



ORIGINAL ARTICLE

Gonial angle, antegonial angle, and bigonial breadth among Chinese and Batak ethnic groups: A panoramic radiographic analysis

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ABSTRACT

Background: Mandibular morphology is a key aspect of antropometry and dentistry, reflecting anatomic variations influenced by genetic, ethnic, and environmental factors. Parameters such as bigonial width, gonial angle, and antegonial angle serve as primary indicators in mandibular morphometric analysis, with applications in orthodontics, maxillofacial surgery, and forensic identification. Population-based morphometric data for local Indonesian groups remain limited. This study addresses this gap by examining mandibular characteristics in Batak and Chinese ethnic groups. This study aimed to compare bigonial width, gonial angle, and antegonial angle between Batak and Chinese groups using panoramic radiographs.

Methods: This cross-sectional, observational, analytic study included 50 subjects (25 Batak and 25 Chinese) at RSGM Prima. Measurements were performed with ImageJ software and analyzed using Shapiro-Wilk normality test, Levene homogeneity test, and independent t-test.

Results: No statistically significant differences were found in gonial angle ($p=0.665$), antegonial angle ($p=0.218$), or bigonial width ($p=0.328$) between the groups.

Conclusion: No significant differences exist in gonial angle, antegonial angle, or bigonial width between Batak and Chinese groups. Mandibular morphometric variations are not determined solely by ethnicity. These parameters should be integrated with other anthropologic markers and primary identification methods for greater accuracy in clinical and forensic applications.

Keywords: mandibular morphology, gonial angle, antegonial angle, bigonial width, panoramic radiography, dental antropometry, ethnic variation

Introduction

Mandibular morphology is an important aspect of anthropometric and dental medicine studies because it reflects anatomic variations influenced by genetic, ethnic, and environmental factors.^{1,2} Parameters such as bigonial width, gonial angle, and antegonial angle serve as primary indicators in mandibular morphometric analysis due to their broad applications in orthodontics, maxillofacial surgery, and forensic identification.³⁻⁶ Studies on differences in these parameters among ethnic groups provide insights into functional adaptations and population-specific jaw growth patterns.^{7,8}

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In mandibular morphometric analysis, bigonial width, gonial angle, and antegonial angle were selected based on their clinical significance and anatomic stability. The gonial and antegonial angles indicate facial growth patterns (vertical or horizontal) and reflect masticatory muscle activity that shapes the mandible. The antegonial angle is also important in forensic analysis due to significant sex differences.⁹ Bigonial width, as a transverse mandibular dimension, shows high sexual dimorphism, making it effective for facial profiling and skeletal identification.^{8,10}

Panoramic radiography was used as the primary modality in this study due to its high accessibility and reliable precision for mandibular morphometric measurements.⁶ Its validity for measuring mandibular angles is comparable to lateral cephalometry.¹¹ Compared with three-dimensional modalities such as cone-beam computed tomography (CBCT), panoramic radiography is more practical for widespread clinical use because of its lower cost while providing simultaneous visualization of both mandibular sides for bilateral analysis.^{3,5}

This study addresses the limited availability of population-based mandibular morphometric data in Indonesia. The Indonesian Chinese population, a Mongoloid group with repeated migrations to the archipelago over thousands of years, exhibits distinct facial and mandibular features. Comparing them with the Batak population, a Proto-Malay group, reveals morphometric diversity.¹² Facial and nasal index data in Indonesian Chinese indicate a very narrow facial type (hyperleptoprosopic), which contrasts anthropologically with the wider Batak facial type (euryprosopic).¹³ Genetic and environmental differences, such as high-fiber diets, may influence mandibular morphology, which is relevant for forensic identification and craniofacial anthropology.¹

Documentation of mandible-specific anatomic variations in these groups not only reflects biologic diversity but also improves orthodontic diagnosis, surgical planning, and forensic identification accuracy in Indonesia.^{1,7} This study fills a literature gap by providing radiographic reference standards for mandibular morphology in Batak and Chinese populations.

This study aimed to compare bigonial width, gonial angle, and antegonial angle between Batak and Chinese groups using panoramic radiographs. The hypothesis was that statistically significant differences exist in mean values of bigonial width, gonial angle, and antegonial angle between the groups. The results are expected to enrich the dental anthropology database in Indonesia and support precision dental services based on local ethnic characteristics.

Method

This study was a quantitative, observational analytic study employing a cross-sectional design. Primary data collection involved panoramic radiographs obtained at the Prima Dental and Oral Hospital (RSGM Prima). Data processing, statistical analysis, and report finalization occurred from November to December 2025. The site was selected due to the availability of standardized digital panoramic radiography facilities and access to diverse research subjects.

The target population consisted of adults from the Batak and Chinese ethnic groups. The accessible population included patients from these groups who visited RSGM Prima during the study period and met the inclusion criteria. Non-probability purposive sampling was used. The total sample size was 50 participants: 25 from the Batak group and 25 from the Chinese group.

