ISSN : 2350-0743

International Journal of Recent Advances in Multidisciplinary Research

Vol. 11, Issue 04, pp.9667-9674, April, 2024

RESEARCH ARTICLE

MANDIBULAR MORPHOMETRIC ANALYSIS ON ORTHOPANTOMOGRAPHS : AN AID FOR AGE AND GENDER DETERMINATION – A FORENSIC STUDY

[1]Dr. Gunjan T Dave, [2]Dr. Neelampari Parikh, [3]Dr. Nileshkumar Patel, [4]Dr. Hemal Joshi and [5]Dr. Ashvinkumar B Rathod

[1]PhD Research scholar, Oral pathology, Gujarat University, Ahmedabad, Gujarat (MDS, Oral Pathology); [2]Department of Oral and Maxillofacial pathology, Faculty of Dental Sciences, Dharamsinh Desai University, Nadiad, Gujarat. (MDS, Oral Pathology); [3]Assistant Professor, Siddhpur Dental College and Hospital (MDS, Oral Pathology); [4]Karnavati School of Dentistry, Gandhinagar Gujarat (MDS, Oral Pathology); [5]Superintendent incharge, CHC Shehera, Panchmahal Dist., Gujarat state, India. MD (P.S.M.)

ARTICLE INFO

Article History

Received 11th January, 2024
Received in revised form
28th February, 2024
Accepted 06th March, 2024
Published online 30th April, 2024

Keywords:

Gender determination, Age estimation, Orthopantomograph, Discriminant function Analysis, Regression analysis.

Corresponding author:
Dr. Gunjan T Dave

ABSTRACT

Background: During the process of unknown person's identification from mutilated remains, gender determination is one of the prefatory procedures. After gender determination, age estimation helps to reduce the range of potential matches for unknown person's identification. Skeletal and dental components are chiefly used in such cases as these two structures survive longest after death of individual. Mandibular bone being more resistant to degradation & destruction, also being durable and retain shape better than other facial bones can be useful in identification. In such situations, orthopantomograph (OPG) has proven to be a valuable tool. Hence present study used mandibular morphological variables on OPG to determine gender and age in a population of Gujarat and also assess accuracy of the same. ***Material and methodology*:** In this retrospective study, data collection consisted of precalibrated OPGs of 200 dentate males & 200 dentate females, after framing inclusion and exclusion criterias. Eleven variables were measured bilaterally on mandible by using mouse driven method using image J software and statistics performed on SPSS software. ***Results and Conclusion:*** Mean values of all variables show gender discriminating features bilaterally, although all not being statistically significant. Discriminant function analysis gave centroid value of -.845 and + .845 on right side and -.832 and +.532 on left side with accuracies of 79.3% and 81.3% respectively. Similarly regression analysis for age estimation in males gave R^2 values of .328 and .306 and in females gave R^2 values of .431 and .454 for right and left side respectively. This leads to inference that OPG can be used for age and gender estimation in population of Gujarat.

Citation: Dr. Gunjan T Dave, Dr. Neelampari Parikh, Dr. Nileshkumar Patel, Dr. Hemal Joshi and Dr. Ashvinkumar B Rathod. 2024. *"Mandibular morphometric analysis on orthopantomographs: An aid for age and gender determination – A Forensic Study", International Journal of Recent Advances in Multidisciplinary Research,* 11, (04), 9667-9674.

INTRODUCTION

Personal identification is crucial part of forensic investigations when the bodies are severely damaged in cases of mass disasters as terrorists' attacks, airplane, train and road accidents, fires, mass murders, and natural disasters such as tsunamis, earth quakes and floods, etc. (1) ,(2) Skeletal and dental components are chiefly used in such cases for identification as these two structures survive longest after death of individual. (3) They also attribute to individual form and help in gender identification and age estimation. (4) Mandibular bone being more resistant to degradation and destruction amongst skull bones, and other soft tissues making the face, can serve as vital component for identification of a person. It is much durable and retains shape better than other facial bones. (4), (5), This makes mandible a pivotal tool in forensic odontology. During the process of unknown person's identification from mutilated remains, gender determination is one of the prefatory procedures. (4) After gender determination is done, age estimation helps to reduce the range of potential matches for unidentified deceased or living individuals.(6) In the case of deceased individuals, post-mortem changes like decomposition, mutilation, or skeletonization can significantly complicate identification, sometimes making it nearly impossible. In such situations, orthopantomography (OPG) has proven to be a valuable tool. This radiological technique, specifically applied to the assessment of dry skulls, offers a practical means of overcoming challenges associated with postmortem changes, contributing to more effective identification processes. (7) Orthopantomograph or panorex or digital panoramic radiograph, being a two dimensional view of maxilla and mandible can be applied for age and gender estimation.(8), (9) It is a single elegant film of image that serves as a remarkable tool in forensic radiology as it gives view of all oral structures. It not only provides better view but also unravels the intricate tapestry of dental morphology and supporting skeletal structures bilaterally. (10) This makes panoramic radiographs a reliable choice when disintegrated human remains are available (2)

Studies have also emphasized the necessity for population-specific osteometric standards due to unique skeletal characteristics in each population.(8) Social and environmental factors, genetics, and hormones play interconnected roles in influencing bone and muscle tissue growth and development. (7), (11). So this study is a step in the direction of verifying these changes in mandibular bone by means of measuring different variables from body and ramus of mandible on OPG in a sample population of Gujarat.

