EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

Vol. 70, 1331:1338, April, 2024

Print ISSN 0070-9484 • Online ISSN 2090-2360

Oral Medicine, X-Ray, Oral Biology and Oral Pathology

Submit Date : 29-01-2024 • Accept Date : 13-03-2024 • Available online: 05-04-2024 • DOI : 10.21608/EDJ.2024.265900.2913

BIZYGOMATIC DISTANCE AND BIMASTOID DIAMETER AS PREDICTORS FOR AGE AND SEX DETERMINATION IN AN EGYPTIAN SAMPLE: AN OBSERVATIONAL CONE-BEAM COMPUTED TOMOGRAPHY STUDY

Walaa Samir Aboelalla* , Fatma Mohamed Hassan** *and* Sherif Shafik El Bahnasy***

ABSTRACT

Background and objectives: Identification of decomposed or incomplete human remains is a challenging mission in forensic medicine. Denser bones, as the mastoid and zygomatic bones, are frequently retrieved intact. This study aimed to evaluate using bizygomatic distance and bimastoid diameter as predictors for age estimation and sex discrimination among a sample of the Egyptian population using Cone-beam computed tomography (CBCT).

Methods: One hundred and fifty CBCT images of Egyptians aged 18 to 67 years (75 males and 75 females) were included in this retrospective observational study. Bizygomatic distance and bimastoid diameter were measured, and data were subjected to statistical analysis.

Results: Comparison of the mean values of bizygomatic distance and bimastoid diameter between males and females revealed significantly higher values in males than females (P-value < 0.001). Comparison of both variables between different age groups did not show any statistically significant difference. The highest accuracy obtained from discriminant function analysis was for the univariate bimastoid distance model (89.3%, 82.7%, and 86.0% for females, males, and whole sample, respectively).

Conclusion: Bizygomatic distance and bimastoid diameter measurements on CBCT images can be valuable tools for sex discrimination among Egyptians when other approaches are unsatisfying.

KEYWORDS: Age estimation, Bimastoid diameter, Bizygomatic distance, Cone-beam computed tomography, Egyptians, Sex discrimination.

* Associated professor, Acting Head of oral Radiology Department Beniseuf university
** Assistant professor of Forensic Medicine and Clinical Toxicology, Faculty of Medicine, Cairo University,
*** Assistant Professor, Oral Radiology, Faculty of Dentistry, The British University in Egypt, Cairo, Egypt

INTRODUCTION

Identifying deceased's skeletal remains and decaying body parts is one of the most complex duties in forensic medicine [1]. Age and sex are considered critical identification parameters in forensic and archaeological cases [2].

The skull is the second-best predictor of sex determination after the pelvis [3,4]. Several cranial metric parameters have been studied for age and sex determination, including cranium maximum length and breadth, bizygomatic distance, mastoid process and foramen magnum dimensions, and paranasal sinuses measurements [5-11]. The crucial point is the ability to analyze bones in fragmented or extensively disfigured states, so it is essential to use denser bones that are frequently retrieved intact [12].

The zygomatic bones have been reported to remain intact even when the skull is badly damaged[12,13]. Likewise, the anatomical position and compact nature of mastoid bone help it withstand traumas[14,15].

Radiologic techniques used for osteometric measurements have several benefits, such as being non-bone destructive, not mandating bone cleaning, and are more practical and feasible than several identification techniques [2].

Cone-beam computed tomography (CBCT) is a novel imaging technique that provides accurate three-dimensional views of craniofacial structures. It has the advantages of high-quality tissue contrast, better resolution, fast scan time, and relatively low cost [1,16,17].

This study aimed to investigate the usefulness of bizygomatic distance and bimastoid diameter as predictors for age estimation and sex discrimination among a sample of the Egyptian population using CBCT.

METHODS

This observational retrospective study comprised 150 CBCT images obtained from a private centre with machine large-field of view. The Faculty of Dentistry, Beni-Suef University Research Ethics Committee approved this study in December 2022 (Approval number: REC-FDBSU/05012023-02/SW).

Study Sample:

The study included 150 CBCT images of Egyptian individuals aged 18-67 years (75 males and 75 females). Images with developmental anomalies, cranial fractures, and pathology affecting the cranial bones and those of subjects aged <18 years were excluded.

