ORIGINAL ARTICLE

Bizygomatic Width and Maxillary Width in Adult Male vs. Female in Indonesia

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ABSTRACT

Introduction: The bizygomatic and maxillary widths are important measurements for understanding sexual dimorphism. In males, larger numbers than females are observed, although different methods would affect the results. Radiograph-based measurements among the Indonesian sample population have not been comprehensively studied and documented. **Method:** We analyzed bizygomatic (zyR-zyL) and maxillary width (mxR-mxL) of 50 Indonesian males and females (19-69 years) from the anteroposterior/AP plain skull X-ray using MicroDICOM software version 2024.2. The intra- and inter-observer analysis were done prior to the actual analysis. Statistical analysis of the difference between sexes was conducted with a significance level of $p < 0.05$ SPSS version 24.0. **Results:** Adult males exhibited a statistically significant greater value in both parameters, with the μ ± SD mm bizygomatic width (zyR-zyL) being 143.30 ± 9.24 mm in males and 133.50 ± 6.82 mm in females ($p < 0.00$). The μ ± SD mm (median ± IQR mm) values of maxillary width (mxR-mxL) are 78.88 ± 5.35 mm (79.45 ± 6.98 mm) for males and 74.08 ± 5.49 mm (74.01 ± 6.65 mm) for females ($p = 0.02$). **Conclusion:** We found that both parameters showed significant differences between sexes, larger in males than in females, and thus can be used for sex determination. Further research is called for with larger sample population numbers and other craniometry measurements to provide a more comprehensive database of sex dimorphism parameters of the Indonesian population.
Malaysian Journal of Medicine and Health Sciences (2026) 22(SUPP6): 41-47. doi:10.47836/mjmhs.22.s6.7

Keywords: Sex differences, Radiography, Cephalometry, Adult, Human and medicine

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INTRODUCTION

Sexual dimorphism in human anthropology is crucial in forensic and other clinical fields. The radiograph has been reported to be a valuable data source for the forensic sexual dimorphism analysis reported in a systematic review that the human ribs radiometry can point out the difference between men and women. The depth of the costal arch, the length of the superior-inferior and anterior-posterior of the specific ribs, and the ribcage's size showed distinct differences between sexes (1).

The physical differences between males and females are vital for the identification process and also can help establish a biological profile of humans (2,3). Sexual dimorphism can be analyzed from the facial features, where the soft and hard tissue morphology represents specific measurements from both sexes. Cranial bone morphology, for example, shows growth and development periods in males and females due to hormonal influence, i.e., estrogen, testosterone, and androgen. Research indicates that male skulls tend to be more elongated than female skulls due to different levels of these hormones, which significantly affect the size and robustness of male skulls, leading to noticeable physical differences between the sexes (4,5). This principle forms the foundation of forensic science, although in post-mortem analysis, sex determination relies heavily on the quality of the recovered skeletal remains (6). The more intact the remains, the higher validity can be obtained (7)). Employing analysis from multiple bones, such as cranium and pelvic bones, would enhance the accuracy rate (8). However, many factors can hinder a post-mortem analysis; in Indonesia, where most of the population are Muslims, this practice is often unacceptable, thus calling for other methods.

In 2001, a cephalometric analysis of 30 young adults was conducted using in vivo measurements. In this study, a bizygomatic width in males was significantly larger compared to females. The participants were from Javanese, Batak, and Chinese ethnicities in Indonesia. However, limitations of this method, i.e., ethical constraints, non-standardized measurements, and different technicality of the researchers, may affect the validity and the reliability of this method (9).

The use of radiograph-based facial anthropometric studies was first reported in 1922 (10). In 1931, cephalometric procedures were established for orthodontic diagnosis and treatment, which had also been used to assess treatment effectiveness and growth processes. In this study, bizygomatic width (zygL-zygR) represents the width of the most lateral zygomatic arch, while maxillary width (mxL-mxR) is the width of the maxilla measured from the bilateral points on the jugal processes, at the intersection of the maxillary tuberosity border line and the zygomatic buttress (10,11). Bizygomatic width is a critical measurement in craniometry and forensic facial reconstruction. The Berry's formula (width of the maxillary central incisor = bizygomatic width / 16), derived from bizygomatic width measurement, has also been widely used to identify sex and can add to the accuracy rate(12).