The aim and objective of the study were as follows

- To identify whether mandible could aid in determining individual's gender using variables from body and ramus of mandible
- To assess whether left or right side of mandible yields more accurate gender identification.
- To assess that the same variables can be used for age determination and that left or right side is better for age determination.
- To establish correlations between variables measured and age.

MATERIALS AND METHODS

Data Collection: The was retrospective study conducted in Department of Oral and Maxillofacial Pathology (OMP) and Department of Oral Medicine & Radiology (OMR) of Karnavati School of Dentistry, Uvarsad, Gandhinagar after obtaining ethical committee approval. The data was collected from records of OMR department. All the orthopantomographs were taken in Genoray Papaya digital machine (90 Kvp, 8mA). For standardisation purposes, the radiographs included were only those taken by a radiographer on the same panorama considering standard exposure parameters. The data collection consisted of orthopantomographs of two hundred (200) dentate males, two hundred (200) dentate females. Subjects were divided into four age groups 15-30, 31-45, 46-60, 61-75. Each age group of male and female had 50 subjects each.

Inclusion criteria for Panoramic radiographs: age >16–75 years, no magnification errors, no pathological lesions.

Exclucion criteria for Panoramic radiographs: magnification and distortion in radiographs, fractures of mandible, developmental disturbances of the mandible or hereditary facial asymmetries of face, history of surgical interventions (fracture & orthognathic), subjects undergoing orthodontic treatment, edentulous mandibles.

Digital Panoramic radiographs were precalibrated (Figure 1). The images were transferred from data of OMR department via CD- ROM to personal laptop. All images were saved in jpeg format. Image j © software (a public domain Java image processing and analysis program) was used for measurement of variables on body and ramus of mandible of panoramic radiographs. Variables were measured on left and right side of mandible by using mouse driven method.

Following variables were measured:

Condylar Length as the distance between the most superior point on the condyle to the most protruded point on inferior border of the ramus (12) [Figure 1].

Coronoid Length as projective distance between coronion and lower wall of bone (12) [Figure 1].

Maximum Ramus Breadth: as the distance between the most anterior point on the mandibular ramus and a line connecting the most posterior point on the condyle (5) [Figure 3].

Minimum Ramus Breadth: as smallest anteroposterior diameter of the ramus. (5) [Figure 3].

Ramal Notch Depth as the distance between the ramus tangent line and the deepest point of the ramus notch concavity (13) [Figure 2].

Gonial Angle: A mandibular line was drawn tangential to the two lowest points on the inferior border of the mandible on either side and a ramus line was drawn tangential to the posterior border of the ramus and the condyle. The intersection of these two lines formed the gonial angle (5) [Figure 2].

Ante gonial Angle was measured by tracing two lines parallel to the antegonial region that intersect at the deepest point of the antegonial notch (14) (The upward curving of the inferior border of the mandible anterior to the angular process (gonion) is known as antegonial notching.it lies at junction of body and ramus) (15) [Figure 3].

Ante gonial Notch Depth was measured as the distance along a perpendicular line from the deepest point of the antigonial notch concavity to a line parallel to the inferior border of the mandible (15) [Figure 3].

Length of body of mandible in MF region as the direct distance from the alveolar process to the inferior border of the mandible, perpendicular to the base at the level of the mental foramen (16) [Figure 1].

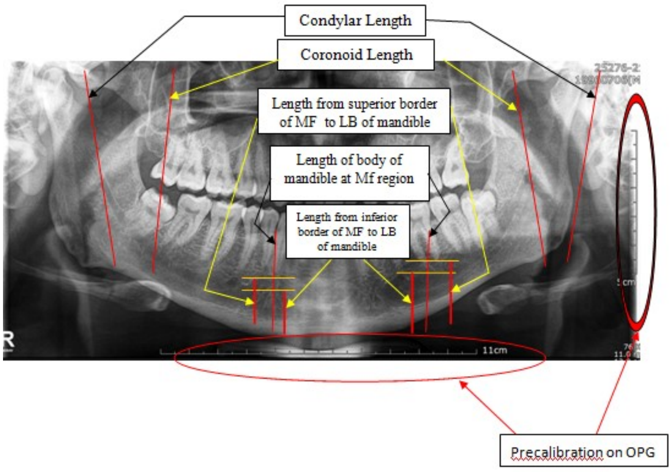


Figure 1. Image Showing Measurement Of Condylar Length, Coronoid Length, Height Of mandible At Mental Foramen Region, Distance From Superior Border Of Mental Foramen To LB Of Mandible, Inferior Border Of Mental Foramen To LB Of Mandible and Precalibration of OPG

