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EVALUATION OF BIZYGOMATIC DISTANCE AND INTERMAXILLARY DISTANCE AS SEXUAL DIMORPHIC TOOLS IN EGYPTIAN ADULTS: A CONE BEAM COMPUTED TOMOGRAPHY STUDY

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ABSTRACT

Objective: To evaluate the accuracy of bizygomatic distance and intermaxillary distance for sex estimation among a group of adult Egyptian population using Cone Beam Computed Tomography (CBCT).

Materials and Methods: One hundred retrospective CBCT scans of adult Egyptian individuals were included in this study (Fifty males and fifty females). The bizygomatic distance and intermaxillary distance were measured on axial CBCT images. All the measurements were statistically analyzed in relation to sex.

Results: Both study measurements (bizygomatic distance and intermaxillary distance) were higher in males than that in females with statistical significance difference. Furthermore, discriminant function analysis showed that the highest overall prediction rates were found in the univariate bizygomatic distance model for both sexes.

Conclusion: Using Cone beam Computed Tomography, bizygomatic distance may be considered a strong sexual dimorphic tool in Egyptian adult population and should continuously be considered for sex estimation through human identification.

KEYWORDS: Cone Beam Computed Tomography, Bizygomatic Distance, Intermaxillary Distance, Sexual Dimorphism, Forensic dentistry

INTRODUCTION

Forensic dentistry is an inter-discipline of forensic medicine with stomatology that provides legal evidence by gathering, testing and evaluating the dental evidence on scientific basis. Recently, the applications of forensic dentistry has been described as the age, sex, species, occupation and living habits, in addition to the identification of individuals that

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aims to enhance and improve forensic dentistry to be more beneficial for forensic medicine even in juridical practice[1].

Sexual Dimorphism is known as the differences in male and female traits in the morphological features which develops under the effect of environmental and genetic factors and is shaped by natural and sexual selection in both animal species and humans[2].

Sex estimation is considered a main problem in the identification of unknown individual. Most of the bones that are usually used for determination of sex such as the pelvis and some long bones, are frequently recovered either in fragments or incomplete form, therefore, it is necessary to use alternate dense bones that are often recovered intact such as the zygomatic bones and the maxillary bones[3–5].

The skull is the most easily sexed part of the skeleton, although sex determination from the skull is not applicable until after puberty. Skull is considered the most frequent sexing bone in the medico-legal cases. It appears to be the main dependable bone exhibiting sexually dimorphic traits, because the skull has a very high resistance to adverse environmental conditions over-time, causing greater stability of dimorphic features as compared to other skeletal bony pieces[5,6].

Radiographic imaging modalities play an important role in forensic science as they provide various morphological data as well as being an easy and accessible methods of examination. These imaging modalities include conventinal x-rays as lateral cephalometric views and postero-anterior views, advanced modalities as computed tomography (CT) and more recently cone beam computed tomography (CBCT)[7–10]. CBCT offers several advantages including good image resolution, accurate measurements, simple technique and at low cost, which made it a widely used modality for forensic studies[11,12].

All the previous background encouraged the author of the current study to evaluate the accuracy of bizygomatic distance and intermaxillary distance for sex estimation among a group of adult Egyptian population using Cone Beam Computed Tomography.

MATERIALS AND METHODS

This study was conducted on 100 retrospective CBCT scans (50 females and 50 males) which were retrieved from the CBCT database of Oral and Maxillofacial Radiology Department, Faculty of Dentistry, Cairo University after the approval of the Ethics Committee, Faculty of Dentistry, Cairo University. All the scans were selected for adult patients above the age of 18 years. The CBCT scans were attained by the Promax 3D Planmeca® system (Helsinki, Finland). All the selected scans were CBCT radiographically imaged by the "Full Face" field of view (FOV) including the whole dimensions of the zygomatic bone and the maxillary sinus. Scans with motion artifacts, metallic artifacts or blurring were excluded. In addition, scans of patients with history of traumatic injury, surgical procedures or any pathology in the regions of interest were excluded. All the study measurements were performed using the Planmeca Romexis viewer 4.2.6.R software.