To the best of our knowledge, radiograph-based craniometry data among the adult Indonesian sample populations has not been widely studied. Whereas its practicality can be highly beneficial, especially to cover measurements from a vast number of sample populations in Indonesia. Hence, we conducted an anthropometric analysis of bizygomatic width and maxillary width from plain skull anteroposterior (AP) view radiographs of adult men and women who were admitted to the hospitals in Surabaya, East Java, Indonesia, over the past 5 years.

MATERIALS AND METHODS

Study Design

This cross-sectional study investigated 50 subjects conducted between 2020 and 2024 who met the inclusion and exclusion criteria. This study measured bizygomatic width and maxillary width to differentiate between male and female. Measurements were performed using MicroDICOM software version 2024.2 (13). Three measurements were taken: two intra-observer measurements and one inter-observer measurement, conducted at three different times. The measurement results were considered valid if no significant difference was found between the measurements, with $p > 0.05$. Subsequently, the data was processed for statistical analysis.

Population and Sample

This study investigated 50 subjects (25 males, 25 females) conducted between 2020 and 2024 at two hospitals in Surabaya, East Java, Indonesia. Inclusion criteria for this study are the antero-posterior/AP plain skull radiographs of men and women aged 19-69 years taken during 2020-2024. The exclusion criteria include poor quality or unclear radiographs (i.e., contrast and position), patients with major trauma, surgical history, or congenital abnormality in the head, and patients with neoplasms or malignancies causing maxillofacial defects.

Data Collection and Processing

Our initial dataset comprised 74 medical records featuring plain skull radiographs from the targeted patients. After applying a multi-step filtering process using inclusion and exclusion criteria, 50 radiographs were identified as meeting the study requirements. These radiographs were then imported into the MicroDICOM software version 2024.2 (13) without significant editing. Subsequently, intra- and inter-observer analyses were conducted using a 20% sample size. To maintain image quality and consistency, all radiographs were standardized to a minimum resolution of 300 dots per inch (dpi) and saved in a .jpeg file format.

The parameters measured in this study were bizygomatic width (zyL-zyR) and maxillary width (mxL-mxR) (Figure 1). Bizygomatic width (zyL-zyR) was measured by drawing a line along the most lateral zygomatic arch, while maxillary width (mxL-mxR) was measured from bilateral points on the jugal processes at the intersection of the maxillary tuberosity border line and the zygomatic buttress. A blinded assessment of parameters (n = 50) was conducted, where skull photographs were categorized by sex blindly. Each photograph was measured twice

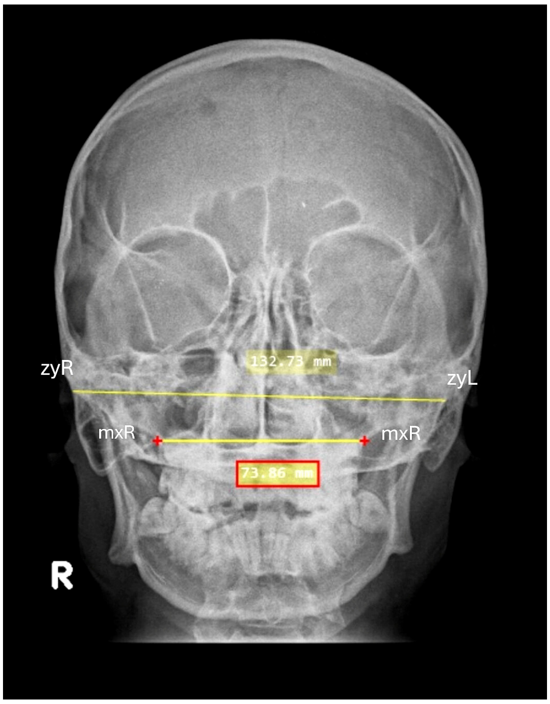

Figure 1: The first yellow line indicates the measurement of bizygomatic width and the second one is the measurement of maxillary width showed in MicroDICOM software.

by one researcher, then again once by a second researcher. The mean (μ) and standard deviation (SD) were calculated for each measurement and analyzed.