According to chronological age, the CBCT images were divided into five groups (group I: 18-29 years, group II: 30-39 years, group III: 40-49 years, group IV: 50-59 years, and group V: ≥ 60 years), with 15 males and 15 females in each group.

Imaging:

A CBCT acquisition was obtained with Planmeca® Viso G7 machine (Planmeca Oy, Helsinki, Finland). The acquisition parameters were as follow: field of view 30 x 30 cm, voxel size 200 μm, tube voltage 100 kV, and current 50 mA.

Image analysis:

All images were interpreted with the Planmeca Romexis® software (Version 6.3., Planmeca Oy, Helsinki, Finland). Images were viewed in dimmed light room via Dell monitor (22-inch, Full HD 1920 × 1080 display). On the multiplanar (MPR) screen, coronal, axial and sagittal views were reoriented to make the linear distance measurements (Figure 1). The bizygomatic distance was measured on axial images as the maximum distance between the most prominent points on the right and left zygomatic arches [16] (Figure 2). Bimastoid diameter was measured as the distance between points of the mastoid processes on the coronal images [5] (Figure 3).

Two oral radiologists with more than ten years of expertise assessed the images in separate sessions. They were blind to each other's results.

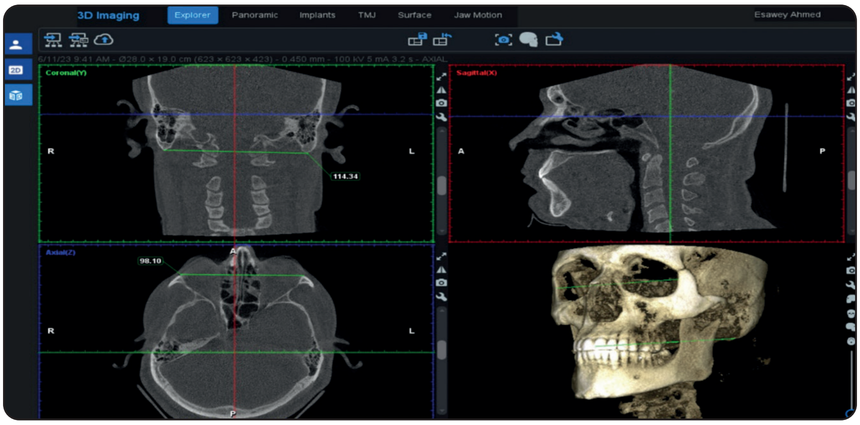

Fig. (1) Planmeca Romexis® software with coronal, axial, sagittal and 3D views of the interpreted CBCT image.

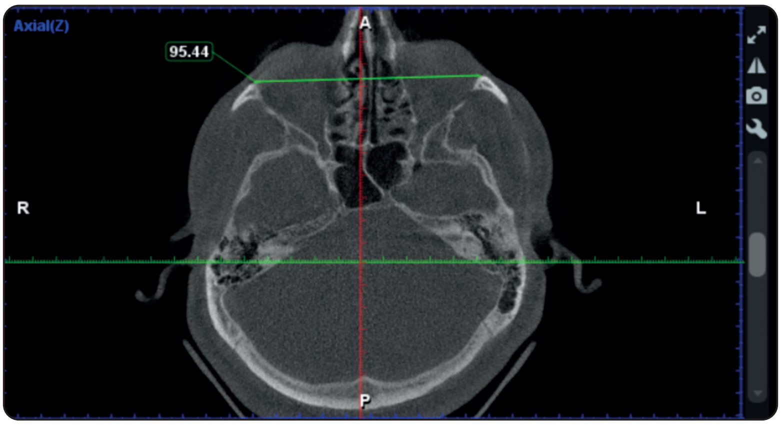

Fig. (2) Bizygomatic distance on an axial CBCT image.

