–70     | 124.18 (7.392)   | 122.08–126.28       | 220.85 (14.554)  | 216.71–224.99       |
### Table 2. Mean and deviation of maximum and minimum inter-ramus distance

| Age Group | Maximum Inter-ramus Distance (mm) | Minimum Inter-ramus Distance (mm) |
|-----------|----------------------------------|----------------------------------|
|           | Mean (SD)                        | IK 95%                           | Mean (SD)                        | IK 95%                           |
| 14–24     | 41.721 (3.9886)                  | 40.575–42.867                    | 37.328 (3.5151)                  | 36.318–38.338                    |
| 25–35     | 41.732 (4.2949)                  | 40.524–42.940                    | 37.443 (4.5747)                  | 36.157–38.730                    |
| 50–59     | 42.752 (4.6324)                  | 41.435–44.068                    | 37.478 (4.4764)                  | 36.206–38.750                    |
| 60–70     | 42.419 (4.5052)                  | 41.139–43.700                    | 37.158 (5.0444)                  | 35.725–38.592                    |

### Table 3. Mean, minimum, and maximum of ramus height and ramus-condylar height

| Age Group | Ramus Height (mm) | Ramus-condylar Height (mm) |
|-----------|------------------|---------------------------|
|           | Median | Minimum | Maximum | Median | Minimum | Maximum |
| 14–24     | 77.453 | 63.350  | 96.894  | 77.364 | 63.300  | 96.785  |
| 25–35     | 78.482 | 63.368  | 103.802 | 77.988 | 63.501  | 103.779 |
| 50–59     | 80.357 | 64.087  | 108.053 | 80.042 | 64.282  | 108.010 |
| 60–70     | 80.209 | 63.804  | 93.671  | 79.959 | 64.445  | 92.718  |

### Table 4. Mean, minimum and maximum of ramus-coronoid height and mental index

| Age Group | Ramus-coronoid Height (mm) | Mental Index (mm) |
|-----------|---------------------------|------------------|
|           | Median | Minimum | Maximum | Median | Minimum | Maximum |
| 14–24     | 71.485 | 60.885  | 90.532  | 4.339  | 3.216   | 6.474   |
| 25–35     | 72.106 | 57.714  | 94.752  | 4.385  | 3.475   | 7.234   |
| 50–59     | 72.498 | 57.849  | 107.947 | 4.806  | 3.074   | 6.702   |
| 60–70     | 72.295 | 57.205  | 87.833  | 4.730  | 2.387   | 6.539   |

### Table 5. Independent t-test of the gonial angle, the bigonial width, the maximum and minimum inter-ramus distance

| Age Group | 14–24 | 25–35 | 50–59 |
|-----------|-------|-------|-------|
| Gonial Angle |       |       |       |
| 25–35      | 0.970 |       |       |
| 50–59      | 0.720 | 0.768 |       |
| 60–70      | 0.657 | 0.703 | 0.908 |

| Bigonial Width |       |       |       |
| 25–35         | 0.993 |       |       |
| 50–59         | 0.730 | 0.700 |       |
| 60–70         | 0.345 | 0.278 | 0.169 |

| Maximum Inter-ramus Distance |       |       |       |
| 25–35                       | 0.989 |       |       |
| 50–59                       | 0.239 | 0.254 |       |
| 60–70                       | 0.417 | 0.435 | 0.717 |

| Minimum Inter-ramus Distance |       |       |       |
| 25–35                        | 0.888 |       |       |
| 50–59                        | 0.854 | 0.969 |       |
| 60–70                        | 0.847 | 0.767 | 0.738 |
The independent t-test results for the gonial angle, the bigonial width, the maximum inter-ramus breadth, and the minimum inter-ramus breadth (Table 5) have a statistically significant value (p-value) greater than 0.05 (p > 0.05). Thus, no statistically significant difference was found among the age ranges for the gonial angle, the bigonial width, the maximum ramus breadth, and the minimum ramus breadth.

