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RESEARCH ARTICLE

Gonial angle and mandibular ramus height in Surabaya population: comparison and correlation analysis in panoramic radiograph

An'nisaa Chusida*✉, Arofi Kurniawan*, Beta Novia Rizky*, Salma Nailah Pradnya Pribadi, Annisa Tiara Diva**, Haura Destina Anandhiyah**, Aspalilah Alias*****

*Department of Forensic Odontology, Faculty of Dental Medicine, Universitas Airlangga, Surabaya, East Java, Indonesia
**Faculty of Dental Medicine, Universitas Airlangga, Surabaya, East Java, Indonesia
***Department of Basic Sciences, Faculty of Dentistry, Universiti Sains Islam Malaysia, Kuala Lumpur, Malaysia
*Jl Prof Dr Moestopo No 47, Surabaya, East Java, Indonesia; ✉ correspondence: an-nisaa-c@fkg.unair.ac.id

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ABSTRACT

One of the crucial steps of identifying an individual is to determine their sex. The mandible, which is the largest and strongest bone in the human face, is a useful tool due to its significant sexual dimorphism. Two features that are recognized for their high sexual dimorphism are the gonial angle and mandibular ramus height. Several studies have shown different results when using both measures to estimate sex, factors that are thought to influence morphological differences include age, population, sex, and physical activity. The objective of this study was to analyze the differences in gonial angle and mandibular ramus height between sexes using panoramic radiography. Additionally, it aimed to analyze the correlation between these measurements and sex. The measurements of the gonial angle and mandibular ramus height were conducted using ImageJ software. Initially, the specific anatomical landmarks were identified, and the software's measurement tools were then employed to accurately assess the height and angle based on these selected points. The sample consisted of secondary data obtained from 70 panoramic radiographs of patients aged 20–45 years at the Dental and Oral Teaching Hospital (RSGMP) of Universitas Airlangga, Surabaya. Data analysis was conducted using the independent t-test and Pearson correlation. There was a significant difference in the mandibular ramus height between sexes, with males having a greater height ($p < 0.05$). It was also discovered that, despite the fact that males exhibited a smaller gonial angle compared to females, this difference was not statistically significant ($p = 0.29$). Furthermore, a significant correlation was observed between mandibular ramus height and sex ($r = 0.498$); however, there was no significant correlation between gonial angle and sex ($r = -0.128$). The study reveals a significant difference in mandibular ramus height between males and females, with males exhibiting greater height. This parameter shows a strong correlation with sex, making it a reliable indicator for sex determination. Conversely, the gonial angle is not suitable for this purpose.

Keywords: gonial angle; human right; legal identity; mandibular ramus height; sex determination

INTRODUCTION

Forensic odontology is a specialized field within forensic science that employs dental expertise to address a variety of cases, including those involving accidents, acts of terrorism, natural disasters, and criminal investigations. Forensic odontology plays a crucial role in assisting forensic investigations by using dental and surrounding tissue characteristics for identification purposes. One specific application involves using the mandible for sex determination, which is a crucial step in the process of identifying an individual.[1,2]

In cases where DNA, fingerprints, and dental records are inadequate for identifying victims, alternative methods become essential. In these cases, the mandible serves as a highly useful tool.[3] The mandible, the largest facial bone, exhibits significant sexual dimorphism and has the durability to resist decomposition and degradation.[3,4] Its growth pattern is influenced by age, reaching a stable point around 17–18 years for females and 19–20 years for males. However, tooth loss and osteoporosis may result in a decrease in the size of the mandible in older individuals.[5,6]

The mandibular ramus exhibits significant sexual dimorphism, particularly in terms of its height and the gonial angle.[7] Saini et al[3] conducted a study on the Indian population, comparing mandibular ramus height among 92 male and 24 female samples, and reported an accuracy of up to 80.2% in sex determination using this parameter. Similarly, Leversha et al[8] found significant differences in ramus height, bigonial width, and gonial angle between males and females in the Far North Queensland population. Variations in the gonial angle can be influenced by factors such as age, population, gender, and physical activity.

Sex determination can be performed using three types of imaging: panoramic radiographs, lateral cephalograms, and Cone-Beam Computed Tomography (CBCT).[9] Panoramic radiographs are among the most commonly used extraoral imaging techniques, providing detailed visualization of the hard tissues in the maxilla and mandible. Due to their high-quality results, panoramic radiographs are effective tools for identifying sexual dimorphism and estimating age.[10] This study aimed to analyze the differences and correlations between these parameters and sex as they were observed on panoramic radiographs, in light of the high accuracy of sex determination through the assessment of the gonial angle and mandibular ramus height.

MATERIALS AND METHODS

This study received ethical clearance from the Health Research Ethics Committee of the Universitas Airlangga Dental and Oral Hospital (approval number: 15/UN3.9.3/Etik/PT/2022). Panoramic radiographs were collected from the Department of Dental Radiology at the Universitas Airlangga Dental and Oral Hospital. The dataset consisted of 70 panoramic radiographs, with an equal distribution of 35 females and 35 males, ranging in age from 20 to 45 years.

