

Mandible – An aid to assess age and gender An forensic based retrospective Cone Beam CT study.

DR. SINDHUJA.N¹, DR. SARASWATHI K GOPAL², DR. MAHESH
KUMAR.P³.

¹ Post graduate, Department of Oral Medicine and Radiology, Meenakshi Ammal Dental College and Hospitals,
Chennai -95

² Professor and Head of the Department, Department of Oral Medicine and Radiology, Meenakshi Ammal
Dental College and Hospitals, Chennai -95

³ Associate professor, Department of Oral Medicine and Radiology, Meenakshi Ammal Dental College and
Hospitals, Chennai -95

CORRESPONDING AUTHOR : Dr. Sindhuja.N,

Post graduate,

Department of Oral Medicine and Radiology,
Meenakshi Ammal Dental College and Hospitals, Chennai-95

ABSTRACT

BACKGROUND: The identification of skeletal remains is of paramount importance in medicolegal investigations and anthropological works. Pelvis and skull were the most often investigated skeletal components for personnel identification. Mandible is a dimorphic, huge and a strong bone, playing a crucial role in cases where the intact skull is not found as in mass disasters it can retain its shape better than other bone and commonly resist post mortem damages. Various parameters in the Mandible can be considered as a valuable tool in gender and age determination since it is highly resistance to damage.

AIMS AND OBJECTIVES: To evaluate various parameters in the Cone beam computed tomography images of male and female patients which would benefit in effective age and gender determination using morphometric measurements of mandible.

MATERIALS AND METHODS: A retrospective study was conducted in 90 archived CBCT images of patients of age 20-65 years. The images were acquired using ProMax 3D Mid Proface. The measurements were taken bilaterally for each patient and a total of 180 sides were evaluated. The study group was divided into three subdivisions; group 1 : age 20-35, group 2 : age 36-50, group 3 : age 51-65. Each group contains 30 samples which was equally divided into 15 males and 15 females. All the images were assessed using RadiAnt dicom viewer software and various metric measurements in mandible were evaluated which height of condyle, height of coronoid, angle between coronoid and condyle, gonial angle, mandibular width, inter Condylar and inter Coronoid distance.

RESULTS: For gender determination, there was a statistically significant difference seen in height of the coronoid, height of condyle, gonion angle on right side, intercondylar and intercoronoid distance with their mean values 6.25 ± 0.49 , 5.85 ± 0.46 , 126.35 ± 7.1494 , 11.39 ± 0.59 , 9.30 ± 0.58 in males and 5.86 ± 0.40 , 5.37 ± 0.44 , 129.63 ± 6.74 , 11.06 ± 0.55 , 9.04 ± 0.45 in females respectively, these differences gave out highly significant results proving these parameters can be used effectively in differentiating between genders. For determining age Regression analysis was done and equation was obtained for it. While substituting the values in equation, it gives a statically significant (p value:0.0270) for age estimation in all the groups.

CONCLUSION: The mandibular parameters like height of the coronoid, height of the condyle, gonion angle intercondylar distance and intercoronoid distance can be effectively used to determine gender and age in forensics for personnel identification

KEYWORDS: Forensic dentistry, Mandible, Cone Beam Computed Tomography.

ABBREVIATIONS: CBCT- Cone Beam Computed Tomography, 2D- 2 Dimension, 3D-3 Dimension, OPG- Orthopantomogram, R- Right, L- Left, ICDR- Intercoronoid distance right, IC DL- Intercoronoid distance left.