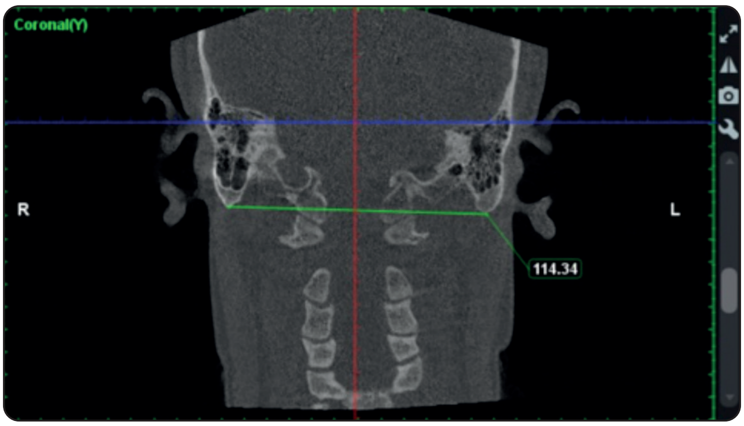

Fig. (3) Bimastoid diameter on a coronal CBCT image.

The export of CBCT data was done anonymously to guarantee examiners' blindness of age and sex. The measurements were repeated two weeks after initial assessment to test for intra-observer agreement.

Sample size calculation:

Sample size calculation was performed using G*Power version 3.1.9.7. A power analysis was designed to have adequate power to apply a two-sided statistical test of the null hypothesis that there is no difference would be found between different groups. By adopting an alpha level of (0.05), a beta of (0.2) (i.e. power=80%) and an effect size (f) of (0.317) calculated based on the results of a previous study [17]; the predicted sample size was a total of 80 samples. We increased the sample to 150 because of its classification of into groups.

Statistical analysis:

The R statistical analysis software version 4.3.2 for Windows was used for the statistical analysis. Categorical data were presented as frequency and percentage, and numerical data as mean and standard deviation (SD). They were analyzed for normality by viewing the distribution and using Shapiro-Wilk's test. One-way ANOVA was used to compare data that were normally distributed. Discriminant function analyses were run to assess gender discriminative ability of studied variables. Correlations were examined via Spearman's rank-order correlation coefficient. Inter and intra-observer reliability were examined by Intraclass Correlation Coefficient (ICC). Significance level was set at p<0.05 in all tests.

RESULTS

This study included 75 males (mean age 43.97±13.47 years, and range 19-67 years) and 75 females (mean age 43.32± 14.42 years, and range 18-66 years). The mean bizygomatic distance was 94.75±4.36 mm, and the mean bimastoid diameter was 103.15±6.15mm.

The ICC for the measured variables showed excellent agreement regarding both intra-observer and inter-observer reliability (ICC > 0.9, P-value < 0.001).

Table (1) shows the mean values of bizygomatic distance and bimastoid diameter in different age groups. No statistically significant difference was observed in both variables with advancing age (P-value >0.05). The correlation between age and both bizygomatic distance and bimastoid diameter did not reveal any statistical significance (Table 2).

TABLE (1)

Measurements	(Mean±SD) (mm)					p-value
	Group I (18-29) years N=30	**Group II (30-39) years N=30**	**Group III (40-49) years N=30**	**Group IV (50-59) years N=30**	**Group V (≥ 60) years N=30**	
Bizygomatic distance	94.66±3.21	94.31±4.99	94.14±3.79	94.39±4.60	96.23±4.88	**0.338**
Bimastoid diameter	103.44±5.81	103.02±6.96	103.52±6.25	102.81±6.11	102.95±5.96	**0.990**

N: number of subjects, SD: standard deviation.

TABLE (2)

Measurements	N	Correlation coefficient (95% CI)	p-value
Bizygomatic distance	150	0.101 (-0.061:0.257)	**0.221**
Bimastoid diameter	150	0.014 (-0.147:0.173)	**0.869**

N: number of subjects, CI= Confidence interval.

Comparison of the mean values of bizygomatic distance and bimastoid diameter between males and females showed statistical significance (P-value <0.001) with higher mean values of both variables in males than females (Table 3).

Discriminant function analysis for sex prediction is illustrated in table (4). The highest accuracy obtained was for the univariate bimastoid distance model (89.3%, 82.7%, and 86.0% for females, males, and overall, respectively), followed by the multivariate model (88.0%, 82.7%, and 85.3%, for females, males, and overall, respectively), while the lowest prediction accuracy was for the univariate bizygomatic distance model (74.7%, 64.0%, and 69.3% for females, males, and overall, respectively).

TABLE (3) Comparison of the measured parameters (Bizygomatic distance and Bimastoid diameter) between males and females.