This study has obtained ethical approval from the ethical committee of Universitas Airlangga Hospital Surabaya, Indonesia, for health research No. 082/KEP/2024 and Husada Utama Hospital Surabaya, Indonesia, No. 25/ KEP-RSHU/VIII/2024.

Data analysis

The data were tabulated in Microsoft Excel, Microsoft Corporation (14), and analyzed using SPSS version 24.0 (14,15). Prior to conducting an independent t-test to analyze potential significant differences in the variables under investigation, Shapiro-Wilk normality tests and Levene homogeneity tests were performed. Subsequently, the analysis of intra- and inter-observer data utilized inferential statistics. Data variables will be summarized using mean and standard deviation, and statistical analysis involved independent t-test and Mann-Whitney test, depending on the normality of data distribution, with a significance level set at $p < 0.05$. The significance of differences in the measurement will determine its suitability for sex determination.

RESULTS

To mitigate potential observational bias, this study incorporated both intra- and inter-observer analyses. The intra-observer analysis, involving two separate observations, revealed no statistically significant differences in the measurements of the bizygomatic width ($p = 0.64$) and the maxillary width ($p = 0.95$). Similarly, the inter-observer analysis of measurements also indicated no statistically significant differences with intra-observer (bizygomatic width $p = 0.93$, maxillary width $p = 0.41$), as shown in Table I and Table II.

Table I. Bizygomatic width. Intra- and inter-observer analysis in 10 sample subjects.

Group	Intra-observer 1 (μ ± SD mm)	Intra-observer 2 (μ ± SD mm)	Intra-observer mean (μ ± SD mm)	Inter-observer 2 (μ ± SD mm)	P between (independent-t test)
Male (n = 5)	147.39 ± 12.55	147.44 ± 12.53	147.41 ± 12.54	147.6 ± 12.49	0.40
Female (n = 5)	131.88 ± 7.03	131.97 ± 6.69	131.95 ± 6.81	131.78 ± 6.90	
p between	0.64		0.93		

Footnotes:
- Data was assessed using an independent t-test with a sample size of 10.
- Two separate intra- observations showed no statistically significant differences (p = 0.64).
- The mean of intra-observer measurements also indicated no significant differences compared to inter-observer measurements (p = 0.93).
- There was no significant difference between males and females (p = 0.40) in a sample of 10 subjects.

Table II. Maxillary width. Intra- and inter-observer analysis in 10 sample subjects.

Group	Intra-observer 1 (μ ± SD mm)	Intra-observer 2 (μ ± SD mm)	Intra-observer mean (μ ± SD mm)	Inter-observer 2 (μ ± SD mm)	P between (independent-t test)
Male (n = 5)	81.60 ± 9.21	81.74 ± 9.20	81.67 ± 9.20	81.64 ± 9.02	0.37
Female (n = 5)	76.31 ± 8.48	76.17 ± 8.61	76.24 ± 8.54	76.50 ± 8.40	
p between	0.95		0.41		

Footnotes:
- - Data was assessed using an independent t-test with a sample size of 10.
- Two separate intra- observations showed no statistically significant differences measurements (p = 0.95).
- The mean of intra-observer measurements indicated no significant differences compared to inter-observer measurements (p = 0.41).
- There was no significant difference between males and females was found (p = 0.37) in a sample of 10 subjects.

The sample consisted of 50 subjects, with an equal representation of males and females (25 males and 25 females) with an age range from 19 to 69 years and a mean age of 36.2 ± 15.95 years for men and 36.68 ± 17.39 years for women. There was no significant difference in age between the groups ($p = 0.84$). The measurements, both intra-observer and inter-observer, also showed no significant difference, with p-values for all measurements of 50 samples > 0.05. Tables III and IV present the μ ± SD mm of bizygomatic width and μ ± SD mm (median ± IQR mm) of maxillary width measurements.

Statistical analysis of both variables in males and females revealed a statistically significant difference between the sex groups. An independent t-test showed a p-value < 0.00 for bizygomatic width (zyR-zyL), with μ ± SD of 143.30 ± 9.24 mm in males and 133.50 ± 6.82 mm in females, indicating a significant difference between males and females. Furthermore, a Mann-Whitney test was chosen for statistical analysis of maxillary width (mxR-mxL) due to the non-parametric nature of the data. This test yielded a p-value of 0.02, suggesting a statistically significant difference between the sexes for this variable as well. Maxillary width (mxR-mxL) exhibited μ ± SD (median ± IQR) values of 78.88 ± 5.35 mm (79.45 ± 6.98 mm) in males and 74.08 ± 5.49 mm (74.01 ± 6.65 mm) in females. The significant difference in bizygomatic and maxillary width between males and females is illustrated via a visual representation of the measurements (Figure 2).