Table 6. P value mann-whitney u test results for ramus height, ramus-condylar height, ramus-coronoid height, and mental index.

|                     | 14–24 | 25–35 | 50–59 |
|---------------------|-------|-------|-------|
| Ramus Height        |       |       |       |
| 25–35               | 0.268 |       |       |
| 50–59               | 0.215 | 0.903 |       |
| 60–70               | 0.221 | 0.786 | 0.605 |
| Ramus-condylar Height|      |       |       |
| 25–35               | 0.201 |       |       |
| 50–59               | 0.103 | 0.786 |       |
| 60–70               | 0.093 | 0.578 | 0.634 |
| Ramus-coronoid Height|     |       |       |
| 25–35               | 0.707 |       |       |
| 50–59               | 0.609 | 0.839 |       |
| 60–70               | 0.763 | 0.951 | 0.725 |
| Article I. Mentalis Index| |       |       |
| 25–35               | 0.398 |       |       |
| 50–59               | 0.632 | 0.105 |       |
| 60–70               | 0.629 | 0.480 | 0.378 |

The Mann-Whitney U test results for ramus height, ramus-condylar height, ramus-coronoid height, and mental index (Table 6) showed a statistical significance value greater than 0.05 (p > 0.05). This indicates that there is no statistically significant difference among the age ranges for the ramus height, the ramus-condylar height, the ramus-coronoid height, and the mentalis index.

3.2 Discussion

This study aimed to determine if there is any difference in the average value of the mandible measurement parameters for ramus height, gonial angle, bigonial width, maximum ramus breadth, minimum ramus breadth, ramus-condylar height, ramus-coronoid height, and mentalis index using panoramic radiographs of 14–35 year old patients and 50–70 year old patients. The age range investigated in this study (14–35 years and 50–70 years) was based on the growth of the jaw when individuals undergo puberty and the acceleration of growth that occurs in the length of mandible [4]. Morphology changes in the mandible could contribute to estimating an individual’s age up to the third decade of life; however, after the third decade, any changes that occur are nearly imperceptible. In old age, changes in the mandible can occur, especially with tooth loss, and if alveolar bone is absorbed, resulting in decreased bone height [3,5]. In this study, 14–35 year old patients were used to represent teenagers and adulthood, and 50–70 year old patients were used to represent old age. In order to observe the pattern of mandible changes due to age, these two age groups were further divided into four categories: 14–24 years, 25–35 years, 50–59 years, and 60–70 years.

Using panoramic radiographs, the measurement of the mandible parameters for ramus height, gonial angle, bigonial width, maximum inter-ramus distance, minimum inter-ramus distance, condylar-ramus height, ramus-coronoid height, and mentalis index were applied only for one side of the mandible. This approach was based on previous research, which stated that there is no statistically significant difference between the left and right side linear and angular measurements of the mandible [3,6,8,11].

The Mann-Whitney U test was performed to analyze the ramus height measurements (Table 6). A p value greater than 0.05 was obtained, which indicates that the change based on age was not
statistically significant. In their study on 42–74 year old patients with full dentures, Raustia and Salonen also found no correlation between age and the height of the ramus [6]. The median value (Table 3) for the 14–24, 25–35 and 50–59 age ranges showed that the ramus height has a tendency to increase; however, a decrease in the ramus height was detected for the age range of 60–70. In their study based in Jordan, Al-Shamout et al. concluded that the ramus height increased during the second and third decades of life, and then it begins to decrease [11]. In his research on old and young subjects with completely edentulous arches, Oksayan et al. found that the ramus height increased as the patient’s age increased, but then it decreased when it reached the stage of edentulous [14]. In his study based in Far North Queensland, Leversha et al. found a high fluctuation in the increases in ramus height as people age; and that parameter decreases steadily in the fifth and sixth decades of life [8].

Analysis of the gonial angle measurements using the independent t-test (Table 5) showed a p value greater than 0.05, which indicates that the changes that occur due to age are not statistically significant. Similar to that finding, several other studies also found no significant difference between the gonial angle and age, including Taleb et al., in a study of the Egyptian population, as well as Chole et al., Dutra et al., Oksayan et al., and Raustia and Salonen [6]. From the overall mean value of the gonial angle (Table 1), it can be seen that the angle size tended to increase with increasing age. Leversha et al. concluded that, in general, the gonial angle will increase as a person ages [8]. That finding is also supported by Al-Shamout et al., who observed an increase of the gonial angle [11]. Conversely, Taleb et al. stated that gonial angle would decrease due to age [6].

Analysis of the bignomial width measurements using the independent t-test (Table 5) showed a p value greater than 0.05. This means that the correlation between the bignomial width and age was not statistically significant. However, the mean value of the bignomial width (Table 1) showed that this parameter increased for the 14–24, 25–35, and 50–59 age ranges, and then it decreased for the 60–70 age range. Similar results were reported by Hesby et al.; that study found that the differences between the bignomial width measurement and age were not statistically significant [8]. Other studies found that a reduction in the bignomial width occurs as people age [11]. This is different from the study by Al-Shamout et al., which reported that the bignomial width increases as people age [11].