Date of Submission: 06-06-2022

Date of Acceptance: 21-06-2022

I. Introduction

The definitive identification of human remains is essential in forensic investigations and anthropological work, mainly during investigation of criminal cases and in the identification of accident or natural disaster victims.⁽¹⁾ The eye of forensics has witnessed various mass disasters and natural calamities

where skeletal remains were the basis for establishing the identity.⁽²⁾ Mandible is a dimorphic, huge and a strong bone, playing a crucial role in cases where the intact skull is not found.⁽³⁾ In mass disasters it can retain its shape better than other bone and commonly resist post mortem damages.⁽⁴⁾ Mandible exhibits many morphological and anatomical changes with gender and advancement in age.⁽⁵⁾ and it exhibits differences in Stages of mandibular development; growth rate and the duration of the growth are different in both the sexes and hence these characteristics can be used as an aid in differentiation of the age and gender.⁽⁵⁾ The oral and maxillofacial radiographic field had discovered tracks which are advantageous to mankind in which the radiographs play a crucial role in personal identification.⁽⁶⁾ The mandible is an important tool for radiological identification due to its ease of imaging.⁽⁵⁾ Studies have demonstrated that CBCT is a highly accurate method in assessing linear and angular measurements of mandibles when they were compared with anatomical measurements.⁽²⁾ This present study describes metric approach such as linear and angular measurements on mandible to estimate age and gender in an Indian population such a model could be used as an auxiliary tool to predict age and gender in personnel identification in forensic context.

II. Materials And Methods

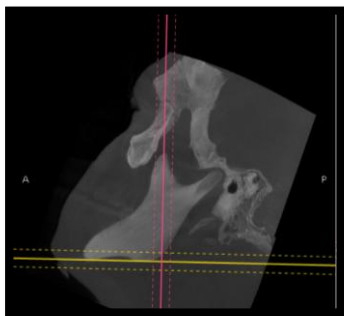
This retrospective study was conducted by obtaining 90 archived CBCT images of patients whose age ranged between 20 to 65 years . All the images were recorded in Planmeca Promax 3D Mid Pro Face machine. The measurements were taken bilaterally for each patient and a total of 180 sides were evaluated. The study population included 45 male and 45 female CBCT images of good quality and the study group was divided into three subdivisions ; group 1 :age 20-35, group 2 : age 36-50 , group 3 : age 51-65. Each group contains 30 samples which was equally divided into 15 males and 15 females. All the images were assessed using RadiAnt dicom viewer software. The images with artifacts, developmental disturbances , pathologies in the jaw region were excluded.

Various paraments such as condyle height ,coronoid height, angle between condyle and coronoid , intercondylar distance and intercoronoid distance, gonion angle and mandibular width were measured , the images were sliced at 10 mm size thickness for measuring condyle height ,coronoid height, angle between condyle and coronoid , intercondylar distance and intercoronoid distance. For measuring gonion angle and mandibular width the slice thickness was increased up to 50mm.

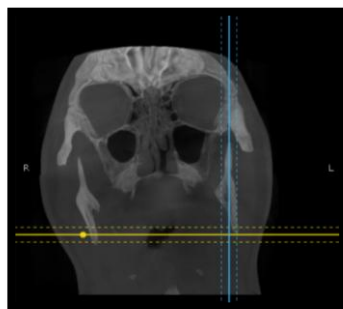
All the CBCT images were standardised prior to measurements such as, the images were tilted in such a way that the lower border of mandible parallel to the horizontal/ Frankfort plane and the intersection point between horizontal and vertical line is place in the deepest portion of sigmoid notch the intersecting line has been cross checked in coronal and axial view. In coronal view ,the intersecting line splits mandible body into two equal halves. In axial view, the intersecting line divides condyle head into two equal halves.

METHODOLOGY FOR METRIC ANALYSIS:

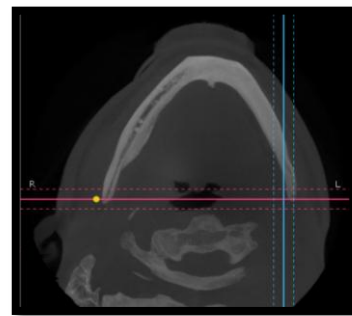
Step 1: standardisation



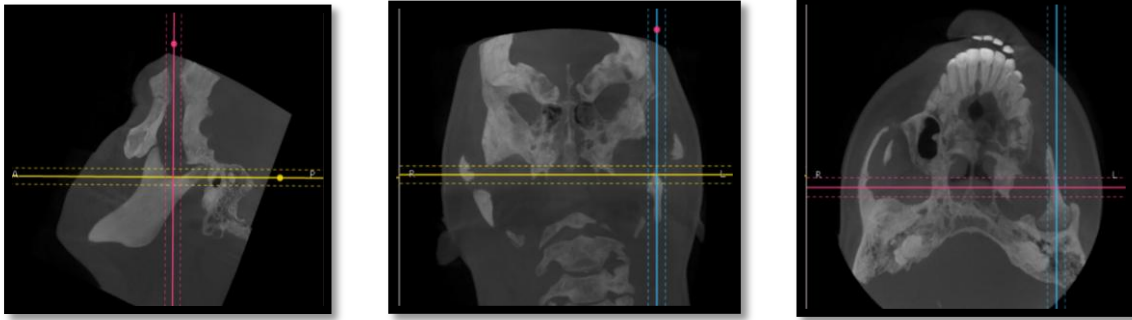
sagittal



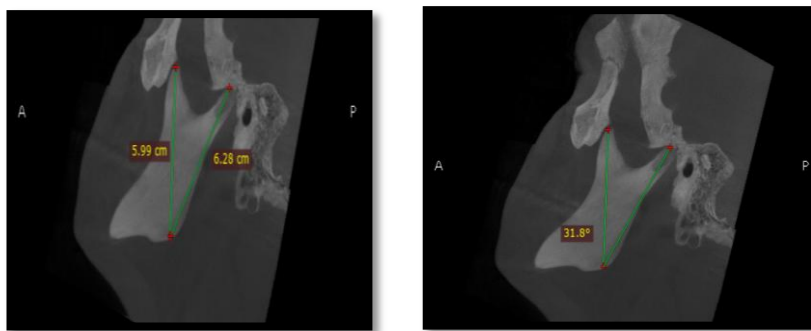
Coronal



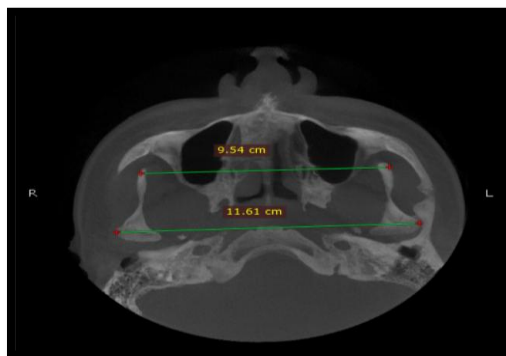
Axial



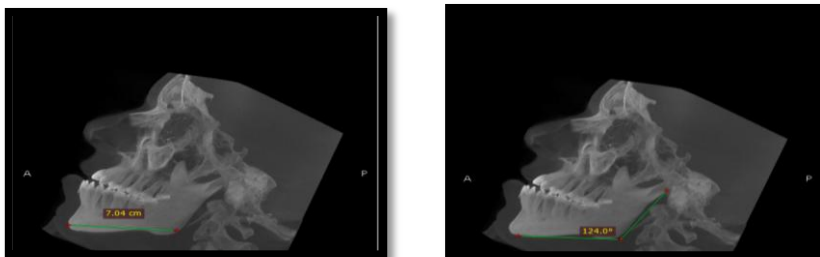
Step 2 : For condylar height and coronoid height, the measurements were taken from highest point in coronoid and condyle till the gonion and for measuring angle between condyle and coronoid , the same reference were used.



Step 3: The measurements for intercoronoid and intercondylar distance was made in axial section from a line drawn from most lateral point on one side to other side.