Measurements	(Mean±SD) (mm)		p-value
	Male N=75	Female N=75	
Bizygomatic distance	96.81±4.42	92.69±3.17	**<0.001***
Bimastoid diameter	107.47±4.90	98.82±3.79	**<0.001***

N: number of subjects, SD: standard deviation.

****Significant (p<0.05).***

TABLE (4) Discriminant function analysis for sex prediction

Analysis		Variable	Coefficient	Fisher's linear DF		Correct prediction rates (%)		
				Male	Female	Male	Female	Overall
Univariate	**1**	**Constant**	-24.63	-317.48	-290.95	64.0%	74.7%	69.3%
		Bizigomatic distance	0.26	6.54	6.26			
	2	**Constant**	-23.54	-301.50	-55.06	82.7%	89.3%	86.0%
		Bimastoid diameter	0.23	5.60	5.15			
Multivariate		**Constant**	-21.99	-279.70	-336.05	82.7%	88.0%	85.3%
		Bizigomatic distance	-0.04	4.19	4.26			
		Bimastoid diameter	0.25	3.28	2.79			

DF: discriminant function

DISCUSSION

Identity is one of the most critical points in forensic investigations. For personal identification, it is essential to estimate the "big four" criteria of forensic anthropology: age, sex, ancestry, and stature, that create the individual's biological profile [18,19].

This study aimed to evaluate using bizygomatic distance and bimastoid diameter as predictors for age estimation and sex discrimination among an Egyptian population sample using CBCT.

In this study, no significant difference was observed in bizygomatic distance or bimastoid diameter between different studied age groups. Also, no significant correlation was detected between age and both variables. Similarly, Chaurasia and Katheriy [13] did not find any significant difference in bizygomatic distance among their study age groups. Also, Okumuş [15] and Buran et al. [2] did not observe any significant changes in bimastoid diameter with advancing age. This finding can be explained as the mastoid is a cranial region with the slowest rate of bone growth [20,21], which may preclude using the bimastoid diameter as an age estimation parameter.

Regarding sex discrimination, our results revealed statistically significant higher values in males than females in bizygomatic distance (96.81±4.42mm in males, and 92.69±3.17mm in females) and bimastoid diameter (107.47±4.90mm in males, and 98.82±3.79mm in females). Similarly, several studies examined the sexual dimorphism in bizygomatic distance using different radiological techniques and reported significantly higher values in males compared to females [1, 12, 13, 16,17, 22). Also, Buran et al. [2] and Amin et al. [23] investigated the bimastoid diameter for sexual dimorphism in Turkish and Jordanian populations, respectively, and verified that it was significantly greater in males than females. Suazo et al. [24] studied 284 adult Brazilian skulls (187 males and 97 females) for forensic sex identification. They ascertained that the best indicators were in areas whose formation is related to the insertion and action of the major muscle groups, as mastoid process, zygomatic bone, mandible, and occipital bone ridges.

In this study, we used the discriminant function analysis to assess the sex discriminative ability of studied variables. Discriminant function analysis is an objective approach for estimating sex, which yields more reliable results by eliminating subjectivity. So, it is frequently employed in sex determination studies [25].

Regarding discriminant function analysis results in this study, the highest accuracy obtained was for the univariate bimastoid distance model (89.3% for females, 82.7% for males, and 86.0% for the whole sample). This finding coincides with Buran et al.'s [2] discriminant model that described an accuracy of 82.7% in females compared to 80.0% in males using the bimastoid diameter. Amin et al. [23] found that the inter-mastoid distance was the best single sex predictor with 87.5% accuracy using CBCT measurements. In addition, Jain and Jasuja [26] studied 100 dried and ossified human skulls and reported an accuracy rate of 75% for bimastoid breadth.

The applied sex prediction model for the bizygomatic distance revealed an accuracy of 74.7% for females, 64.0% for males, and 69.3 % for the whole sample. Adel et al. [18] reported the bizygomatic distance as the single most discriminant sex dimorphic of their study variables among Egyptians with an accuracy of 74%. Higher accuracy sex prediction rates of bizygomatic distance were observed in previous studies; Mahakkanukrauh et al. [27] described 84.3% accuracy in the Thai population, and Dayal et al. [28] reported 75.8% accuracy in black South Africans. This difference could be explained by the variations in sample size, populations, and the measurement approaches.