The independent t-test results for the maximum inter-ramus breadth measurements (Table 5) showed a p value greater than 0.05. This indicates that the correlation between changes in the maximum inter-ramus distance and an individual’s age are not statistically significant. The results for the average value of the maximum distance inter-ramus distance (Table 2) demonstrate a tendency for that distance to increase in the age ranges of 14–24, 25–35, and 50–59, and then it starts to decrease in the age range of 60–70. Shaw et al. found no significant changes in the width of the ramus between age groups for both genders [9]. In their study in India, Muskaan and Sarkar found a reduction in the maximum inter-ramus distance due to age; however, the determination of age could only be used on a study sample of women [3]. A study conducted by Ghaffari et al. using computed tomography (CT) scans of 125 subjects aged 21–50 concluded that the inter-ramus distance decreased with age [6].

Independent t-test results for the minimum inter-ramus distance measurements showed a p value greater than 0.05 (Table 5). This indicates that the correlations between the changes in the minimum distance ramus and an individual’s age are not statistically significant. However, based on the average value shown in Table 2, the value of the minimum inter-ramus distance increased in the age ranges of 14–24, 25–35, and 50–59, but it decreased in the age range of 60–70. Shaw et al. found no significant changes in the width of the inter-ramus distance between age groups for each gender [9]. Muskaan and Sarkar stated that the minimum inter-ramus distance decreased with increasing age; however, the determination of the age could only be used on a study sample of women [3]. Ghaffari et al. concluded that the inter-ramus distance decreased with increasing age [6].

The Mann-Whitney U test results of the ramus-condylar height measurements showed a p value greater than 0.05 (Table 6). This indicates that the correlation between the height change of the ramus-condylar and an individual’s age was not statistically significant. However, the median value (Table 3) demonstrates that the ramus-condylar height increased in the age ranges of 14–24, 25–35, and 50–59, and then it decreased in the age range of 60–70. Numerous previous studies of ramus-condylar height
using panoramic radiographs reported that this correlation could only be seen with gender. Taleb and Beshlawy stated that ramus height was the most significant predictor of gender [6].

The Mann-Whitney U test results for the ramus height measurement showed a p value greater than 0.05 (Table 6). This indicates that the correlation between the changes in the ramus height due to an individual’s age was not statistically significant. However, the value of the ramus height increased in the age ranges of 14–24, 25–35, and 50–59, and then it decreased in the age range of 60–70. This finding is different from the results reported by Taleb and Beshlawy, which stated that the coronoid level was the most significant factor associated with increasing age. Muskaan and Sarkar found that ramus-coronoid height often decreased as an individual’s age increased.

The Mann-Whitney U test results for the mentalis index measurements showed that the p value was greater than 0.05. This indicates that the correlation between the changes in the mentalis index and an individual’s age are not statistically significant. However, the mean of the data (Table 4) shows that the value of the mentalis index increased in the age ranges of 14–24, 25–35, and 50–59, and then it decreased in the age range of 60–70. Muskaan and Sarkar stated that the mentalis index decreased as the age increased, which is similar to Mostafa et al., who found that the reduction in the mentalis index occurred as individuals aged [3,15].

The result of this present study showed that the changes in the mandibular parameters were not statistically significant for the 14–35 year old patients and the 50–70 year old patients. However, the results for several of the parameters were similar to the findings reported in previous studies, some of which stated that the mandibular parameters showed significant changes as the study subjects aged. Theoretically, as a person ages, the mandible undergoes articulation movement in the glenoid fossae. The condylar and ramus grow both superiorly and posteriorly to the space of the movement. This results in an increase in the height and width of the ramus, which accommodates masticatory function and the widening of the pharyngeal space. In addition, the masticatory muscles keep the mandible at its insertion site where the gonial angle is maintained by the insertion of the medial pterygoid and the masseter muscles. As people age, slight anatomical changes may occur on the remaining tooth. Masticatory muscle activity also prevents the gonial angle from changing its shape/size [12–14]. Some studies have reported that the average value of the mandible angle and the ramus remain unchanged once an individual reaches adulthood until he or she reaches the age of 70, or so, unless numerous tooth loss occurs [11, 15]. Changes in the morphology of the jaw occur due to aging because of excessive tooth loss and progressive muscular atrophy. When tooth loss occurs, the alveolar bones undergo remodeling, resulting in changes at the gonial angle site. Bone resorption occurs at the posterior and inferior edge of the mandible and at the insertion area of the masseter muscle, which triggers an increase in the mandible angle. The reduction of the ramus height is the result of the decompensated loss of the alveolar ridge [12–15].