Step 4: For measuring mandibular width , a line was drawn from gonion to menton and linear measurement were recorded. For measuring gonion angle , a tangent line was drawn from lower border of mandible and to the lateral border of head of condyle



Step 5:

Gender estimation formulae: $-22.31 + (2.69 * L \text{ Condylar height}) - (2.68 * R \text{ Condylar height}) - (1.375 * L \text{ Coronoid height}) + (3.545 * R \text{ Coronoid Height}) - (0.97 * L \text{ angle between condyle and coronoid}) + (0.127 * R$

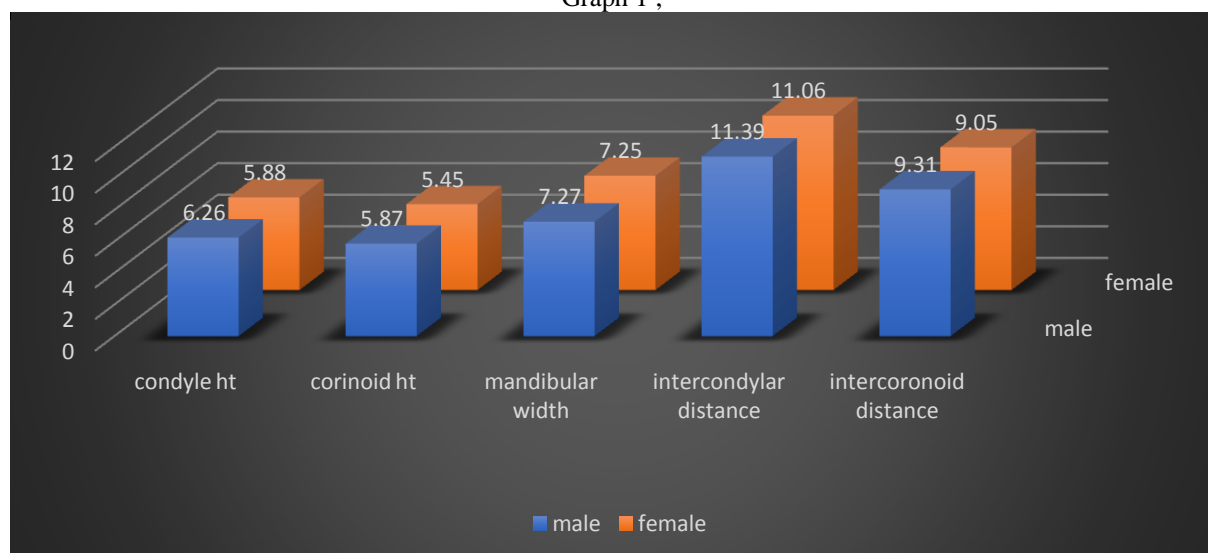
Angle between condyle and coronoid) + (0.051*L Gonial Angle) – (0.034*R Gonial Angle) – (0.193*L Mandibular Width) + (1.039*L Intercondylar Distance) – (0.386* Intercoronoid distance) = Discriminant value
Age estimation formulae : -75.2+0.27*L Condyle height-4.10*R Condyle height – 1.24*L Coronoid height+5.02*R Coronoid height -0.83 L Angle between condyle and coronoid + 1.97*R angle between condyle and coronoid + 0.534*L Gonial Angle -0.54*R Gonial Angle – 0.45*L Mandibular Width+ 0.001*R Mandibular Width + 4.26*Intercondylar distance+6.988*Intercoronoid distance.

- The data was compiled and analyzed using SPSS software and the results were tabulated