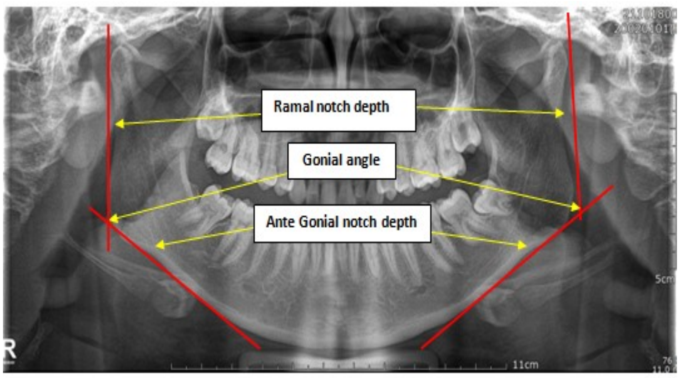
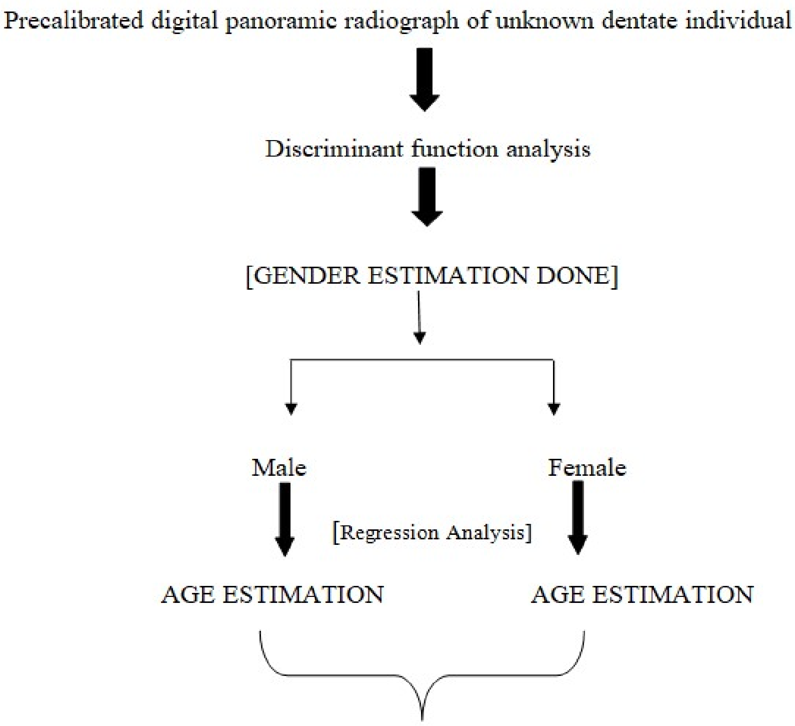


Figure 2. Image Showing Measurement of Left and Right Gonial Angle, Ramal Notch Depth and Ante Gonial Notch Depth



Leads to identification of unknown individual/suspect (or narrows down potential missing person/suspect list)

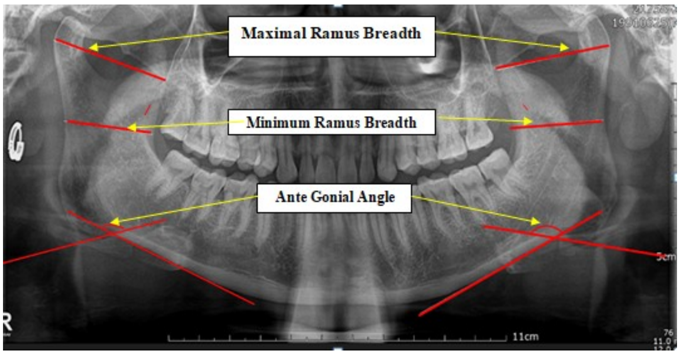


Figure 3. Image Showing Measurement Of Left And Right Maximum Ramus Breadth, Minimum Ramus Breadth, Ante gonial Angle

Table 1. Mean and standard deviation of all variables on right side of mandible of male (n = 200) and female (n=200)

Variable	Male		Female		Independent sample test
	Mean	Std. deviation	Mean	Std. deviation	Sig (2-tailed) P-value
Condylar Length	6.0065	.60180	5.5852	.42047	.000*
Coronoid Length	5.3023	.68970	5.0196	.43596	.000*
Maximum Ramus Breadth	3.3047	.55478	3.3009	.39168	.936
Minimum Ramus Breadth	2.3567	.49287	2.4487	.35257	.032#
Gonial Angle	116.8394°	7.95246°	120.2531°	5.96507°	.000*
Ramal Notch Depth	.2912	.17959	.2107	.11918	.000*
Ante gonial Angle	160.3136°	8.80872°	164.7022°	6.46384°	.000*
Ante gonial Notch Depth	.2993	.20028	.1755	.12805	.000*
Length Of Body Of Mandible At Mf Region	2.5273	.49147	2.5199	.33490	.859
Length From Superior Margin Of Mf To Lower Border Of Mandible	1.0461	.48699	1.1052	.32042	.095*
Length From inferior Margin Of Mf To Lower Border Of Mandible	.6005	.45925	.7372	.27272	.023#

All linear measurements in centimeter – cm, angles - ° (degree)
Significance → * = highly significant at level of 0.001, # = significant at level of 0.05

***Height From Superior Border Of Mental Foramen To Lower Border Of Mandible (SM - LBM))And Height From Lower Border Of Mental Formen To Lower Border Of Mandible (LM - LBM)*:** The tangents were drawn to the superior and inferior borders of the foramen and the perpendiculars were drawn from the tangents to the lower border of the mandible bilaterally. The distance was measured from the superior aspect of the mental foramen to the lower border of the mandible and the inferior aspect of the mental foramen to the lower border of the mandible (17) [Figure 1]. All the variables were measured bilaterally and tabulated separately for male and female subjects in Microsoft Excel ©

Statistical Analysis

The measurements were subjected for statistical analysis like mean, standard deviation, t-tests, Pearson's correlation, discriminant functional analysis, regression analysis using IBM SPSS software (version 23) © for purpose of age and gender estimation.