CONCLUSIONS

In conclusion, the bizygomatic distance and bimastoid diameter were significantly higher in males than females; however, no statistical significance was observed with advancing age. The bimastoid diameter presented the best sexual dimorphism among Egyptians, with the highest sex prediction accuracy in discriminant function analysis. Both bizygomatic distance and bimastoid diameter could be used as predictors for sex discrimination in forensic anthropology when other tools are inconclusive. Future studies in different populations with larger sample size are recommended to develop discriminant functions with optimal sex prediction accuracy unique for each population.

Declaration of interests: None.

Funding: None.

Human participants: The present study uses retroactive radiographic data. No subjects were exposed to radiation for the purposes of this study alone.

Ethical approval: The present research was designed and performed in accordance with the ethical principles outlined in the Declaration of Helsinki. The Faculty of Dentistry, Beni-Suef University Research Ethics Committee approved this study in December 2022 (Approval number: REC-FDBSU/05012023-02/SW).

REFERENCES

1. Patil K, Mahesh KP, Sanjay CJ, Vijayan MP, Nagabhushana D, Ramesh A. Bizygomatic distance as a predictor of age and sex determination: a morphometric analysis using cone beam computed tomography. Eur J Anat 2022; 26 (4): 457-463. doi.org/10.52083/WGES2700

2. Buran F, Can IO, Ekizoglu O, Balci A, Guleryuz H. Estimation of age and sex from bimastoid breadth with 3D computed tomography. Rom J Leg Med 2018; (26): 56-61.

3. Krogman WM, Iscan MY. The Human Skeleton in Forensic Medicine, Springfield, IL: Charles C. Thomas; 1986.

4. Bruzek J, Murail P. Methodology and reliability of sex determination from the skeleton in forensic anthropology and medicine. Humana Press. 2006; pp. 225- 242.

5. Ekizoglu O, Hocaoglu E, Inci E, Can IO, Solmaz D, Aksoy S, Buran CF, Sayin I. Assessment of sex in a modern Turkish population using cranial anthropometric parameters. Legal medicine (Tokyo, Japan) 2016; 21, 45–52. https://doi.org/10.1016/j.legalmed.2016.06.001

6. Passey J, Pandey S, Passey N, Singh R, Singh R, Kumar A. Radiographic Evaluation of Mastoid Parameters for Sexual Differentiation in North Indian Population. Cureus 2021;13(6):e16011. https://doi.org/10.7759/cureus.16011

7. Kranioti EF, Işcan MY, Michalodimitrakis M. Craniometric analysis of the modern Cretan population. Forensic Sci Int. 2008;180(2-3):110.e1-110.e1105. doi:10.1016/j.forsciint.2008.06.018

8. Hosseini A, Soleimannejad M, Javadi A, Kazemifar A, Darabi S, Pourkeramat S. Sex and Age Determination by Measurement of Foramen Magnum Dimensions on Computer Tomography Scanning Study in the Iranian Population. The Journal of craniofacial surgery 2021;32(7): e604–e607. https://doi.org/10.1097/SCS.0000000000007580

9. Hemanthakumar S, Saraswathi Gopal K, Mahesh Kumar P. Assessment of sexual dimorphism using 3D CBCT image data among Indians. Bioinformation 2022; 18(3): 231–238. https://doi.org/10.6026/97320630018231

10. Amin MF, Hassan EI. Sex identification in Egyptian population using Multidetector Computed Tomography of the maxillary sinus. Journal of forensic and legal medicine 2012; 19(2): 65–69. https://doi.org/10.1016/j.jflm.2011.10.005

11. Wanzeler AMV, Alves-Júnior SM, Ayres L, da Costa Prestes MC, Gomes JT, Tuji FM. Sex estimation using paranasal sinus discriminant analysis: a new approach via cone beam computerized tomography volume analysis. International journal of legal medicine 2019; 133(6): 1977–1984. https://doi.org/10.1007/s00414-019-02100-6

12. Jehan M, Bhadkaria V, Trivedi A, Sharma SK. Sexual dimorphism of Bizygomatic distance and maxillary sinus using CT scan. J Dent Med Sci 2014; 13:91-5.