The radiographs were selected based on the following criteria: panoramic radiographs of adults between the ages of 20 and 45, in high-quality images that were clear, without significant distortion. Furthermore, the gonial angle and mandibular ramus height were measured using ImageJ software. Ramus height was measured from the highest point of the condylar head to the most prominent point on the inferior border of the ramus (Figure 1). The gonial angle was calculated at the intersection of two tangents: one along the posterior border of the mandibular ramus and the

Figure 1. Measurement of mandibular ramus height
a: the most prominent point on the inferior border of the ramus
b: the most superior point of the mandibular condyle

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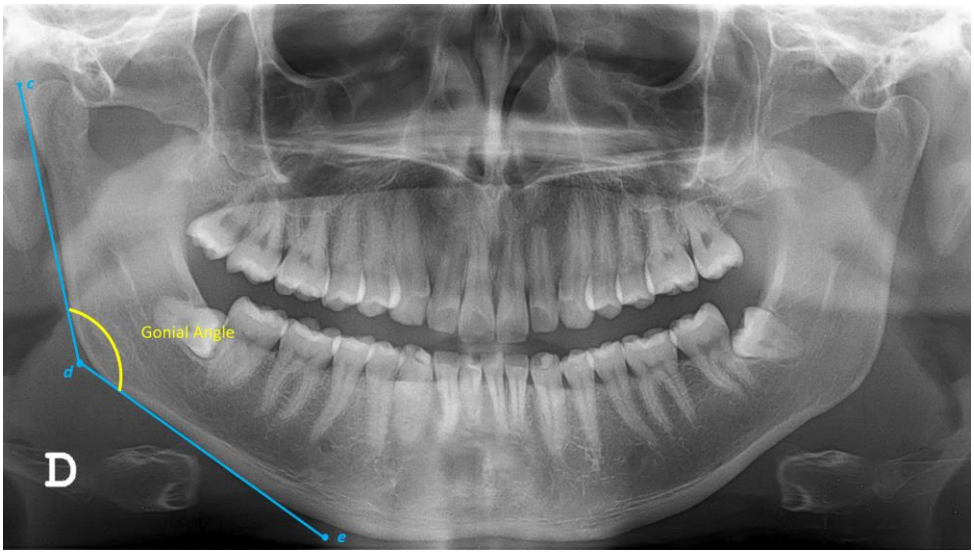

Figure 2. Gonial angle measurement
c: the most superior point of the mandibular condyle
d: gonion
e: the most inferior point along the lower border of the mandibular corpus

other along the inferior border of the mandibular body (Figure 2).[7]

To measure the gonial angle, digital panoramic radiographs were imported into the ImageJ software. The angle measurement tool was selected, and a line was drawn from the most superior point of the mandibular condyle to the gonion and then to the most inferior point of the lower edge of the mandibular corpus, forming the gonial angle. The measurement was completed by selecting the "measure" function in the application.

For the mandibular ramus height, the same digital panoramic radiographs were used in ImageJ. The length measurement mode was selected, and a line was drawn from the most superior point of the mandibular condyle to the most prominent point on the inferior border of the ramus. The height was then recorded by clicking the "measure" function in the software.

Additionally, average values were obtained by measuring each parameter bilaterally. In order to minimize any potential bias, each digital panoramic radiograph was carefully measured three times by the same observer, with a one-week interval between measurements.

The statistical analysis was conducted using IBM SPSS Statistics version 26.0 (IBM, Armonk, New York, USA). Moreover, Cronbach's alpha, the Shapiro-Wilk test, and the Levene test were employed to evaluate the reliability, normality, and homogeneity of the data distribution, respectively. Furthermore, this study employed the independent t-test to analyze the differences in gonial angle and mandibular ramus height between sexes. In addition, the Pearson correlation test was employed to assess the correlation between these measurements and sex.

RESULTS

The present study involved 70 panoramic radiographs of patients (35 males and 35 females) aged 20 – 45 years. The descriptive analysis showed that the average gonial angle of females was 121.76° ± 6.50°, whereas in males was 120.08° ± 6.75°. On the other hand, the mandibular ramus height was found to be higher in males than females.

Based on the Shapiro-Wilk test was indicated that the data were normally distributed (p-value > 0.05). Subsequently, the independent t-test was conducted to evaluate the difference in mandibular

Table 1. Descriptive statistics and comparison test of Mandibular Parameters between males and females

Mandibular parameter	Sex	n	Mean ± SD	Mean difference	Sig.	Remarks	r-value
Gonial angle (degrees)	Female	35	121.76 ± 6.50	1.062	0.292	nonsignificant	-0.128
	Male	35	120.08 ± 6.75				
Mandibular ramus height (mm)	Female	35	58.58 ± 3.61	4.730	0.000*	significant	0.498
	Male	35	62.95 ± 4.11				

parameters between males and females (Table 1). The results showed that a significant difference was observed in the mandibular ramus height between sexes ($p < 0.05$). However, there was no significant difference in the gonial angle between sexes ($p > 0.05$), indicating that sex did not affect the gonial angle.