For each selected subject, after importing the DICOM file to the software, the CBCT dataset was adjusted such that the sagittal plane was aligned with the ANS, and the axial plane was aligned with the Frankfurt plane. Magnification was permitted to be used by the radiologist performed this study to allow for better visualization. Additionally, the software screen brightness and contrast were optimized.

In this study, the maximum bizygomatic distance and the maximum intermaxillary distance were selected to be measured as CBCT dimorphic parameters. The maximum bizygomatic distance is defined as the maximum distance between the most prominent points on the right and left zygomatic

arches [5,13–17] **(Fig. 1)**. While, the maximum intermaxillary distance is known as the maximum distance between medial walls of right and left maxillary air sinuses [5,15,16,18] **(Fig. 2)**. Both distances were measured on CBCT axial images.

Each of the two measured distances (bizygomatic distance and intermaxillary distance) was obtained on three successive CBCT axial images so as to select the finest image with the widest distances could be achieved [12] **(Figs. 3 & 4)**.

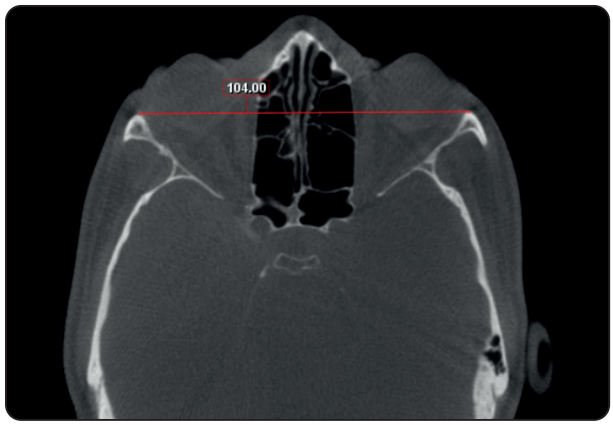

Fig. (1) The maximum bizygomatic distance on an axial CBCT image.

Fig. (2) The maximum intermaxillary distance on an axial CBCT image.

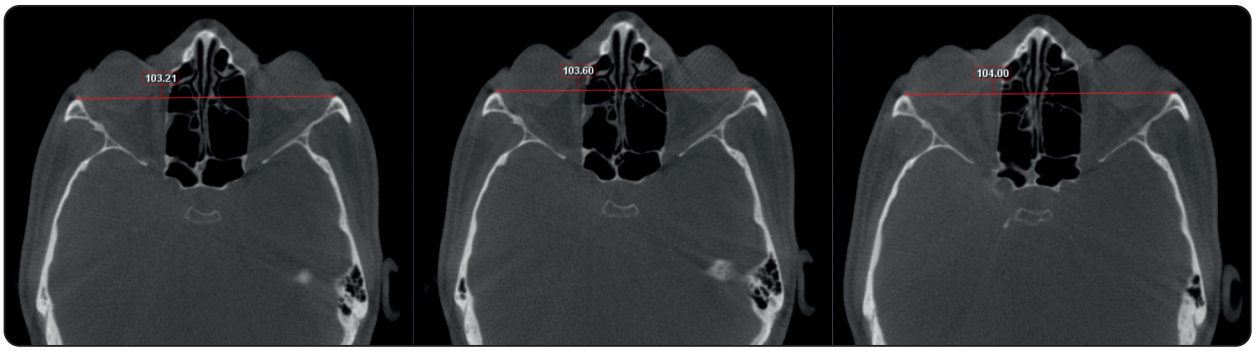

Fig. (3) The measurement of the bizygomatic distance on three successive axial CBCT images.