RESULTS AND OBSERVATIONS

These findings of Table 1 and 2 suggest that condylar and coronoid lengths are longer, notch depths are deeper and mandibular body height in mf region is longer in males than females bilaterally. Further gonial and antegonial angle are obtuse and mental foramen is relatively higher in females on right and left side of mandible. Additionally, independent sample t test done suggests that condylar length, coronoid length, gonial angle, ramal notch depth, antegonial angle, ante gonial notch depth show statistically significant difference bilaterally and that morphological variables on both sides of mandible show gender discriminating features. Discriminant function analysis for gender determination shows box's M statistic and canonical discriminant functions for right side and left side of mandible. The findings in the tables suggest that there are significant differences in covariance structures of variables and that discriminant function is statistically significant and discriminates between both genders from values of variables bilaterally.

Table 2. Mean and standard deviation of all variables on left side of mandible of male (n = 200) and female (n=200)

VARIABLE	Male		Female		Independent sample test
	Mean	Std. deviation	Mean	Std. deviation	Sig. (2-tailed) P-value
Condylar Length	6.0013	.65469	5.5899	.40039	.000*
Coronoid Length	5.3550	.80655	5.1508	.44277	.002#
Maximum Ramus Breadth	3.3217	.60812	3.3457	.39196	.639
Minimum Ramus Breadth	2.4428	.69209	2.4877	.35324	.415
Gonial Angle	117.3881°	8.62345°	121.0138°	5.87261°	.000*
Ramal Notch Depth	.2926	.18857	.2148	.12411	.000*
Ante gonial Angle	159.5292°	8.79064°	165.2942°	7.35224°	.000*
Ante Gonial Notch Depth	.3112	.22238	.1765	.13208	.000*
Length Of Body Of Mandible At Mf Region	2.5797	.47611	2.5605	.34567	.645
Length From Superior Margin Of Mf To Lower Border Of Mandible	1.0718	.44842	1.0895	.33940	.657
Length From inferior Margin Of Mf To Lower Border Of Mandible	.6549	.43024	.7084	.30706	.153

All linear measurements in centimeter - cm, angles - ° (degree)
Significance → * = highly significant at level of 0.001, # = significant at level of 0.05

Table 3. Box's M Statistic for right and left side

	Box's M	F Approx	df1	df2	Sig.
Right side	282.472	4.157	66	505077.163	.000
Left side	463.525	6.821	66	505077.163	.000

Table 4. Canonical Discriminant Functions for right and left side

Discriminant function/test	Eigenvalue	Canonical Correlation	Wilks' Lambda	Chi-square	Df.	Sig.
Value for right side	.717	.646	.582	212.237	11	.000
Value for left side	.695	.640	.590	207.181	11	.000

Table 5. Standardized discriminant And Classification Coefficients, Structure Matrix And Group Centroids For Variables on right side

Variables	Standardized discriminant Function Coefficients	Structure Matrix	Classification Function Coefficients		Functions at Group Centroids
			Male	**Female**	
Condylar Length	.875	.480	62.458	65.305	Female : . -.845
Coronoid Length	.195	.290	-8.981	-8.411	
Maximum Ramus Breadth	.626	.005	-9.782	-7.581	
Minimum Ramus Breadth	-.879	-.127	31.199	27.733	
Ramal Notch Depth	-.198	.313	9.844	7.646	
Gonial Angle	-.137	-.287	3.571	3.538	
Ante gonial Angle	-.179	-.336	2.213	2.173	
Ante gonial Notch Depth	.831	.436	56.832	65.185	
Length of Body of Mandible at Mf Region	-.045	.011	-27.796	-27.977	
Length From Superior Border Of Mf To LB of mandible	-.020	-.098	-3.672	-3.755	Male : .845
Length from Inferior Border Of Mf To LB of mandible	-.052	-.133	-6.574	-6.806	
(Constant)			-538.109	-546.934	

Equation for gender determination from variables measured on right side of mandible :

Male = - 538.409 + 62.458 (Condylar Length) – 8.981 (Coronoid Length) – 9.782 (Maximum Ramus Breadth) + 31.199 (Minimum Ramus Breadth) + 9.844 (Ramal notch depth) + 3.571 (Gonial Angle) + 2.213 (Ante gonial angle) + 56.832 (Ante gonial notch depth) -27.296 (Length of Body of Mandible at Mf Region) – 3.672 (Length from superior border of MF to LB of mandible) - 6.574 (Length from inferior border of MF to LB of mandible)

Female = -546.934 + 65.305 (Condylar Length) – 8.411 (Coronoid Length) -7.581 (Maximum Ramus Breadth) + 27.733 (Minimum Ramus Breadth) + 7.646 (Ramal notch depth) + 3.538 (Gonial Angle) + 2.173 (Ante gonial angle) + 65.185 (Ante gonial notch depth) – 27.977 (Length of Body of Mandible at Mf Region) – 3.755 (Length from superior border of MF to LB of mandible) – 6.806 (Length from inferior border of MF to LB of mandible)

Table 5 and 6 show - standardized discriminant and classification coefficients, structure matrix and group centroids for variables on right and left side respectively. Values mentioned for classification function coefficients for male and female led to the equations mentioned under the table with constant value.