Inclusion criteria were as follows: confirmed membership in the Batak or Chinese ethnic group via questionnaire; age 20-40 years; complete dentition (excluding third molars); voluntary participation confirmed by signing an informed consent form after explanation; and high-quality panoramic radiographs with clear visualization. Exclusion criteria included: history of facial or maxillofacial trauma or fracture that could alter native bone structure; history of conditions affecting jaw hard tissue morphology, such as osteoporosis, osteosarcoma, hyperparathyroidism, ameloblastoma, cherubism, multiple myeloma, cleidocranial dysplasia, fibrous dysplasia, osteomyelitis, or periodontitis with significant bone resorption; history of jaw surgery, such as orthognathic surgery; and clinically evident facial asymmetry or congenital craniofacial anomalies.

Hardware used included a digital panoramic radiography unit and a computer workstation with adequate specifications for image measurement software. Basic diagnostic instruments consisted of a mouth mirror, probe, and tweezers. Software included ImageJ for accurate, validated measurements of angles and widths on digital radiographs, and SPSS version 25 for all statistical analyses. Other research instruments comprised pens and notebooks for documentation, as well as research forms including informed consent sheets, sample screening forms, and data collection worksheets for systematic recording of measurements.

Personal protective equipment consisted of gloves and medical masks worn by the researcher during initial subject screening.

The study began with an application for ethical clearance from the Health Research Ethics Committee of Prima Indonesia University to ensure adherence to ethical principles for human subjects research, including respect for persons, beneficence, and justice. Research permission was obtained from RSGM Prima management. The researcher screened patients meeting inclusion criteria, provided complete explanations of the study's purpose, procedures, benefits, and potential risks, and obtained informed consent signatures from consenting participants as evidence of voluntary involvement. Consenting subjects then underwent panoramic radiography performed by on-duty radiographers following applicable standard operating procedures. Subject head position was standardized using the machine's head positioner, with the midsagittal plane perpendicular to the floor and the Frankfort plane parallel to the floor.

All digital radiographs were analyzed by the principal investigator using ImageJ software. Prior to measurement, images were calibrated if a reference scale was present.



Figure 1. Measurement of gonial angle (red line), antegonial angle (green line), and bigonial width (yellow line)

The gonial angle was measured by drawing two lines: the first connecting the inferior gonial angle point to the lower mandibular border, and the second tangent to the posterior ramus border and condyle.¹⁰ The antegonial angle was measured by drawing two straight lines parallel to each side of the antegonial region, intersecting at the deepest point of the antegonial notch, with each line touching the lowest point on the mandibular body.¹⁴ Bigonial width was measured by drawing a horizontal line digitally from the right gonial angle to the left gonial angle on the panoramic radiograph.⁴

Data analysis was performed using SPSS version 25. Normality was assessed with the Shapiro-Wilk test, followed by Levene's test for homogeneity. If data from both groups were normally distributed ($p > 0.05$), the independent samples t -test was used. If one or both groups were not normally distributed ($p \leq 0.05$), the nonparametric Mann-Whitney U test was applied. The significance level (α) was set at 0.05. If $p < 0.05$, the null hypothesis was rejected, indicating a statistically significant difference. If $p \geq 0.05$, the null hypothesis was not rejected, indicating no statistically significant difference.

Results

Analysis of 50 subjects, comprising 25 Chinese Indonesian individuals and 25 Batak individuals, yielded variable mandibular morphometric data. Table 1 presents the initial characteristics of these jaw measurements, summarizing the mean, median, and standard deviation for the three variables studied.

Descriptively, the Batak group showed larger mandibular dimensions than the Chinese Indonesian group, particularly in bigonial width (22.88 ± 1.39 cm) and antegonial angle (163.53°). The reverse occurred for the gonial angle, where the Chinese Indonesian group had a slightly more obtuse mean (122.49°) than the Batak group (121.68°). Median values indicated consistent similarity in mandibular angle shape between the two groups.

Table 1. Descriptive statistics of mandibular parameters in Chinese Indonesian and Batak populations

Variable	N	Mean	Median	Standard Deviation
Chinese Indonesian				
Gonial angle (°)	25	122.49	121.30	7.50
Antegonial angle (°)	25	160.41	162.71	9.94
Bigonial width (cm)	25	22.46	22.60	1.77
Batak				
Gonial angle (°)	25	121.68	121.72	5.92
Antegonial angle (°)	25	163.53	166.30	7.61
Bigonial width (cm)	25	22.88	22.64	1.39

Before comparative analysis, the data underwent prerequisite statistical tests. Shapiro-Wilk normality tests showed normal distribution for all data ($p > 0.05$). Levene's test for homogeneity of variance confirmed equal variances between groups for all variables. These results satisfied the assumptions of normality and homogeneity, allowing use of the independent samples t-test for hypothesis testing. This bivariate analysis determined whether the descriptively observed physical differences held statistical significance.