DISCUSSION

The increasing prevalence of crime globally necessitates a greater understanding of criminal activity and its impact. The lack of evidence often hinders effective investigation, making victim identification a pressing issue. Forensic science plays a crucial role in crime resolution, and the unique nature of human dentition

Table III. Bizygomatic width. Comparison between men and women.

Group	Intra-observer 1 (μ ± SD mm)	Intra-observer 2 (μ ± SD mm)	Intra-observers mean (μ ± SD mm)	Inter-observer (μ ± SD mm)	Mean intra- and inter- observer (μ ± SD mm)	p between (independent-t test)
Male (n = 25)	143.28 ± 9.23	143.26 ± 9.23	143.26 ± 9.23	143.35 ± 9.26	143.30 ± 9.24	< 0.00
Female (n = 25)	133.57 ± 6.80	133.56 ± 6.80	133.56 ± 6.80	133.45 ± 6.84	133.50 ± 6.82	
p between	0.64		0.75			

Footnotes:
- Intra- and inter-observer reliability was assessed using an independent t-test with a sample size of 50.
- There were no statistically significant differences in intra-observer measurements (p = 0.64).
- The mean of intra-observer and inter-observer analysis also indicated no statistically significant differences (p = 0.75).
- The independent t-test revealed a significant difference between males and females (p < 0 .00), with μ ± SD mm in males of 143.30 ± 9.24 mm and in females of 133.50 ± 6.82 mm.

Table IV. Maxillary width. Comparison between men and women.

Group	Intra-observer 1 (μ ± SD mm)	Intra-observer 2 (μ ± SD mm)	Intra-observers mean (μ ± SD mm)	Inter-observer (μ ± SD mm)	Mean intra- and inter- observer (μ ± SD mm)	p between (independent-t test)
Male (n = 25)	78.90 ± 5.46	78.98 ± 5.39	78.84 ± 5.30	78.88 ± 5.35	79.45 ± 6.98	0.02
Female (n = 25)	74.00 ± 5.50	73.94 ± 5.53	74.20 ± 5.47	74.08 ± 5.49	74.01 ± 6.65	
p between	0.85		0.24			

Footnotes:
- Intra- and inter-observer reliability was assessed using an independent t-test with a sample size of 50.
- There were no statistically significant differences in intra-observer measurements (p = 0.85).
- The mean of intra-observer and inter-observer analysis also indicated no statistically significant differences (p = 0.24).
- Intra- and inter-observer reliability was assessed using the Mann-Whitney test, which revealed a significant difference between males and females (p = 0.02), with median values of 79.45 (IQR = 6.98) and 74.01 (IQR = 6.65) for males and females, respectively.

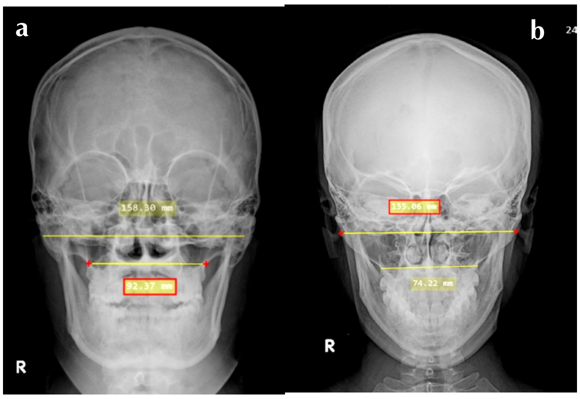

Figure 2: A comparative analysis of the bizygomatic and maxillary widths in males (a) and females (b) revealed a statistically significant difference (p < 0.00 and p = 0.02, respectively). The measurements, obtained using MicroDICOM software and visually represented by a yellow line, demonstrate that males exhibit significantly larger bizygomatic and maxillary widths compared to females.

provides valuable information for identifying victims (12). Initial identification involves sex determination, followed by the estimation of age and stature based on the established sex. Forensic science and anthropology utilize morphological and morphometric analyses of skeletal remains to ascertain sex (16). Methods for determining sex from skeletal remains generally fall into two categories: subjective visual assessments and objective morphometric measurements (7,17).

