Estimating Sex in an Indonesian Population Using the Mean Value of Eight Mandibular Parameters in Panoramic Images

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Abstract

To obtain mean values for estimating sex based on eight mandibular parameters in panoramic secondary data. The mandible has been proven to be one of the most useful tools for estimating sex after the pelvis because it is the most durable facial bone and resists every disintegration process. The eight mandibular parameters can be assessed through radiographic analysis. Various mandibular parameters can be used to estimate sex, including ramus height, gonial angle, bigonial width, condylar ramus height, coronoid ramus height, maximum ramus breadth, minimum ramus breadth, and mental index. This study used panoramic images of 200 subjects (100 males and 100 females) aged 14–35 years. All parameters were measured using AutoCAD 2016 software, and the data was analyzed using the IBM SPSS statistics program. The values of the mandibular parameters are higher in males than in females, except for the gonial angle. The differences in ramus height, bigonial width, condylar ramus height, coronoid ramus height, maximum ramus breadth, and minimum ramus breadth in males and females were statistically significant ($p < 0.01$). However, the differences in the gonial angle and the mental index were not statistically significant ($p > 0.05$). Except for the gonial angle and the mental index, mandibular parameters on panoramic images show high sexual dimorphism, so these measurements may be useful for estimating sex.

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Introduction

Sex estimation is an important step in the process of identifying an individual because further investigations rely on it. Bone, the most solid tissue in the human body, is often intact even when there is serious trauma to the body. Sex can be determined with 95% accuracy using the pelvic bone and 90% accuracy using the cranial bone. After the pelvis, the mandible is the most useful tool for determining sex because it is the most durable facial bone and resists every disintegration process.[1] One of the methods used to assess mandibular measurements is radiographic analysis. There are several advantages to using a panoramic image: It provides a bilateral, vertical view of the mandible.[2] There are also some disadvantages: The image in panoramic images can lead to distortion. Poor images can also result from ghost imaging, static distortion, faults in processing, and patient head movement. Generally, however, this technology is easy to obtain and can be used to assess all of the mandibular vital structures.[3,4]

The present study used digital panoramic images. Nowadays, digital imaging is widely used in dental practices because it does not have the disadvantages of conventional radiography, such as conventional processing and high doses of radiation. Digital imaging also allows practitioners to manipulate the images on a computer, which can help avoid interpretative errors.[5] A study by Al-Shamout et al. demonstrated that males have higher gonial angle values than females.[3] The present study found the same result, although a few studies have found that females have higher

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gonial angle values and concluded that the effects of sex and age on gonial angle measurements are still uncertain.[3] The present study also found that older individuals have a larger gonial angle and higher bigonial width values than younger ones. In addition, Larheim and Svanaes found that gonial angle measurements taken using a panoramic radiograph were almost identical to those taken on a dry mandible.

According to a study by Abu-Taleb et al. on significant morphology changes in size during growth and remodeling, ramus height and condylar ramus height show the strongest sexual dimorphism.[6] Meanwhile, Giles et al. (1964), who studied an American population, found high sexual dimorphism in ramus height, maximum ramus breadth, and minimum ramus breadth, with 85% significance.[7]

In another study, Marinescu et al. sought to determine sex using chin height, bigonial width, and bicondylar width measurements, based on the Buikstra and Ubelaker standard. They found the highest level of sexual dimorphism in the bigonial width measurement, which could be used to determine sex with 80.5% accuracy.[8] A few studies have also used the mental index as a standard site while assessing mandibular anatomy. Mostafa et al. found that males have a higher mental index value than females, and that the difference is statistically significant. This difference was found in all age groups, but no significant difference was seen in male and female mental indices when the measurement was done on individuals from a different country.[9] Hence, this study sought to obtain the mean values for eight different mandibular parameters for males and females in an Indonesian population.

Materials and methods

This cross-sectional study was conducted from June to August 2016 and used panoramic images of 200 subjects (100 males and 100 females) aged 14–35 years. The dental records were taken from the Dental and Oral Educational Hospital, Faculty of Dentistry, Universitas Indonesia. The sample subjects were Indonesians aged 14–35 years, and selected panoramic radiographs with high-quality images were included in this study. Digital panoramic radiographs were taken using a panoramic Cranex Tome (from the Soredex Orion Corporation, Helsinki, Finland). Patients with systemic disease or with pathological or fractured mandible development were excluded from the study. The mandible was measured on the most visible side because previous studies have found no statistically significant differences between the left and right sides.[2,3,6] All parameters were exported and measured using the Auto CAD 2016 software.