13. Chaurasia A, Katheriya G. Morphometric evaluation of Bizygomatic distance and maxillary sinus width as dimorphic tool- A CBCT study. Int J Maxillofac Imaging. 2016;2(4):123–8.

14. Kanchan T, Gupta A, Krishan K. Estimation of sex from mastoid triangle – A cran*io*metric analysis. Journal of Forensic and Legal Medicine 2013; 20(7): 855–860. https://doi.org/10.1016/j.jflm.2013.06.016

15. Okumuş O. Determination of age and sex using bimastoid diameter: a cone beam computed tomography Study. Odovtos International Journal of Dental Sciences 2022; 24(2): 157-163. https://dx.doi.org/10.15517/ijds.2022.48365

16. Aishwarya R, Patil K, Mahima VG, Jaishankar HP, Sanjay CJ, Nagabhushana D. Bizygomatic Distance and Maxillary Sinus Dimensions as Predictors for Sex Determination: A Morphometric Analysis using Cone Beam Computed Tomography. International Journal of Current Research and Review 2021; 13(11):10-16. DOI: http://dx.doi.org/10.31782/IJCRR.2021.131601

17. Abu El-Dahab O, Dakhli I. The Role of Cone Beam Computed Tomography in Sex Identification of a Sample of Egyptian Population Using Maxillary Sinus Predictors. Oral Surgery, Oral Medicine, Oral Radiology 2018; 6(1):4-9. doi: 10.12691/oral-6-1-2

18. Adel R, Ahmed HM, Hassan OA, Abdelgawad EA. Assessment of Craniometric Sexual Dimorphism Using Multidetector Computed Tomographic Imaging in a Sample of Egyptian Population. Am J Forensic Med Pathol. 2019;40(1):19-26. doi:10.1097/PAF.0000000000000439

19. Krishan K. Anthropometry in forensic medicine and forensic science-'forensic anthropometry'. Internet J Forensic Sci 2007:2:1-8. [DOI: 10.5580/1dce].

20. Yilmaz MT, Yüzbasioglu N, Cicekcibasi AE, Seker M, Sakarya ME. The evaluation of morphometry of the mastoid process using multidetector computed tomography in a living population. J Craniofac Surg. 2015;26(1):259-263. doi:10.1097/SCS.0000000000001216

21. Allam F, and Allam M. Sex discrimination of mastoid process by anthropometric measurements using multidetector computed tomography in Egyptian adult population. Egyptian Journal of Forensic Sciences 2016; 6(4):361-369.

22. Kenawy S. Evaluation of Bizygomatic Distance and Intermaxillary Distance as Sexual Dimorphic tools in Egyptian Adults: A Cone Beam Computed Tomography Study. Egyptian Dental Journal 2023; 69(4): 2697-2704. doi: 10.21608/edj.2023.209708.2540

23. Amin W, Saleh M-W, Othman D, Salhab D and Thunaibat H. Osteometric Assessment of the Mastoids for Gender Determination in Jordanians by Discriminant Function Analysis. American Journal of Medical and Biological Research. 2015; 3(4):117-123. doi: 10.12691/ajmbr-3-4-7

24. Suazo GIC, Zavando MDA, Smith RL. Performance Evaluation as a Diagnostic Test for Traditional Methods forForensic Identification of Sex. Int. J. Morphol. 2009; 27:381-6

25. Patil KR, Mody RN. Determination of sex by discriminant function analysis and stature by regression analysis: a lateral cephalometric study. Forensic Sci Int. 2005;147(2-3):175-180. doi:10.1016/j.forsciint.2004.09.071

26. Jain D, Jasuja OP, Nath S. Sex determination of human crania using Mastoid triangle and Opisthion-Bimastoid triangle. J Forensic Leg Med. 2013;20(4):255-259. doi:10.1016/j.jflm.2012.09.020

27. Mahakkanukrauh P, Sinthubua A, Prasitwattanaseree S, Ruengdit S, Singsuwan P, Praneatpolgrang S, Duangto P. Craniometric study for sex determination in a Thai population. Anatomy & cell biology 2015; 48(4), 275–283. https://doi.org/10.5115/acb.2015.48.4.275

28. Dayal MR, Spocter MA, Bidmos MA. An assessment of sex using the skull of black South Africans by discriminant function analysis. Homo. 2008;59(3):209-221. doi:10.1016/j.jchb.2007.01.001