In forensic anthropology, both qualitative and quantitative techniques are used. Qualitative methods focus on the visual interpretation of histological and radiographic images to describe skeletal characteristics. Medical records provide contextual information, such as evidence of past trauma (e.g., fractures from accidents) that can be corroborated through radiographic examination. Quantitative methods, conversely, rely on objective measurements. Morphometrics, a key quantitative technique, is applied to biological profiling and encompasses histological and radiographic data. The inclusion of osteometric measurements allows for the statistical analysis of population variation (18). Further research is required to investigate morphological variations across age groups, given that technological advancements leading to reduced physical activity can negatively impact adolescent growth and development. Changes in physical activity patterns are hypothesized to impede upper-segment anthropometric growth, consequently diminishing adolescents' physical capabilities. (19).

This study confirms previous research findings, showing that males have wider bizygomatic and maxillary widths than females. A study in India investigated bizygomatic width in 30 individuals (15 males, 15 females) using cone-beam computed tomography (CBCT) and linear measurements with Planmeca Romexis software version 5.3. The study found a significant difference in bizygomatic width between males and females (p = 0.001), with a mean of 97.0693 ± 4.89 mm for males and 90.7153 ± 3.92 mm for females (20).

Similarly, another study in Chhattisgarh, India, using a similar methodology (n = 102, 51 males and 51 females), yielded significant results (p = 0.000) with a mean bizygomatic width of 93.11 ± 4.77 mm for males and 89.09 ± 3.7 mm for females. The study also utilized CBCT diagnostics, and the measurements were performed using ITK-SNAP software version 3.4.0 (21).

A previous study in 2014 compared linear analysis and logistic regression using skull collections from several countries (Portugal, France, and Thailand). Linear measurements were performed using digital calipers (Portugal and Thailand) and a digitizer (France). A significant difference in bizygomatic width was found between males and females in Portugal (male: n = 53, 51 ± 19 years old; female: n = 54, 57 ± 20 years old, p = 0.02), while no significant results were observed in France (male: n = 25, 50 ± 10 years old; female: n = 25, 56 ± 13 years old, p = 0.59) and Thailand (male: n = 47, 63 ± 14 years old; female: n = 45, 63 ± 16 years old, p = 0.93). The average measurement results were not reported in this journal (22).

A Chinese study compared multiple cephalometric points from sagittal and vertical sections, measuring bizygomatic width and maxillary width, which were categorized into three groups based on angular differences (low, average, and high-angle groups). The study was conducted in China with participants aged 18-25 years, using diagnostic CBCT data. In measuring bizygomatic width, the low-angle group showed an average of 125.18 for males (n = 28) and 118.75 for females (n = 40), the average-angle group showed an average of 122.46 for males (n = 41) and 166.12 for females (n = 63), while the high-angle group showed an average of 124.01 for males (n = 24) and 117.91 for females (n = 45). For linear measurements of maxillary width, the low-angle group showed an average of 71.15 for males (n = 28) and 67.59 for females (n = 40), the average-angle group showed an average of 68.10 for males (n = 41) and 66.93 for females (n = 63), while the high-angle group showed an average of 65.73 for males (n = 24) and 64.81 for females (n = 45). Although no statistical comparison was performed, the data clearly indicates a difference in linear measurements of both variables between males and females (17).

A recent study conducted in Brazil in 2024 investigated sex determination using maxillary width measurements obtained from CBCT 3D Axeos equipment from Dentsply Sirona (n = 100, 50 males and 50 females). Their findings showed a significant difference (p < 0.001) between males and females, with a mean maxillary width of 60.6 ± 5.24 mm for males and 57.3 ± 4.79 mm for females. These results align with our findings, which also demonstrate a consistent difference between males and females with mean maxillary widths of 77.86 mm and 73.82 mm, respectively (23).