After all images were calibrated, eight parameters were measured using the mouse-driven method, as shown in Figure 1.

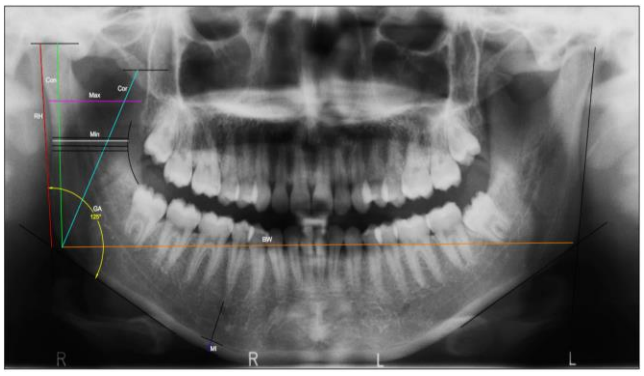

Figure 1: Measurements of the mandible parameters on a panoramic image

Ramus height (RH)*:* The distance from the most superior lateral point to the most inferior lateral point of the ramus.

Gonial angle (GA)*:* The angle between the ramus and the body of the mandible. It is formed by the intersection of the inferior border of the mandible and the posterior border of the ramus and the condylar.

Bigonial width (BW)*:* The distance between the two gonions (Go). The gonion is the most inferior, posterior, and lateral point from the perspective of the mandible's external angle.

Condylar ramus height (Con): The distance from the highest point of the condylar to the intersection of the orientation line and the inferior border of the ramus.

Coronoid ramus height (Cor): The distance from the highest point of the coronoid to the intersection of the orientation line and the inferior border of the ramus.

Maximum ramus breadth (Max): The distance between the most anterior point of the ramus to the most posterior point of the ramus; this measurement passes through the sigmoid notch.
Minimum ramus breadth (Min): The smallest anterior–posterior diameter of the ramus.

Mental index (MI): The width of the mandibular cortical in the mental foramen region. This was measured on a line that passes perpendicular to the tangent, from the lower border of the mandible and through the inferior border of the mental foramen.[10]

In this study, the Technical Error Measurements (TEM) was also determined to identify any variability in the measurement process. Lower TEM values indicate more accuracy and consistency in the measurements.[11]

All mean values were also calculated for statistical analysis. Statistical analysis was performed using the IBM SPSS Statistics program. A Kolmogorov-Smirnov normality test was selected because the total sample of the study included more than 50 samples. The data was presented using the mean and standard deviation (SD). An independent sample t-test and Mann-Whitney U test were used to compare the measurements taken from males and females, if applicable. The significance level was set at $p < 0.05$.

Results

Repeated measurements were performed to obtain the intra-observer and inter-observer reliability. Table 1 shows the Technical Error Measurements. According to Dahlberg's formula, the most common TEM is 0.8 mm. In this study, intra-observer and inter-observer reliability were below 0.8 mm, indicating high liability.

A Kolmogorov-Smirnov normality test showed that, in this study, only the measurements for ramus height, maximum ramus breadth, and condylar ramus height were normally distributed; the other five variables were not normally distributed. An independent sample t-test was then performed on the normally distributed variables to compare mean values between two different groups, and a Mann-Whitney U test was performed on the other five variables that were not normally distributed.

Table 1: Technical Error Measurements

Reliability Test	Ramus height	Bigonial width	Maximum ramus breadth	Minimum ramus breadth	Condylar ramus height	Coronoid ramus height	Mental index
Inter-observer (mm)	0.540	0.631	0.791	0.442	0.355	0.701	0.572
Intra-observer (mm)	0.512	0.459	0.495	0.353	0.504	0.581	0.379

Table 2 shows the mean values for all variables. All linear measurements are shown in millimeters, and angular measurements are shown in degrees. Males had higher values than females for the ramus height, bigonial width, maximum ramus breadth, minimum ramus breadth, condylar ramus height, coronoid ramus height, and mental index. However, the gonial angle had lower values in males than in females. Meanwhile, the independent sample t-test and the Mann-Whitney U test showed statistically significant differences between the sexes for all variables, except for the gonial angle and the mental index. The p-value was set to > 0.05. A highly significant difference between the sexes was observed for ramus height, condylar ramus height, and coronoid ramus height ($p < 0.0001$).

Table 2: Mean values of all variables.