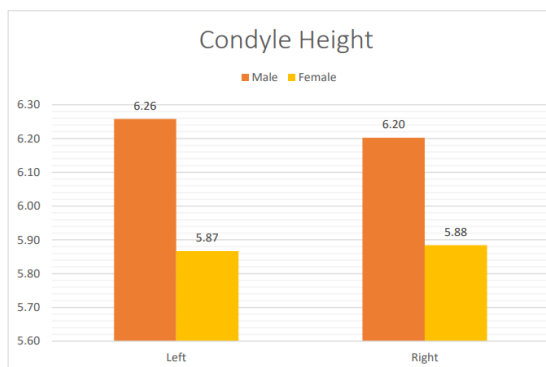
III. Results

This study evaluated various parameters of mandible in full skull CBCT images of male and female patients for age and gender determination. In analysing all the parameters between the right and left side there was only minor differences observed [TABLE 1] which shows either any side measurement can be used to differentiate between genders. Table 1 and graph 1 shows Descriptive analysis of mean values and standard deviation for determining gender differences between study subjects of both male and female. the statistical analysis of condylar height (graph 2) , coronoid height (graph 3) , angle between condyle and coronoid (graph 4), gonion angles (graph 5) ,mandibular width (graph 6), intercondylar distance and intercoronoid distance (graph 7) , shows significant P values for condyle , coronoid heights in both sides and gonion angle on right side and also significant p value is observed in intercondylar and intercoronoid distance. As far as Age estimation is considered, a regression formula is derived by using ANOVA test which gave out results with a significant p value of 0.0270. Graph 1 shows correlation of various parameters in which there is a significant difference in mean values between gender as males are having more values comparing to females.

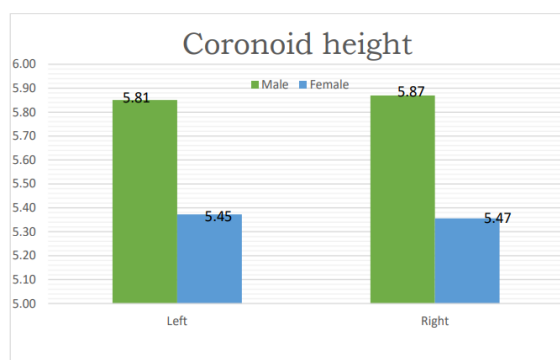
Graph 1 ;



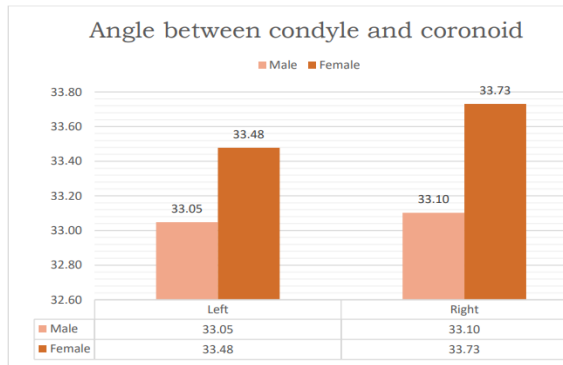
Graph 2;



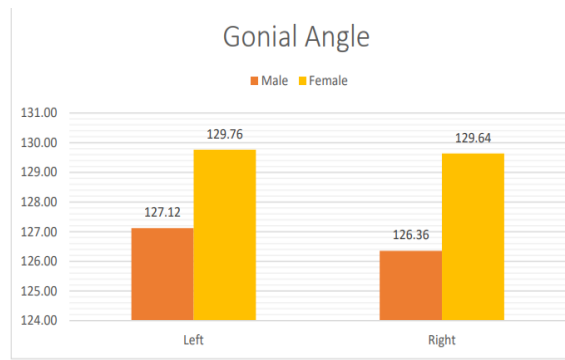
Graph 3;



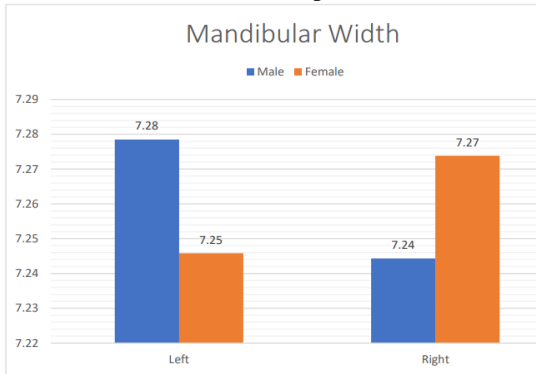
Graph 4;