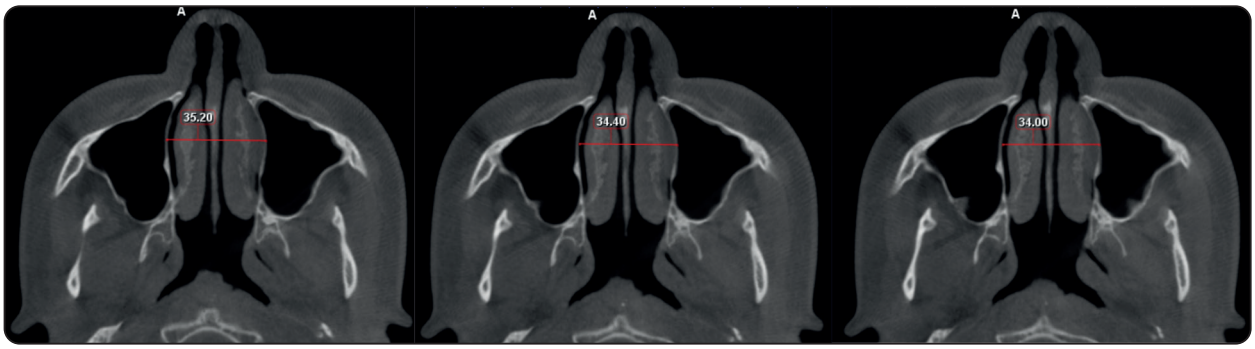

Fig. (4) The measurement of the intermaxillary distance on three successive axial CBCT images.

Statistical analysis

Numerical data was represented as mean and standard deviation (SD) values. Shapiro-Wilk's and Levene's tests were used to test for normality and variance homogeneity. Data were normally distributed, had variance homogeneity and were analyzed using independent t-test. Sex prediction from studied variables was done using discriminant function analysis. AUC values were compared using Delong method. The significance level was set at $p<0.05$ within all tests. Statistical analysis was performed with R statistical analysis software version 4.1.3 for Windows.

RESULTS

I. Comparison between Males and Females

Results of the comparison between sexes in different tested variables presented in **(Table 1)** showed males to have significantly higher bizygomatic and intermaxillary distances than females ($p<0.001$). Values for both measurements are presented in **(Fig. 5)**.

II. Discriminant Function Analysis and ROC Curve

Results of discriminant analysis models that were built for sex prediction are presented in **(Table 2)**. The highest male prediction rates were found in univariate bizygomatic model (80.0%) while the highest female prediction rates were found in the same model as well as the multivariate model (88.0%). The highest overall prediction rates were found in the univariate bizygomatic distance (84.0%). The intermaxillary model had the lowest prediction rates in all categories. ROC curve for the prediction of all tested model is presented in **(Fig. 6)**. The highest AUC was found in the multivariate model (0.923, 95%CI [0.869:0.974]), followed by the univariate bizygomatic model (0.910, 95%CI [0.852:0.968]), while the lowest AUC was found in the intermaxillary distance model (0.723, 95%CI [0.625:0.821]). AUC for the intermaxillary model was found to be significantly different from the other models ($p<0.001$). While the difference between the other models were found statistically non-significant ($p=0.289$).

TABLE (1) Difference between genders

Measurements	(Mean±SD) (mm)		Mean difference (95%CI)	t-value	p-value
	Male	Female			
Bizygomatic distance	96.87±4.11	88.67±4.53 8.20	8.20 (6.49:9.92)	9.48	<0.001*
Intermaxillary distance	36.12±3.53	33.30±2.94	2.82 (1.53:4.11)	4.33	<0.001*

significant (p<0.05)