	Mean (SD)		P-value
	Females	Males	
Ramus height	76.6 (7.44)	83.6 (8.19)	0.000*
Gonial angle	124.6° (0.65)	122.8° (0.77)	0.206**
Bigonial width	223.2 (1.45)	229.4 (1.42)	0.004**
Maximum ramus breadth	39.7 (4.97)	41.7 (4.83)	0.004*
Minimum ramus breadth	33.9 (0.45)	35.7 (0.41)	0.005**
Condylar ramus height	76.4 (7.45)	83.4 (8.18)	0.000*
Coronoid ramus height	72.0 (0.75)	78.8 (0.81)	0.000**
Mental index	4.9 (0.09)	5.1 (0.11)	0.459**

* Independent sample t-test, ** Mann-Whitney U test

Discussion

In females, puberty starts at age 10; in males, it begins at age 13 or 14. The mandible grows and dental mineralization develops rapidly during this period. Mandible growth stops at age 14 in females and 16 or 17 in males. This increases mandible sexual dimorphism, which concentrates in the ramus after age 13. Peak bone mass occurs at age 35 for both sexes, and this is the reason for subject age limits chosen for the present study.[12]

In this study, 200 mandibles were assessed using digital panoramic images to compare the characteristics of male and female mandibles in the Indonesian population. Eight parameters that have been evaluated in several studies and found to be useful for determining sex are ramus height, bigonial width, gonial angle, maximum ramus breadth, minimum ramus breadth, condylar ramus height, coronoid ramus height, and mental index. In the present study, it was found that males tend to have higher values for all of these mandible parameters except the gonial angle. The differences between males and females were highly statistically significant for ramus height, condylar ramus height, and coronoid ramus height (p-value = 0.0001); no statistically significant difference was found between the gonial angles or the mental indices of males and females (p-value > 0.05).

These results are similar to those of a study by Al-Shamout et al. that examined a Jordanian population (103 males, 106 females, aged 11–69 years). Al-Shamout et al. found that ramus height and bigonial width had significantly higher mean values in males than in females.[2] With normal craniofacial development, the average horizontal growth of the mandible during puberty is 2 mm per year for males and 1.5 mm per year for females.[13]

However, in this study, no statistically significant difference was found in the gonial angle measurements of females and males. The present study found that females have higher mean gonial angle values than males, which agrees with the findings of Abu-Taleb et al. in an Egyptian population (105 males, 86 females, aged 6–70 years). Subject with stronger masseter and anterior temporal muscles tend to

have smaller gonial angles. According to a study by Coquerelle et al. on the relationship between the human mandible and dental development, the gonial angle in twenty-year-old males tends to point backwards and up. Abu-Taleb et al. also observed that mean condylar ramus height and mean coronoid ramus height were significantly higher in males than in females.[6] These results were similar to those of the present study. The ramus and the condylar were found to experience the greatest morphological changes in size, and they often undergo remodeling during growth.[7]

Another study by Indira et al. on an Indian population (50 males, 50 females, and aged 20–50 years) found similar results when comparing the maximum and minimum ramus breadth measurements. The means of both of these measurements were significantly higher in males than in females. Indira et al. also found that the minimum ramus breadth has strongest sexual dimorphism of all the mandibular parameters. Giles also found significant differences in these measurements at 85%.[7] Putra measured the maximum ramus breadth values in an Indonesian population using a caliper on dry mandibles and found a statistically significant difference between males and females.[14]

The present study also observed a correlation between mental index and sex. There was no statistically significant difference between the mental indices of males and females, but the mean for males was higher than that of females. A study by Mostafa et al. on an Egyptian population found a statistically significant difference between the mental indices of males and females aged 20–30, but found no significant difference between males and females aged 30–40.[9]

This difference from the results of the present study may be caused by race, age grouping, or overall sample differences. The mental foramen is one of the landmarks that has a stable relationship with the base of the mandible, so it can be used as a reference point in this study. However, the mental index is often used to detect osteoporosis. The mental index increases until age 49 and then decreases until age 70. Mandibular bone loss tends to occur in older individuals because of general thinning and increased mandible cortex porosity. Therefore, in the present study, no correlation was observed between mental index and sex.[9,15]

A few points should be mentioned regarding the use of radiograph analysis for mandibular assessment. The accuracy of measurements performed on a panoramic radiograph depends on the adjustment of the head position and proper use of the reference plane according to the protocol. When the head position moves even slightly from the focal trough, the horizontal dimension of the panoramic image changes, particularly in the anterior region, because of the large variation in image magnification.[16] Lighting conditions also play a significant role when interpreting digital images. When interpreting these images, the intensity of the light can be reduced, or a hooded laptop display can be used in bright clinical environments. However, the most important variable when interpreting radiograph images is the observer. Hence, many studies include two or more observers to ensure more accurate results.[17]

Conclusions

This study concludes that measuring mandibular parameters on panoramic images may be useful for estimating sex as sexual dimorphism on these parameters is high in Indonesian populations. The gender differences in ramus height, bigonial width, maximum ramus breadth, minimum ramus breadth, condylar ramus height, and coronoid ramus height were statistically significant. However, no statistically significant differences were found between the sexes for the measurements of the gonial angle or the mental index.