The Pearson correlation test was also performed to analyze the correlation between the mandibular parameters and sexes. Based on the analysis, it was revealed that there was no significant correlation between the gonial angle and sex, as indicated by a correlation coefficient of -0.128 ($r > 0$). In contrast, there was a strong positive correlation between the mandibular ramus height and sex, with a correlation coefficient of 0.498 ($r > 0$).

DISCUSSION

This study revealed a significant difference in the mandibular ramus height between males and females, with males exhibiting significantly greater measurement (p-value < 0.05). This finding aligns with previous research conducted by Najm and Abbas, who also discovered a significant difference in the mandibular ramus height between sexes.[11] The difference in the mandibular ramus height between males and females may be attributed to differing bone remodeling patterns. These patterns are influenced by various factors such as genetics, population differences, muscle mass, masticatory muscle activity, hormones, and the socioeconomic environment. In terms of bone growth, there are some notable distinctions between males and females. In males, the periosteal surface is mainly affected, whereas in females, it is the endosteal surface that is primarily affected. As a result, males tend to have larger bone sizes compared to females.[12]

Hormone levels, such as testosterone and estrogen, play a significant role in affecting bone growth in both males and females. Testosterone in males contributes to thicker and larger bones. In contrast, higher estrogen levels and lower testosterone levels in females result in an increase in bone mass rather than bone width. This increase in bone mass is a result of greater endosteal apposition compared to periosteal apposition.[13] Additionally, males typically exhibit greater masticatory force, leading to larger mandibular dimensions.[14]

This study found that there was no significant difference in the gonial angle between males and females. This finding is consistent with previous research conducted by Prakoeswa et al,[15] which indicated that the gonial angle was affected more by age than by sex. Similarly, Bulut et al.[16] found that there was no statistically significant difference in the gonial angle between males and females in the 20–39 and 40–59 age groups. However, there was a significant difference in the 60–80 age group. The age range of 20 to 45 years was selected for this study because previous research has demonstrated that pre-pubertal mandibular dimensions are inconsistent, making the mandible a reliable indicator for sex identification only after puberty. Additionally, in older individuals, the mandible is more susceptible to osteoporosis and bone density loss, which could affect its accuracy in sex determination.[16] In addition, other studies have reported contradictory results, showing significant differences in gonial angles between sexes. Study conducted by Ghazani et al on right and left gonial angles in both sexes showed that male was higher than female.[17] These inconsistencies may be attributed to variations in sample inclusion criteria and sex ratios in other studies.

The masseter muscle's strength contributes to variations in gonial angle. It has been observed that males generally possess greater muscle strength, which can lead to a reduction in the mandibular angle. As a result, males have a smaller angle compared to females.[18] Various factors, such as hormones, nutrition, and occupation, play a role in determining the gonial angle. These factors contribute to population-specific differences.[18] Severe malnutrition can also lead to a decrease in muscle strength, which can affect the gonial angle.[19] Certain occupations, particularly those involving young athletes, have the potential to affect hormone levels. In addition, research conducted by Almeida-Neto et al. demonstrated a strong correlation between hormonal and maturation markers and neuromuscular performance. The research found that athletes with high testosterone levels exhibited greater muscle strength.[20]

There was a moderate correlation between mandibular ramus height and sex, as indicated by the Pearson correlation test (r = 0.498). In contrast, there was no significant correlation between gonial angle and sex, as indicated by a correlation coefficient of -0.128. These findings are consistent with research conducted by Prakoeswa et al, which also found no statistically significant difference in gonial angles between males and females.[15] On the other hand, research conducted by Leversha et al revealed a significant correlation between gender and gonial angle.[7] The discrepancy in results may be attributed to the limited sample size and variations in the sex ratio of the samples.

The gonial angle can be measured using both lateral cephalograms and panoramic radiographs. A study by Radhakrishnan et al involving 50 samples (25 males and 25 females) with an average age of 23 years examined the accuracy of these two imaging methods in measuring the right and left gonial angles. The study found no significant difference between the measurements obtained from panoramic radiographs and those from lateral cephalograms.[21] In this study, mandibular ramus height and gonial angle were measured using panoramic radiographs. Panoramic radiographs were selected due to their high-quality imaging, which allows for accurate measurement of parameters related to sexual dimorphism and age estimation. The variation in results could also be caused by the quality of the panoramic radiographs and different inclusion criteria, such as the presence of missing teeth, which can alter masticatory muscle strength and subsequently affect the gonial angle.[22] Additionally, the varying distribution of age groups in the samples studied could potentially affect the significance of the findings.[11] A limitation of this study is the reliance on secondary data, which required adjustments to meet the established inclusion criteria, thereby limiting the sample size.

CONCLUSION

The study reveals a significant difference in mandibular ramus height between males and females, with males exhibiting greater height. This parameter shows a strong correlation with sex, making it a reliable indicator for sex determination. Conversely, the gonial angle is not suitable for this purpose. Further research should be conducted with a larger sample size and include diverse populations while adhering to consistent or improved sampling standards to obtain more representative results.

CONFLICT OF INTEREST

The authors declare no competing interests.

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