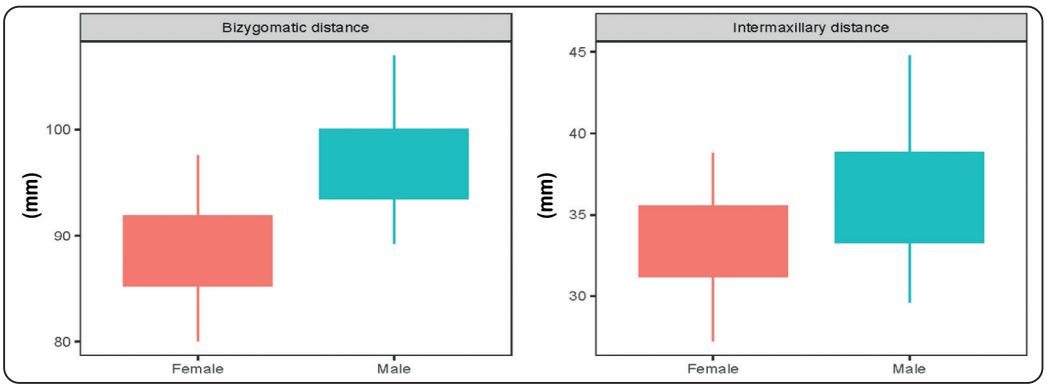

Fig. (5). Box plot showing variables in different sexes

TABLE (2) Discriminant analysis

Analysis		Variable	Coefficient	Fisher's linear DF		Correct prediction rates (%)		
				Male	Female	Male	Female	Overall
Univariate	1	Constant	-21.44	-251.48	-210.81	80.0%	88.0%	84.0%
		Bizygomatic distance	0.23	5.17	4.74			
	2	Constant	-10.68	-62.41	-53.16	66.0%	60.0%	63.0%
		Intermaxillary distance	0.31	3.42	3.15			
Multivariate		Constant	-22.94	-287.59	-241.65	78.3%	88.0%	83.0%
		Bizygomatic distance	0.21	4.94	4.52			
		Intermaxillary distance	0.10	2.63	2.43			

DF: discriminant function

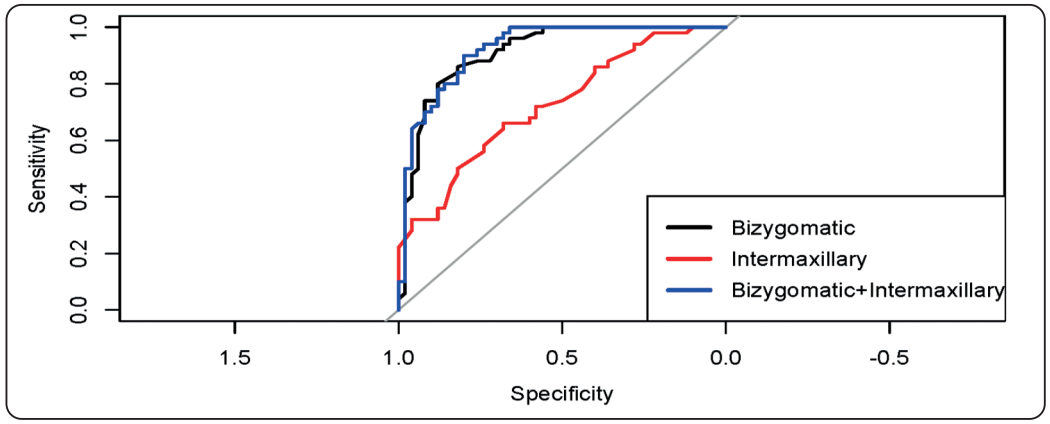

Fig. (6) ROC curve for discrimination models

DISCUSSION

Concerning forensic medicine, sexual dimorphism is a very essential preliminary step on the way of establishing positive individuality of the deceased individual. According to many researches, the accuracy rate of sex determination is 98% from the pelvic bone together with the skull and 90 to 95% from the skull with the long bones [5,6,19,20].

Following the pelvic bone, the skull is the most easily sexed bone of the human skeleton. However, sex determination from the skull bone is not reliable till puberty[12,21]. The structures of craniofacial region have the benefit of being composed basically of hard tissues that are relatively durable and indestructible[22].

Two hundred and eighty four adult Brazilian skulls (187 males and 97 females) were examined in a study performed by Suazo et al.,2009[23] and sixteen known sexual dimorphism skull morphological indicators were obtained. The study found that the best sexual dimorphism indicators were found in relation to bones which formation is linked to the major muscles insertion and action as the zygomatic bone, the mastoids and the mandible[24].

The current study aimed to evaluate the accuracy of bizygomatic distance and intermaxillary distance for sex estimation among a group of adult Egyptian population using Cone Beam Computed Tomography of 100 subjects comprising of 50 males and 50 females.

In this study, discriminant function analysis was chosen to be performed within the statistical analysis after finishing the CBCT measurements because it represents an objective method for sex estimation[22,25]. Moreover, discriminant function analysis overcomes subjective approaches which provides more reliable results. Therefore, it is widely used in sex discrimination researches[24].