These interplay of sexual hormones and varying strengths of masticatory muscles collectively causes difference in mandibular morphology which is reflected in many variables of ramus and body of mandible (16). Noteworthy is the impact of various factors such as nutrition, diet, climate, and pathologies on bone development patterns, leading to differing growth trajectories between males and females (7). Also studies have shown that the morphological changes in the mandible primarily stem from the individual's age and occlusal status. (22) So in this study, different morphological variables of mandible have been used to know the accuracy of gender determination and age estimation from mandible and measured 11 variables per side of the mandible totalling 22 variables per OPG, for age and gender determination within the Gujarat population. Present study reveals a significant trend, indicating that the mean values of both *Condylar height and Coronoid height* are markedly higher in males compared to females. A thorough review of existing literature, including many studies (2), (5), (7), (9), (13), (18), (21) (23), (24), (25), (26) have consistent observations in relation to condylar and coronoid length similar to present study. The collective evidence supports the assertion that condylar height and coronoid height are the most dimorphic vertical variables in the mandible, underscoring their significance in gender determination.

Table 6. Standardized discriminant And Classification Coefficients, Structured Matrix And Group Centroids For Variables on left side

Variables	Standardized discriminant Function Coefficients	Structure Matrix	Classification Function Coefficients		Functions at Group Centroids
			Male	Female	
Condylar Length	.987	.456	69.542	66.517	Female : -.832
Coronoid Length	-.330	.189	-5.503	-4.658	
Maximum Ramus Breadth	-.066	-.028	28.585	28.800	
Minimum Ramus Breadth	.067	-.049	8.115	7.911	
Ramal Notch Depth	-.454	.293	-37.246	-32.512	
Gonial Angle	-.064	-.295	3.422	3.436	
Ante gonial Angle	-.234	-.428	2.884	2.932	Male : .832
Ante gonial Notch Depth	1.351	.443	106.521	94.234	
Length of Body of Mandible at Mf Region	.038	.028	-27.991	-28.143	
Length From Superior Border Of Mf To LB Of Mandible	.865	-.027	-21.058	-24.675	
Length From Inferior Border Of Mf To LB Of Mandible	-.607	-.086	-5.619	-2.918	
(Constant)			-644.821	-637.221	

Equation for gender determination from variables measured on left side of mandible

Male = -644.821 + 69.542 (Condylar Length) – 5.503 (Coronoid Length) + 28.585 (Maximum Ramus Breadth) + 8.115 (Minimum Ramus Breadth) – 37.246 (Ramal notch depth) + 3.422 (Gonial Angle) + 2.884 (Antigonial angle) + 106.521 (antigonial notch depth) – 27.991 (Length of Body of Mandible at Mf Region) – 21.058 (Length from superior border of MF to LB of mandible) -5.619 (Length from inferior border of MF to inferior border of mandible)

Female = - 637.221 + 66.517 (Condylar Length) – 4.658 (Coronoid Length) + 28.800 (Maximum Ramus Breadth) + 7.911 (Minimum Ramus Breadth) – 32.512 (ramal notch depth) + 3.436 (Gonial Angle) + 2.932 (antigonial angle) + 94.234 (antigonial notch depth) – 28.143 (Length of Body of Mandible at Mf Region)– 24.675 (Length from superior border of MF to LB of mandible) - 2.918 (Length from inferior border of MF to LB of mandible)

Table 7. Accuracy of equations for right side and left side

	Right side				Left side			
	Original		Cross Validation		Original		Cross validation	
Gender	Male	Female	Male	Female	Male	Female	Male	Female
Accuracy of equations	75.5%	83%	74.5%	81.5%	79%	83.5%	76%	82.5%
	79.3%		78%		81.3%		86.3%	

The equation for gender determination formed are with the purpose that, when the values of measurement of variables on right side of mandible are measured on digital panoramic radiographs, are substituted in the equation of right side, if the value obtained is between 0 and -.845 it will be female and if the value is between 0 and .845, it will be male. Similarly on following same procedure for left side if the value obtained is between 0 and -.832 it will be female and if the value is between 0 and .832, it will be male. This leads to accuracy of equations derived to determine gender which is better for left side as compared to right side of mandible as shown in Table 7. Multiple regression analysis for age estimation shows R^2 values of .328 for males' right side and .454 for females' left side, serving as strong predictors of age within their respective genders. Table 10 shows Pearson's correlation between age and the variables of body and ramus of mandible in males and females. The values suggest that as age increases, in males, all the variables except gonial angle and ante gonial angle on left side show negative correlation with age, i.e. as age increases all variables decrease in value. Similar are the findings in female subjects except gonial angles and right ramal notch depth all the variables show negative correlation with age. On the contrary, ramal and ante gonial notch depths show positive correlation with age bilaterally in males and females.