Graph 5;



Graph 6;



Graph 7;

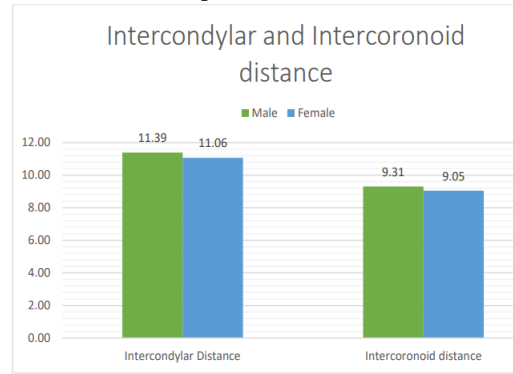


Table 1 ;

Parameters	Side	Gender	Mean	SD	P value
Condyle height	Left	Male	6.2578	.49996	0.001
		Female	5.8671	.40108	
	Right	Male	6.2024	.47599	0.001
		Female	5.8842	.40818	
Coronoid height	Left	Male	5.8509	.46270	0.001
		Female	5.3729	.44821	
	Right	Male	5.8698	.49385	0.001
		Female	5.3556	.39695	
Angle	Left	Male	33.0478	3.29516	0.49
		Female	33.4778	2.63929	
	Right	Male	33.1022	3.69700	0.35
		Female	33.7311	2.68648	
Gonial Angle	Left	Male	127.1174	7.91326	0.11
		Female	129.7644	7.82191	
	Right	Male	126.3565	7.14941	0.021
		Female	129.6356	6.74804	
Mandibular Width	Left	Male	7.2785	.52990	0.78
		Female	7.2458	.59028	
	Right	Male	7.2443	.47226	0.73
		Female	7.2738	.49865	
Intercondylar Distance	Male	11.3926	.59436	0.008	
	Female	11.0642	.55510		

Inter-Coronoid distance	Male	9.3076	.58125	0.019
	Female	9.0469	.45354	

Table 2;

ANOVA						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3052.632	12	254.386	1.242	0.0270 ^b
	Residual	15970.664	78	204.752		
	Total	19023.297	90			
a. Dependent Variable: Age						
b. Predictors: (Constant), ICDR, M WidthR, G angleL, MwidthL, AngleR, ICDL, CheightL, Co HeightR, GangleR, AngleL, CheightR, Co HeightL						

IV. Discussion

Forensic odontology or forensic dentistry is the application of dental knowledge to criminal and civil laws that are enforced by police agencies in the criminal justice system. Keiser-Neilson⁽⁷⁾ defined forensic dentistry as “branch of forensics that in the interest of justice deals with the proper handling and examination of dental evidence and the proper evaluation and presentation of dental findings” Determination of age and gender of an individual in forensics is of prime importance for administrative, ethical, medico-legal issues.⁽⁸⁾ Various studies in past decades suggested that mandible can be used as an aid for personnel identification as it is a dimorphic bone and undergoes changes in various stages of life (Scheuer, 2002; Durić et al., 2005; Hu et al., 2006)⁽⁶⁾. Several studies which were conducted for gender and age estimation were done using Digital Panoramic radiographs and lateral cephalogram which is a 2 D radiographic imaging. Hence information obtained from 2D radiograph remains inadequate in assessing fine details of 3D structure . Thus, lead to the introduction of 3D imaging technologies such as Cone beam computed tomography .⁽⁹⁾ This study utilizes CBCT which has its greatest advantages such as spatial resolution , lower radiation dose, rapid scan time for personnel identification in forensics.

The present study focusses on estimating the age and gender by mandibular morphometric measurements using CBCT imaging. The main principle of this study is to measure various parameters in mandible and compare the values between gender and different age groups as mandible has morphological differences between males and females and also age changes during different phases of life.