Reviewing the literature, one study was found which was performed by Abu El Dahab & Dakhli.,2018[16] on Egyptians investigating the probability of sex determination from the CBCT radiographic maxillary sinus measurements including the bizygomatic and intermaxillary distances. In their study, the mean values of both measurements (bizygomatic and intermaxillary distances) in males (93.5 and 35 respectively) were higher than in females (88.7 and 32.7 respectively) which had proved statistical significance. Their findings were in concordance with that obtained in the current study, wherein the mean values of both measurements among males were (96.87 and 36.12) and among females were (88.67 and 33.3). On the other hands, their discriminant analysis results showed that only the intermaxillary distance was a significant predictor for sex.

Regarding the bizygomatic distance, the current study results came in concordance with Latta et al., 1991[26] where in their study, the bizygomatic width in black and white men differed significantly from black and white women respectively in edentulous patients. Ewunonu and Anibeze., 2013[27] found the same significant difference between males and females in Nigerian Population. In addition to Jehan et al., 2014[18] who found that the mean ± SD of bizygomatic distance in males was 9.55±0.41cm and in females was 9.26±0.52cm and Chaurasia and Katheriya., 2016[5] whose results stated that the mean ± SD of the bizygomatic distance in males was 96.66±4.14 cm and in females was 94.97±2.87 cm. Supporting these results, Mathew and Jacob., 2020[15] assessed the bizygomatic distance of 100 patients by CBCT and found that the overall values of the bizygomatic distance were significantly greater ($p < 0.05$)in males as compared to females. Also, Patil et al.,2022[17] concluded that the CBCT linear measurements of the bizygomatic distance can be used in forensic purposes to help in sex determination as in their study, there was statistically significant difference in the bizygomatic distance among different sexes, with males showing comparatively higher values than females.

In addition, Osvaldo et al.,2012[24] performed a study on 100 adult skulls to prove the presence of sexual dimorphism by nine cranio-metric measurements. Discriminant analysis model, considering all the obtained variables showed that the greatest variable to differentiate the sex groups was the bizygomatic distance.

On the other hand, Jehan et al., 2014, Chaurasia and Katheriya., 2016 and Mathew and Jacob., 2020[5,15,18] found no statistically significant difference between males and females regarding the intermaxillary distance. These results difference may be due to many factors such as the genetic and environmental factors of different populations and sinus pneumatization process in different age groups found in these studies[16,18,28].

It should be noted that the bizygomatic distance represented an important feature in sexual dimorphism in many populations and should continuously be considered for sex estimation through human identification.

CONCLUSION

The analysis of the current study results concluded that both measurements (bizygomatic distance and intermaxillary distance) showed significant values for sex determination. Among them, the best sexual dimorphism was presented by the bizygomatic distance. Through discriminant function analysis, the highest overall prediction rates were found in the univariate bizygomatic distance model (84.0%).