DISCUSSION

Many previously done studies have shown that mandibular ramus as well as body can differentiate between genders with high accuracy. (5), (9), (18), (19), (20), (16) Additionally, the dimensions of the mandible can be influenced by the contractile activity of the masticatory muscles. (21) Sexual hormones, including androgens and estrogen, exert profound influences on the development of morphological distinctions in cranio-skeleton, including mandible.

On the right side, our findings indicate that *maximum ramus breadth* is slightly greater in males (3.3047) than females (3.3009), though statistically not significant. Conversely, on the left side female mean values for maximum ramus breadth (3.3217) surpasses the values of male maximum ramus breadth (3.3217*). Minimum ramus breadth* mean values of females are bilaterally (right: 2.4487, left: 2.4877) greater than males minimum ramus breadth values bilaterally (right: 2.3567, left: 2.4428) respectively, with no statistically significant difference. These observations align with Muskaan A et al's (23) study, where younger females exhibited greater values for maximum and minimum ramus breadth. While Sandeepa NC et al (11) observed in their study that minimum ramus breadth is having slightly greater mean value than male counterpart in only younger age group. The findings of Nagaraj et al (27)were similar to findings of present study, they observed no significant difference between male and female subjects in term of maximum and minimum ramus breadth. Similarly Behl A et al (28) observed no significant difference between both genders in terms of right maximum ramus breadth and left minimum ramus breadth in their study. Lastly, Rajkumari et al (2)observed no significant difference between genders in terms of right minimum ramus breadth in their study. Notably, variations exist among different studies. Conversely, Indira et al (8) and More et al (3) reported contrary results, highlighting the influence of ethnic diversity and varied reference points for measurement. Considering the impact of chewing patterns and muscular forces on ramal breadth, due to attachment of masseter and medial pterygoid muscles to the lateral and medial surfaces of the ramus, respectively, there is potential for diverse bone deposition and resorption. (More etl). *Ramal Notch Depth* measurement was identified as the distance along a perpendicular line from the deepest point of the ramus notch concavity (29). Present study showed deeper ramal notch depth in males than females in dentate subjects on both right and left side and the difference was statistically significant. Similar were findings of Sairam et al in young and old dentate subjects on both right and left side of the ramus in their study. We can note here that ramal breadth and ramal notch depth have inverse relationship. These findings suggest that increased masticatory forces in males causing excessive resorption of ramal breadth and thereby increasing ramal notch depth. Another variable which shows more values in males than females on both right and left side is *Ante gonial notch depth* with statistically significant difference. Kolodzieg et al. suggested that the extreme depth of the antigonial notch may carry predictive value for facial growth, serving as an indicator of mandibular development (15). Shaminey et al (26) and Chole et al (31) did find higher mean values of AND in males but no statistically significant difference between male and female values were found. Ghosh et al (15) measured antegonial notch depth bilaterally, but did not show statistically significant difference between male and female in all age groups.

Present study reveals statistically significant differences in *antegonial angles* between males and females. Mean values of antegonial angles are higher in females in both the right and left sides. The antegonial region, situated at the lower mandible, undergoes bone resorption, leading to decreased antegonial angles and increased depths. Hormonal changes influencing bone metabolism and variations in muscular activity in the antegonial region may contribute to gender differences(30), (15). When comparing the findings of antegonial angles, findings of present study align closely with those of Ghosh et al. (2010) (15), Chole et al. (2013) (31), Singh B et al. (2016) (14), and Shahroom NSB et al. (2020) (30), despite variations in the statistical tests employed. Sexual hormones, including androgens and estrogen, exert profound influences on the development of morphological distinctions in cranioskeletals among different genders as well as variations in the pace of growth during adulthood. Notably the rate of bone growth in adult women tends to be less rapid when compared to men. This observation aligns with the findings of Enlow in 1982, who articulated that local factors, such as robustness of masticatory muscles and bite force, wield a significant influence on craniofacial skeletal transformations. In broad terms, men typically possess stronger muscles and exhibit greater bite force capabilities in contrast to women. (16) Consequently this leads to greater accumulation of bone along the lower border of the mandible in men as opposed to women.

These interplay of sexual hormones and varying strengths of masticatory muscles collectively causes difference in mandibular morphology across the gender. (16)These reasons may be responsible for increased ante gonial notch depth and decreased antegonial angles in males and also increased condylar and coronoid height in males. Our study reveals a observation that *gonial angle* exhibits a greater mean value in females (120.2531, 121.0138) compared to males (116.8394, 117.3881). This intriguing finding may be attributed to the influence of greater masticatory forces, resulting in a smaller gonial angle in males. Additionally, gender differences in mandibular rotation, with females showing a downward and backward rotation and males displaying a forward rotation, also impact the gonial angle. (30) These findings align consistently with research conducted by various authors. (2), (5), (7), (10), (13), (18), (28), (30), (31). However, contradictory observations were noted in other studies by Upadhyay et al (2012) ((31))and Bhuyan et al (2018) (21), where males exhibited higher gonial angle values than females. Dutra et al, (32) on the other hand, found no significant differences between genders in relation to the gonial angle, potentially attributed to diverse ethnic populations and prevalent habits, as suggested by Bhuyan et al.