Table 2. Independent t-test results for mandibular parameters

Variable	t	p	Mean Difference	95% CI	
				Lower	Upper
Gonial angle	0.425	0.672	0.812	-3.028	4.653
Antegonial angle	-1.244	0.219	-3.115	-8.149	1.919
Bigonial width	-0.920	0.362	-0.413	-1.316	0.489

Table 2 shows that significance values (p) for gonial angle ($p = 0.672$), antegonial angle ($p = 0.219$), and bigonial width ($p = 0.362$) indicated no significant differences. The 95% confidence intervals included zero, reinforcing the conclusion of no meaningful differences between the Batak and Chinese Indonesian groups for these parameters. This suggests that, despite distinct genetic backgrounds and anthropologically different facial types, the two ethnic groups exhibit similar mandibular morphometric profiles on panoramic radiographs.

Discussion

The mean gonial angle was slightly larger in the Chinese ethnic group than in the Batak ethnic group. However, the independent t-test showed no statistically significant difference between the groups, indicating that gonial angles were generally similar. This finding aligns with Esfehni et al.² who reported no meaningful differences in gonial angles among Iranian populations. The lack of significant differences may result from influences beyond ethnicity, such as age and masticatory muscle activity.³ Similar jaw functional activity across individuals can lead to adaptive gonial angle development based on masticatory needs.¹⁰ Mandibular bone remodeling, which occurs throughout life, also shapes the gonial angle.⁵ Mechanical loads from mastication trigger mandibular bone changes, reducing prominent variations in gonial angle among individuals and ethnic groups.¹⁵

The mean antegonial angle was larger in the Batak ethnic group than in the Chinese ethnic group, but the difference was not statistically significant. This result agrees with Magar et al.⁶ in an Indian population and Temur and Önsüren⁷ in a Turkish population, both of which found wide individual variation in antegonial angles and no consistent statistical differences between ethnic groups. This pattern relates to masticatory muscle activity and mandibular basal morphology as adaptations to functional and environmental factors.⁶ Masticatory muscles near the antegonial angle impose mechanical loads that induce bone remodeling; stronger muscles produce smaller antegonial angles. In contrast, weaker muscle activity or low chewing loads result in larger (more obtuse) antegonial angles due to resorption without adequate bone deposition. Mandibular basal form, determined by growth patterns, also affects antegonial angle values: vertical growth patterns with short rami show larger angles, whereas horizontal growth patterns with tall rami show smaller angles.⁶

For bigonial width, the Batak ethnic group showed a larger mean value than the Chinese ethnic group. This descriptive finding aligns with Ismail and Nasution¹³ who noted that Batak individuals typically have broader (euryprosopic) faces, whereas Chinese individuals tend toward narrower (hyperleptoprosopic) faces. These facial type differences arise from genetic variations influencing craniofacial growth patterns, including mandibular width and facial proportions during development. Although the independent t-test indicated no

statistical significance, this likely reflects substantial intra-group variation in bigonial width, which weakens inter-group mean differences. Morphological diversity in mandibular characteristics among individuals from both groups further explains why descriptive differences do not appear in inferential tests. Inter-ethnic mandibular variations persist due to complex interactions among ethnic, genetic, and jaw function factors: genetics sets basal mandibular size and growth direction, while jaw function patterns like chewing activity and masticatory muscle loads drive adaptation and remodeling.²

These findings provide comprehensive data on facial structure, particularly mandibular characteristics, which inform orthognathic surgical planning.^{5,11} Such data guide treatment approaches to balance facial function and esthetics. Panoramic radiographs, especially gonial angle, antegonial angle, and bigonial width parameters, also support orthodontic care by identifying facial form tendencies and mandibular growth patterns.³⁻⁵ In forensic odontology, these parameters aid race identification by revealing mandibular morphology.^{2,3} In Indonesian populations, Batak groups tend toward euryprosopic faces, whereas Chinese groups show hyperleptoprosopic faces.^{12,13} These traits appear in panoramic radiographs via morphometric parameters like gonial angle, antegonial angle, and bigonial width.^{4,14} However, mandibular morphometrics should integrate with multivariate analysis and other anthropological markers to improve race-based identification accuracy, given high individual variability within ethnic groups.

Conclusion

Comparison of gonial angle, antegonial angle, and bigonial width between Batak and Chinese ethnic groups using panoramic radiographs revealed no statistically significant differences in these mandibular parameters. Descriptively, the Batak group showed larger mean bigonial width and antegonial angle, while the Chinese group showed a slightly larger mean gonial angle, but none reached statistical significance ($p > 0.05$). These results indicate that mandibular morphometric variation involves factors beyond ethnicity. In clinical dental, orthodontic, and oral surgery practice, treatment planning should rely on individual anatomic characteristics rather than ethnicity-based protocols. For forensic identification, these parameters offer low discriminatory power between Batak and Chinese groups, necessitating combination with other anthropological parameters and primary methods like DNA analysis and odontograms for greater accuracy. Future studies should develop multivariate models integrating multiple mandibular parameters with age and sex considerations and establish comprehensive cross-ethnic mandibular morphometric databases in Indonesia to advance forensic odontology and dental anthropology based on local populations.

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