A research study was performed in Ohio (n= 35; 15 males, 20 females) that investigated the effects of Rapid Maxillary Expansion (RME) therapy. Maxillary width was measured before therapy, non-significant results (p = 0.055) were obtained between males and females, with an average of 59.5 ± 3.3 for males and 57.2 ± 3.6 for females. The study was conducted using CBCT. The aforementioned studies also corroborate the findings of a 2012 study that compared linear measurements derived from conventional radiographs and CBCT scans. The results revealed significant variations not only in bizygomatic and maxillary widths but also in cranial width, interorbital width, mandibular width, and intermolar widths of both the maxillary and mandibular first molars (24). Our findings are consistent with those of the aforementioned studies, demonstrating a significant difference between males and females, suggesting that both bizygomatic and maxillary width measurements can serve as a basis for sex determination. The observed differences in measurements may be attributed to variations in race, diagnostic methods (previous studies utilized CBCT while ours employed plain skull X-rays), and measurement tools, which can also contribute to discrepancies in results.

The limitation of this study is this research focused on a specific population in Surabaya, East Java, Indonesia; it may not be applicable to other populations, and the limited sample size also restricts the generalizability of the results. Despite this, the study of bizygomatic and maxillary widths offers a relatively straightforward and cost-effective approach that can be readily implemented by any trained analyst. The measurements can be conducted remotely, eliminating the need for on-site analysis and providing greater flexibility and cost-effectiveness compared to CBCT. Consequently, the study's findings can serve as a foundation for further forensic investigations and various clinical applications, including orthodontic anomaly treatment and plastic surgery procedures. Furthermore, this study's findings specifically provide valuable data for understanding the distinctive characteristics of the diverse ethnic groups in Indonesia.

CONCLUSION

This study demonstrated comparable data between radiograph-based craniometry to the previous analysis and other methods. A significant difference in the linear measurements of two parameters to determine sex from the facial features can be used for this purpose. A larger size of bizygomatic and maxillary width in adult males compared to adult females is observed among the Indonesian sample population. Further research involving a larger sample size and exploring other craniometric indicators is needed to provide a database for sex dimorphism analysis in forensic and clinical fields.

ACKNOWLEDGEMENTS

The authors would like to express our sincere gratitude to the Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia, for the invaluable opportunity to contribute to the advancement of medical knowledge and for facilitating the publication of this research. We are deeply indebted to Airlangga University Hospital Surabaya and Husada Utama Hospital Surabaya for their generous support and collaboration. Their willingness to participate in this study and their assistance throughout the research process were instrumental in its completion. The authors are also grateful to the Faculty of Medicine, Petra Christian University, Surabaya, Indonesia, for their generous financial support, which played a crucial role in the successful completion and publication of this research. This research would not have been possible without the dedication and support of all these institutions and individuals.