Values of length from *Superior and inferior margin of mf to lower border of mandible* on right side and left side present distinctive results concerning the location of the mental foramen in males and females. These variations may be attributed to the diverse racial composition of our study population, as highlighted by Sahni et al. (34) Notably, females in our study exhibit a higher location of the mental foramen compared to male subjects. Importantly, there is statistically significant difference observed on both the right and left sides between male and female subjects with respect to all three variables. These results are similar to the findings of Sahni P et al (34), Asrani et al (16), Suragimath et al, (35) Dosi T et al. (20) and Shaminey et al. (26) However, findings of present study are contradictory to the findings of Vodanovic et al, (36) who proposed that the parameter of height from the inferior border of the mental foramen to the lower border of the mandible does not correlate with gender discrimination. Present study used discriminant function analysis for determining gender because of its ability to differentiate between groups. (5) It is reliable, reproducible, reduces researcher's subjective judgement. (11) It can also suggest that which combination of variables can best predict group. (5) It's clear that the accuracy rates for gender determination using mandible can vary between different studies and populations. Here are some of the accuracy rates from various studies: Sandeepa NC et al 92%(11) , Karmakar et al 89.67% (37), Poongodi et al 80.2% (7), Talesb NSA et al 79.6% (18), Indira et al: 76%(8), Kumar BS 76%(24), Sambhana et al 75.8% (5), Jambunath et al 72%(9), Nagraj et al 71 %, (27) More et al: 69%,(3) Samantha et al 60%.(12) In our study accuracy of gender determination was computed to be 81.3% for left side and 79.3% for right side. Present study used linear regression analysis for age estimation and also investigated relation of each variable with age. The R^2 values obtained in present study for male subjects were .299 and .298 for right side and left side respectively. While in females the R^2 values were 0.468 and 0.449 of left side and right side respectively. These results are comparable to that of Sairam et al (13) who in their study used multiple regression analysis and calculated R^2 value of 0.124 and 0.10 for their study subjects for whole samples including males and females.

Talesb NSA et al calculated stepwise linear regression analysis in their study in Egyptian population and inferred that coronoid height was significantly related to age determination in males and females. (18) Rajkumari S et al computed linear regression analysis and inferred that coronoid height, maximum ramus breadth and gonial angle are the parameters contributing to predicting age. (2) Shahban AAE-R et al in their study calculated regression equation using mental foramen variables for younger age groups only.(17) Asrani et al inferred that age estimation can be done for dentate subjects using mental foramen indices bilaterally using regression analysis. (16) In comparison with above mentioned studies our study determined length from superior border of mental foramen to lower border of mandible and length from inferior border of mental foramen to lower border of mandible were the only variables which were significantly contributing to the regression equation for age determination in males on right side as well as left side. Additionally on right side ramal and gonial notch depth were contributing to age estimation in males. In females condylar length, coronoid length, antegonial notch depth and length from inferior border of mental foramen to lower border of mandible contribute statistically significantly to the regression equation of age determination bilaterally while ramal minimum breadth, ramal notch depth, antegonial angle, antegonial notch depth and length from superior border of mental foramen to lower border of mandible contribute to equation of age estimation on right side with statistical significance of 0.000. On computing relationship between age and variables of male and female subjects, condylar length, coronoid length, maximum ramus breadth, minimum ramus breadth, length of body of mandible, length from superior and inferior border of mental foramen to lower border of mandible show negative correlation values. This shows that as age increases the values of these variables in male and female decrease bilaterally.

Contradictory observations were found by and Rajkumari et al (18) in relation to condylar length and coronoid length, maximum and minimum ramus breadth (18)Further contradictory observations were inferred by Shaaban AAE et al, in reference to variables of mental foramen region, who observed a positive correlation between these variables and age until the age of 17, after which no correlation was found.(16) Discrepancies in these findings may arise from variations in the populations studied, and various other environmental factors. (18). Except right RND in females, all RND values of all subjects show positive correlation with age i.e. as age increases RND increases in male subjects bilaterally and in female subjects on left side. This verifies inverse relationship of RND and ramus breadth. Importantly, our study indicates that the gonial angle did'nt show correlation with age, in study subjects, aligning with the findings of Taleb NSA et al, (18) Rajkumari S et al (2) in 2019, and Chole et al in 2013(31). While Leversha et al (10) observed an increase in the gonial angle with age, this difference was not statistically significant in older age groups.(10) Similar trends were observed by Bhuyan et al (21)and , Poongodi et al (7)and Shahroom et al. (29) Conversely, Behl et al (2020) concluded that the gonial angle decreases with age.(28) Antegonial angle correlates with the age of females, showing a decrease as age increases. This finding is in agreement with Ghosh et al., though their study did not distinguish between genders.(15) No statistical correlation was observed between age and antegonial angle in males in present study, consistent with the findings of Dutra et al.(32) and Shahroom et al (30).