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Declaration of Interest

The authors report no conflict of interest.

References

1. Tejashree B, Thakur M, Palve D, Bhondey A, Dhengar Y, Chaturvedi S. Sex Determination by Using Mandibular Ramus - A Forensic Study. J Adv Med Dent Sci Res 2016;4(2):1–6.
2. Muskaan A, Sarkar S. Mandible-An Indicator for Age and Sex Determination Using Digital Orthopantomogram. Sch J Dent Sci 2015;2(1):82–95.
3. Al-Shamout R, Ammoush M, Alrbata R, Al-habahbah A. Age and Gender Differences in Gonial Angle, Ramus Height and Bigonial Width in Dentate Subjects. Pak Oral Dental J. 2012;32(1):81–7.
4. Owens AM, Johal A. Near-End of Treatment Panoramic Radiograph in the Assessment of Mesiodistal Root Angulation. Angle Orthod 2008;78(3):475–81.
5. Sabarudin A, Tiau YJ. Image Quality Assessment in Panoramic Dental Radiography: A Comparative Study Between Conventional and Digital Systems. Quant Imaging Med Surg 2013;3(1): 43–8.
6. Abu-Taleb NS, El Beshlawy DM. Mandibular Ramus and Gonial Angle Measurements as Predictors of Sex and Age in an Egyptian Population Sample: A Digital Panoramic Study. J Forensic Res 2015;6(5):1-7.
7. Indira AP, Markande A, David MP. Mandibular Ramus: An Indicator for Sex Determination - A Digital Radiographic Study. J Forensic Dent Sci 2012;4(2):58–62.
8. Marinescu M, Panaitescu V, Rosu M. Sex Determination in Romanian Mandible Using Discriminant Function Analysis: Comparative Results of A Time-Efficient Method. Rom J Leg Med 2013;21(4):305–8.
9. Mostafa RA, El-Ashiry MK, Farid MM. Effect of Age, Sex, and Dental Status on Mental and Panoramic Mandibular Indices of the Mandible. Egyptian J Oral Maxillofac Surgery 2011;2(1):22–6.
10. Dutra V, Yang J, Devlin H, Susin C. Radiomorphometric Indices and Their Relation to Gender, Age, and Dental Status. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005;99(4):479–84.
11. Harris EF, Smith RN. Accounting for Measurement Error: A Critical but Often Overlooked Process. Arch Oral Biol 2009;54(suppl 1):107–17.
12. Coquerelle M, Bookstein FL, Braga J, Halazonetis DJ, Weber GW, Mitteroecker P. Sexual Dimorphism of the Human Mandible and Its Association with Dental Development. Am J Phys Anthropol 2011;145(2):192–202.
13. Standerwick RG. Analysis of Average Horizontal and Vertical Mandibular Growth Components Relative to the Horizontal Plane as Determined from Cross-sectional Cephalometric Normal Standards. J Dent App 2014;1(4):55–60.
14. Putra R, Kristiani S, MAR M. Difference in Maximum Width of Mandibular Ramus for Indonesian Male and Female. Dental Forensic Journal 2016;3(1):24–30.
15. Ghouse N, Nagaraj T, James L, Swamy NN, Jagdish CD, Bhavana TV. Digital Analysis of Linear Measurements Related to the Mental and Mandibular Foramina in Sex Determination. J Med Radiol Pathol Surg 2016;2(3):5–9.
16. Stramotas S, Geenty JP, Petocz P, Darendeliler MA. Accuracy of Linear and Angular Measurements on Panoramic Radiographs Taken at Various Positions in Vitro. Eur J Orthod 2002;24(1):43–52.
17. Kutcher MJ, Kalathingal S, Ludlow JB, Abreu M, P latin E. The Effect of Lighting Conditions on Caries Interpretation with A Laptop Computer in A Clinical Setting. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;102(4):537–43.