REFERENCES

1. Liu F, Dang YH. Research Progress on Forensic Dentistry. Vol. 33, Journal of Forensic Medicine. 2017. p. 175–80.
2. Dursun C, Gül S, Özdemir N. Sexual size and shape dimorphism in Turkish common toads (Bufo bufo Linnaeus 1758). Anat Rec. 2022;305(6):1548–58.
3. Amin MF, Hassan EI. Sex identification in Egyptian population using Multidetector Computed Tomography of the maxillary sinus. J Forensic Leg Med. 2012;19(2):65–9.
4. Al-Taei JA, Jasim HH. Computed Tomographic Measurement of Maxillary Sinus Volume and Dimension in Correlation to the Age and Gender : Comparative Study among Individuals with Dentate and Edentulous Maxilla. J Baghdad Coll Dent. 2013;25(1):87–93.
5. 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.
6. Teke HY, Duran S, Canturk N, Canturk G. Determination of gender by measuring the size of the maxillary sinuses in computerized tomography scans. Surg Radiol Anat. 2007;29(1):9–13.
7. David MP, Saxena R. Use of frontal sinus and nasal septum patterns as an aid in personal identification: A digital radiographic pilot study. J Forensic Dent Sci. 2010;2(2):77–80.
8. Perlaza NA. Sex determination from the frontal bone: A geometric morphometric study. J Forensic Sci. 2014;59(5):1330–2.
9. Cossellu G, De Luca S, Biagi R, Farronato G, Cingolani M, Ferrante L, et al. Reliability of frontal sinus by cone beam-computed tomography (CBCT) for individual identification. Radiol Medica. 2015;120(12):1130–6.
10. Verma K, Nahar P, Pal Singh M, Mathur H, Bhuvaneshwari S. Use of frontal sinus and nasal septum pattern as an aid in personal identification and determination of gender: A radiographic study. J Clin Diagnostic Res. 2017;11(1):ZC71–4.
11. Issrani R, Prabhu N, Sghaireen MG, Ganji KK, Alqahtani AMA, Aljamaan TS, et al. Cone-Beam Computed Tomography: A New Tool on the Horizon for Forensic Dentistry. Int J Environ Res Public Health. 2022;19(9): 1–12.
12. Kenawy S, Mousa A. Foramen Magnum as Dimorphic Tool for Sex Determination in the Egyptian population using Cone Beam Computed Tomography: A Retrospective Study. Egypt Dent J. 2022;68(4):3381–90.
13. Ahn BS, Oh SH, Heo CK, Kim GT, Choi YS, Hwang EH. Cone-beam computed tomography of mandibular foramen and lingula for mandibular anesthesia. Imaging Sci Dent. 2020;50(2):125–32.
14. Ariji Y, Ariji E, Yoshiura K, Kanda S. Computed tomographic indices for maxillary sinus size in comparison with the sinus volume. Dentomaxillofacial Radiol. 1996;25(1):19–24.
15. Mathew A, Jacob L. 3D evaluation of maxillary sinus in gender determination: A cone beam computed tomography study. J Indian Acad Oral Med Radiol. 2020;32(4):384–9.
16. 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 Med Oral Radiol [Internet]. 2018;6(1):4–9. Available from: http://pubs.sciepub.com/
17. Patil K, Mahesh KP, Sanjay CJ, Vijayan MA, 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):457–63.
18. Jehan M, Bhadkaria V, Trivedi A, Sharma SK. Sexual Dimorphism of Bizygomatic distance & Maxillary sinus using CT Scan. IOSR J Dent Med Sci. 2014;13(3):91–5.
19. Saunders SR. Epigenetic variants of the human skull. By G. Hauser and G. F. De Stefano. Stuttgart: E. Schweizerbart'sche Verlagsbuchhandlung. 1989. vi + 301 pp., figures, tables, index. DM 128, (cloth). Am J Phys Anthropol. 1990;83(4):504–5.
20. KROGMAN WM. The human skeleton in forensic medicine. I. Postgrad Med. 1955;17(2).
21. Sidhu R, Chandra S, Devi P, Taneja N, Sah K, Kaur N. Forensic importance of maxillary sinus in gender determination: A morphometric analysis from Western Uttar Pradesh, India. Eur J Gen Dent. 2014;3(01):53–6.
22. 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 SPEC.ISS.):175–80.

23. Suazo Galdames IC, Zavando Matamala DA, Smith RL. Performance evaluation as a diagnostic test for traditional methods for forensic identification of sex. Int J Morphol. 2009;27(2):381–6.

24. Oliveira OF De, Tinoco RLR, Daruge Júnior E, Terada ASSD, Silva RHA da, Paranhos LR. Sexual dimorphism in Brasilian human skulls: discriminant function analysis. J Forensic Odontostomatol. 2012;30(2):26–33.

25. Steyn M, Işcan MY. Sexual dimorphism in the crania and mandibles of South African whites. Forensic Sci Int. 1998;98(1-2):9–16.

26. Latta GH, Weaver JR, Conkin JE. The relationship between the width of the mouth, interalar width, bizygomatic width, and interpupillary distance in edentulous patients. J Prosthet Dent. 1991;65(2):250–4.

27. Ewunonu EO, Anibeze CIP, Eo EOE. Anthropometric study of the Facial Morphology in a South-Eastern Nigerian Population. Cit Ewunonu EO Anibeze CIP [Internet]. 2013;2(4):314–23. Available from: www.humanbiologyjournal.com

28. Sharan A, Madjar DMDD. Maxillary sinus pneumatization following extractions: a radiographic study. Int J Oral Maxillofac Implants. 2008;23(1).