This current study stated that mandibular parameters such as condyle height , coronoid height shows statistically significant changes between both genders which was in accordance with the study done by Saraswathi. K.Gopal et al in 2018⁽¹⁰⁾ , Julia Gabriela Dietrichkeit Pereira et al in 2020⁽¹¹⁾ and Saini, et al in 2011⁽¹²⁾ . The intercondylar distance evaluation between the genders for determining sex shows significant difference between males and females which came in accordance with the OPG study done by Aprajita Sikka et al⁽¹³⁾ and Khalid Mohammed Ahmed in 2016⁽¹⁴⁾ but this is not in accordance with OPG study by M. Shahabi et al in 2009⁽¹⁵⁾

This study gave out results for gonial angle as significant changes were observed between male and female which came in accordance with a study done by Payal et al in 2015⁽¹⁶⁾ and Kharoshah et al in 2010.⁽¹⁷⁾

Revant.H.Chloe et al in 2013⁽¹⁸⁾ evaluated gonial angle for gender estimation and found statistically significant changes in gonion angle between males and also females had significant larger angle than males which came in accordance with this study . A study done by Saraswathi Gopal, K. in 2016⁽⁷⁾ , evaluated height of the coronoid, height of the condyle between genders and showed significant higher values in males which is also observed in this present study

Our study stated that intercoronoid distance shows significant changes between males and females with values being higher in males comparing to females, these results came in accordance with the study done in 2021 by Supraja et al⁽¹⁹⁾. This current study resulted that mandibular parameter can correlate with age with significant value of 0.0270 , this is in agreement with the OPG study done by Poongodi et al in 2015⁽²⁰⁾ and lateral cephalometric study done by Can Pelin et al in 2018⁽²¹⁾.

Parameters such as mandibular width, angle between condyle and coronoid shows insignificant changes between genders which is in agreement with the study done in 2018 by Saraswathi. K.Gopal⁽¹⁰⁾. Kharoshan et al in 2010 stated in his study done using spiral CT that gonial angle values are higher in males compared to females which is in contradiction to our study⁽¹⁷⁾. Julia Gabriela Dietrichkeit Pereira⁽¹¹⁾ in 2020 evaluated bones of Brazilian population and proposed a model for gender determination which shows accuracy of 90% whereas the proposed model in our current study shows 80% accuracy.

Furthermore, to our best knowledge there is no statistically significant results obtained when compared with right and left side, thus either side can be used for personnel identification

V. Conclusion

Age and gender estimation is an important component and fundamental aspect in forensic science in the identification of individuals. Bones are more resistant to thermal, chemical and post-mortem changes thus they can be used as a reliable approach in identification of deceased victim. As dental professionals, we can continue to play a key role by maintaining quality records and thus could be a part of the investigating team in the field of forensics. This present study was carried out using mandibular metric measurements in CBCT which shows positive correlation with age and gender (i.e., there is significant difference between males and females in most parameters and also these parameters show significance between different age groups). Based on the results of this current study, this morphometric measurement method should be considered as one of the reliable biomarkers for personnel identification in human biology studies and, also in the forensic context.