REFERENCES

1. Zaidun NH, Alias A, Chung E, Wei Lin N, Sakaran R, Zulkiflee NDI, et al. Anthropometric measurements analysis for sex determination in human ribs: a systematic review. Malays J Med Health Sci. 2024;20(2):275–284. doi:10.47836/mjmhs.20.2.36
2. Krishan K, Chatterjee PM, Kanchan T, Kaur S, Baryah N, Singh RK. A review of sex estimation techniques during examination of skeletal remains in forensic anthropology casework. Forensic Sci Int. 2016;261:165.e1–165.e8. doi:10.1016/j.forsciint.2016.02.007
3. Gonzбlez-Colmenares G, Sanabria Medina C, Rojas-Sбnchez MP, Leyn K, Malpud A. Sex estimation from skull base radiographs in a contemporary Colombian population. J Forensic Leg Med. 2019;62:77–81. doi:10.1016/j.jflm.2019.01.006
4. Roche AF, Lewis AB, Wainer H, McCartin R. Late elongation of the cranial base. J Dent Res. 1977;56:802–808. doi:10.1177/00220345770560071501
5. Lieberman DE, Pearson OM, Mowbray KM. Basicranial influence on overall cranial shape. J Hum Evol. 2000;38(2):291–315. doi:10.1006/jhev.1999.0335
6. Kanchan T, Gupta A, Krishan K. Estimation of sex from mastoid triangle: a craniometric analysis. J Forensic Leg Med. 2013;20(7):855–860. doi:10.1016/j.jflm.2013.06.016
7. Musilovб B, Dupej J, Velemнnskб J, Chaumoitre K, Bruzek J. Exocranial surfaces for sex assessment of the human cranium. Forensic Sci Int. 2016;269:70–77. doi:10.1016/j.forsciint.2016.11.006
8. Kurniawan A, Athalia SA, Prakoeswa BFWR, Rizky BN, Chusida A, Yudha M, et al. Cephalometric radiograph-based approach for sex determination using maxillary sinus index in Surabaya, Indonesia. Eur J Anat. 2023;27:663–668. doi:10.52083/DHPM3206
9. Sofwanhadi R. Cephalometric patterns on Javanese, Bataks and Chinese students in Jakarta. Makara J Health Res. 2001;5(2):39–44. doi:10.7454/msk.v5i2.5592
10. Nur M, Kayipmaz S, Bayram M, Celikoglu M, Kilkis D, Sezgin OS. Conventional frontal radiographs compared with frontal radiographs obtained from cone beam computed tomography. Angle Orthod. 2012;82(4):579–584. doi:10.2319/080311-488.1
11. Broadbent BH. A new X-ray technique and its application to orthodontia. Angle Orthod. 1931;1(2):45–66.
12. Abitha T, Santhanam A. Correlation between bizygomatic and maxillary central incisor width for gender identification. Braz Dent Sci. 2019;22(4):458–466. doi:10.14295/bds.2019.v22i4.1775
13. MicroDicom. MicroDicom DICOM Viewer (software).
14. Microsoft Corporation. Microsoft Office LTSC Professional Plus 2021 (software).
15. IBM Corp. IBM SPSS Statistics for Windows, Version 24.0. Armonk (NY): IBM Corp.; 2016.
16. Kurniawan A, Sosiawan A, Nurrahman TF, Chusida A, Rizky BN, Prakoeswa BFWR, et al. Predicting sex from panoramic radiographs using mandibular morphometric analysis in Surabaya, Indonesia. Bull Int Assoc Paleodontol. 2023;17:32–40.
17. Ning R, Guo J, Li Q, Martin D. Maxillary width and hard palate thickness in men and women with different vertical and sagittal skeletal patterns. Am J Orthod Dentofacial Orthop. 2021;159(5):564–573. doi:10.1016/j.ajodo.2019.12.023
18. Anjani RCS, Artaria MD, Singsuwan P, Arunorat J, Mahakkanukrauh P. Biological identification of skulls in Indonesian and Thai populations: ancestry estimation, sex determination, stature estimation, and age estimation. Int J Morphol. 2024;42:137–146. doi:10.4067/S0717-95022024000100137
19. Akbar IK, Purwanto B, Setijono H. Comparison of antropometry and physical abilities between trained and untrained individuals in second growth phase. Folia Med Indones. 2020;55(4):280–284. doi:10.20473/fmi.v55i4.17323
20. R A, K P, VG M, HP J, Sanjay C, D N. Bizygomatic distance and maxillary sinus dimensions as predictors for sex determination: a morphometric analysis using cone beam computed tomography. Int J Curr Res Rev. 2021;13(16):10–16.

doi:10.31782/IJCRR.2021.131601
21. Sivasamy I, Ramakarishna P, Johaley S, Sikdar SD, Jain SK, Diwan RK. Evaluation of maxillary and sphenoidal sinus volume and bizygomatic width using cone beam computed tomography: a promising tool for sex determination. J Indian Acad Oral Med Radiol. 2024;36(3):297–300. doi:10.4103/jiaomr.jiaomr_86_24
22. Santos F, Guyomarc'h P, Bruzek J. Statistical sex determination from craniometrics: comparison of linear discriminant analysis, logistic regression, and support vector machines. Forensic Sci Int. 2014;245:204.e1–204.e8. doi:10.1016/j.forsciint.2014.10.010
23. de Araujo CM, de Jesus Freitas PF, Ferraz AX, Quadras ICC, Zeigelboim BS, Priolo Filho S, et al. Sex determination through maxillary dental arch and skeletal base measurements using machine learning. Head Face Med. 2024;20(1). doi:10.1186/s13005-024-00446-w
24. El H, Palomo JM. Three-dimensional evaluation of upper airway following rapid maxillary expansion: a CBCT study. Angle Orthod. 2014;84(2):265–273. doi:10.2319/012313-71.1