In this present study, the decreases in the mentalis index value due to aging were not statistically significant. The reduction of the mentalis index or bone loss due to aging could be caused by decimation or the porosity of the mandible cortex. At about 65 years of age, about one-third of bone mineral is lost. Several factors are involved in age-related bone loss, including decreased physical activity, decreased secretion of estrogen, diet, race, and heredity [15].

The difference in the results between this present study and previous studies might be due to the differences in the age groups investigated. This study only included two age groups: teenagers and adults, 14–35 year old subjects and 50–70 year old subjects. The subjects were further divided into four smaller groups: 14–24 years, 25–35 years, 50–59 years, and 60–70 years. In addition to the age ranges, the dental factors that are used in a study also affect the results. This is shown in studies that use different dental factors to determine the relationship between the gonial angle and age. Oksayan et al. studied individuals with complete edentulous (24 subjects, mean age 69.7 years), old dentate (24 subjects, mean age 62.2 years), and young dentate (24 subjects, mean age 18.8 years); they also found no significant difference in the gonial angle based on age [14]. However, Leversha et al. investigated subjects aged 18–69 and without complete edentulous; they found that the gonial angle increased due to increasing age [8].
Several factors need to be considered when measuring the mandible parameters using panoramic radiographs. The use of panoramic radiographs cannot be separated from the possibility that distortion and magnification will affect the accuracy of the measurement. Errors might occur because of the size or shape of the focal trough, and this will produce a distorted image. Ghost images, image summation, and errors when processing and moving patients can result in low quality images [16]. In addition, mistakes in positioning the patient's head can affect the panoramic image results. Panoramic radiographs have a narrow focal trough in the anterior and posterior angles widened, so that any change in the patient's head position would have a large effect on the degree of magnification in the anterior region. It has been reported that distorted and blurred images can occur when the patient's head moves sagittally about 1 cm in front of or behind the ideal position and laterally 3 cm from the ideal position [17, 18].

Difficulties in measuring mandible parameters using a digital panoramic radiograph include determining the reference point on the radiograph when viewed through the screen. When the morphology of the parameters is measured by radiographs, the consistency of the method is determined by the ability of the observers to determine the reference point on the radiograph. Paewinsky et al. noted that when the boundary is a gray zone, not a line, the observer must decide whether the reference point is at the beginning, middle, or end of the zone [19]. In addition, determining the parameters of the mandible can also be difficult due to image overlapping on the radiograph, such as mandibular coronoid processes that are in line with the zygomatic arch and the lateral pterygoid plate of the sphenoid bone. In determining the mentalis index, the mental foramen is often seen to overlap with the roots of the premolars. This can lead to errors in determining whether a radiolucent area is the mental foramen or a radiolucent lesion in the apical region of the mandible premolar [21, 22]. The conditions at the time of the interpretation of radiographs also play an important role in determining the optimal viewing conditions, as a small dense area can be detected on a radiograph. The room lighting should be reduced when interpreting the images. In addition, the use of a cover around the screen can also help reduce the surrounding light. However, the observer’s experience and ability to set the contrast and brightness of the image is as important as the lighting condition [23].

One limitation in this study is the individual’s dental status (full dentition, partial edentulous, complete edentulous). An individual’s dental status could influence the structure and function of the masticatory muscles, which can affect the size of the parameters of the mandible. Moreover, this research study was only conducted on two age groups, so further study with other age ranges is needed to determine if there is a significant change in the size of the mandible based on age. The sample size used in this study is relatively small, so it cannot represent the overall population in Indonesia. Furthermore, the researchers did not compare the measurements based on the panoramic radiographs with direct measurements of the mandibular bone.

4. Conclusion
From this study, it can be concluded that the average value of the mandible parameters, including the ramus height, the gonial angle, the bigonial width, the maximum inter-ramus distance, the minimum inter-ramus distance, the ramus-condylar height, the ramus-cornealoid height, and the mentalis index, using panoramic radiographs of 14–35 year old patients and 50–70 year old patients, showed a tendency to increase or decrease due to age; however, the changes were not statistically significant. The results of this study are not consistent with the findings reported in previous studies. Therefore, to be a baseline for estimating age, additional research needs to be conducted in order to determine if the mandible parameters can be used to estimate the age of people in Indonesia.

To support this study, additional research, with a larger sample that is more representative of the population of Indonesia, is required. Furthermore, future research should address other factors, including the status of teeth, study samples with other age ranges, and a comparison of the measurements using panoramic radiographs with direct measurements of the mandibular bone.
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