References

- [1]. Abu-Taleb NS, El Beshlawy DM. Mandibular ramus and gonial angle measurements as predictors of sex and age in an Egyptian population sample: A digital panoramic study. *J Forensics Res.* 2015;06(05).
- [2]. Assari A, Alasmari B, Aleid M, Salem M. Characteristics of mandibular parameters in different age groups. A CBCT assessment. *EC Dental Science.* 2017; 14:95–103.
- [3]. Leversha J, McKeough G, Myrteza A, Skjellrup -Wakefiled H, Welsh J, Sholapurkar A. Age and gender correlation of gonial angle, ramus height and bigonial width in dentate subjects in a dental school in Far North Queensland. *J Clin Exp Dent.* 2016;8(1): e49-54.
- [4]. B.D. Chaurasia textbook of Head and neck anatomy. Volume 3. sixth edition
- [5]. Tandon R, Ramesh A, Velpula N, Taiyebali Zardi F, Kanakagiri M. Determination of age and gender using condylar height and coronoid height- An orthopantomographic study. *Int j maxillofac imaging.* 2020;4(3):87-90.
- [6]. D. F. Determination of sex in South African Blacks by discriminant function analysis of mandibular linear dimensions a preliminary investigation using the Zulu local population". *Forensic Science, Medicine and Pathology.* 2006;2. 4:263–268.
- [7]. Dr. Saraswathi Gopal K. Sex Determination with Mandibular Ramus – A Retrospective Study Based on Cone Beam Computer Tomography. *International J Information Res and Rev.* 2016;03(ue, 05):2328–2329
- [8]. K SG, G HB, Kumar N. Implant Backtracking -A Valuable Tool in Forensic Identification- An Advanced Radiological Cbct Study. *Asian Journal of Science and Technology.* 8:20
- [9]. Venkatesh E, Venkatesh Elluru S. Cone beam computed tomography: Basics and applications in dentistry. *J Istanbul Univ Fac Dent.* 2017;51(0).
- [10]. Gopal SK. "Measure It Right"- Mandible in Forensics as an Aid in Gender Determination: A Retrospective 3D Cone Beam Computed Tomographic Study." *International Journal of Current Advanced Research.* 2018;07(8):15143–15148.
- [11]. Jg DP, Kf L, Silva RH A. Mandibular Measurements for Sex and Age Estimation in Brazilian Sampling. *Acta Stomatol Croat.* 2020; Sep;54(3):294-301.
- [12]. Saini V, Srivastava R, Rai RK, Shamal SN, Singh TB, Tripathi SK. Mandibular ramus: an indicator for sex in fragmentary mandible. *J Forensic Sci.* 2011;56 Suppl 1: S13-S16.
- [13]. Sikka, Aprajita and Anjali Jain. Sex Determination of Mandible: A Morphological and Morphometric Analysis. *International J Con. Med Res.* 2016 2454-7379 | ICV: 50.43
- [14]. Ahmed KM, Ayad CE. Normative morphometry of adult Sudanese mandible: A 3D computerized tomography -based study. *IOSR j dent med sci.* 2016;15(07):82-87.
- [15]. Shahabi M, Ramazan Zadeh B, Mokhber N. Comparison between the external gonial angle in panoramic radiographs and lateral cephalograms of adult patients with class I malocclusion. *Journal of Oral Science.* 2009;51(3):425–429.
- [16]. Dhaka P, Mathur E, Sareen M, Baghla P, Modi A, Sobti P. Age and gender estimation from mandible using lateral cephalogram. *CHRISMED J Health Res.* 2015;2(3):208.
- [17]. Kharoshah MAA, Almadani O, Ghaleb SS, Zaki MK, Fattah YAA. Sexual dimorphism of the mandible in a modern Egyptian population. *J Forensic Leg Med.* 2010;17(4):213-215.
- [18]. Chole RH, Patil RN, Balsaraf Chole S, Gondivkar S, Gadail AR, Yuwanati MB. Association of mandible anatomy with age, gender, and dental status: a radiographic study. *ISRN Radiol.* 2013; 2013:453763.
- [19]. Supraja S, Anuradha A, Guduru V, Kiresur M, Pasupuleti M, Vignatha P. Importance of sexual dimorphism of the maxillary sinus and mandibular inter coronoid distance of Vijayawada City population in Andhra Pradesh: Original research. *J Forens Sci Med.* 2021;7(3):91.
- [20]. Poongodi V, Kanmani R, Anandi MS, Krithika CL, Kannan A, Raghuram PH. Prediction of age and gender using digital radiographic method: A retrospective study. *J Pharm Bioallied Sci.* 2015;7(Suppl 2): S504-8.
- [21]. Can pelin, HandePamukçu, YağmurZengin, Hale Öktem, Ayla Kürkçüoğlu. Age estimation using mandibular dimensions: a preliminary study. *Euras J Anthropol.* 2018 9(2):41-48