In present study, as age increases in male and female subjects, antegonial notch depth increases on both the right and left sides. This contrasts with Ghosh et al.'s findings, where no correlation with age was observed (15). This retrospective study done in Gujarat population has provided valuable insights leading to a firm conclusion that Gender determination can be done with highest accuracy using all the variables together and that left side of mandible is a better predictor of gender than right side. Similarly age estimation can be done using same variables with left side being better predictor in females and right side being better predictor in males. Most of the morphological variables show correlation with age except gonial angle in male and female bilaterally, antegonial angles in males bilaterally and right ramal notch depth in females.

Acknowledgement: Dr. Anil patel, Senior Lecturer dept of Oral and Maxillofacial Pathology for assistance in Data collection, Dr Virendra chavda, Associate Professor, MBA Department, Gandhinagar institute for Management for biostatistics.

Conflict of Interest: none.

Financial Support: Nil.

REFERENCES

1. Krishan K, Kanchan T, Garg AK. Dental Evidence in Forensic Identification - An Overview, Methodology and Present Status. Open Dent J. 2015; 9:250–6.
2. Rajkumari S, Nikitha K, Monisha S, Nishagrade S, Thayumanavan B, Murali BA. Role of Orthopantamograph in Forensic Identification: A Retrospective Study Among Chennai Population. J Pharm Bioallied Sci. 2019 May;11(Suppl 2):S393–6.
3. More CB, Vijayvargiya R, Saha N. Morphometric analysis of mandibular ramus for sex determination on digital orthopantomogram. J Forensic Dent Sci. 2017;9(1):1–5.
4. Hazari P, Hazari R, Mishra S, Agrawal S, Yadav M. Is there enough evidence so that mandible can be used as a tool for sex dimorphism? A systematic review. J Forensic Dent Sci. 2016;8(3):174. doi: 10.4103/0975-1475.195111
5. Sambhana S, Sanghvi P, Mohammed R, Shanta P, Thetay AR, Chaudhary V. Assessment of sexual dimorphism using digital orthopantomographs in South Indians. J Forensic Dent Sci. 2016;8(3):180. DOI: 10.4103/0975-1475.195113
6. Duangto P, Janhom A, Prasitwattanaseree S, Mahakkanukrauh P, Iamaroon A. Age Estimation Methods in Forensic Odontology. J Dent Indones. 2016 Dec 31;23(3):74–80.
7. Poongodi V, Kanmani R, Anandi M, Krithika C, Kannan A, Raghuram P. Prediction of age and gender using digital radiographic method: A retrospective study. J Pharm Bioall Sci. 2015;7(6):504.
8. Markande A, David M, Indira A. Mandibular ramus: An indicator for sex determination - A digital radiographic study. J Forensic Dent Sci. 2012;4(2):58.
9. Jambunath U, Govindraju P. Sex Determination by using Mandibular Ramus and Gonial Angle – a Preliminary Comparative Study. 2016;3(11):3 278-3280
10. 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. doi:10.4317/jced.52683
11. Sandeepa N, Atheer Abdulhade Ganem2. Mandibular Indices for Gender Prediction: A Retrospective Radiographic Study in Saudi Population. J Dent Oral Health. 2017 Nov 17;3(9):7.
12. Samatha K, Byahatti S, Ammanagi R, Tantradi P, Sarang C, Shivpuje P. Sex determination by mandibular ramus: A digital orthopantomographic study. J Forensic Dent Sci. 2016;8(2):95-8.
13. Sairam V, Potturi GR, Praveen B, Vikas G. Assessment of Effect of Age, Gender, and Dentoalveolar Changes on Mandibular Morphology: A Digital Panoramic Study. Contemp Clin Dent. 2018 Mar;9(1):49–54.
14. Singh B, Singh S, Narang RS, Kaur K, Singh S, Kaur P. To Assess the Values of Gonial & Antegonial Angle on Panoramic Radiograph and their Role in the Gender Determination. 2016;2(4):4.
15. Ghosh S, Vengal M, Pai Km, Abhishek K. Remodeling of the antegonial angle region in the human mandible: A panoramic radiographic cross-sectional study. Med Oral. 2010;e802–7.
16. Asrani V, Shah J. Mental foramen: A predictor of age and gender and guide for various procedures. J Forensic Sci Med. 2018;4(2):76-84.
17. Shaaban A, El-Shall O. Study of Age and Gender Related Variations in Position of Mental Foramen of Some Egyptians Using Digital Panoramic Radiography. Ain Shams Journal of Forensic Medicine and Clinical Toxicology. 2017 Jun 1;29(2):36–47.
18. 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 Forensic Res 2015, 6: : 308 DOI: 10.4172/2157-7145.1000308
19. Sairam V, Geethamalika M, Kumar P, Naresh G, Raju G. Determination of sexual dimorphism in humans by measurements of mandible on digital panoramic radiograph. Contemp Clin Dent. 2016;7(4):434-9.
20. Dosi T, Vahanwala S, Gupta D. Assessment of the Effect of Dimensions of the Mandibular Ramus and Mental Foramen on Age and Gender Using Digital Panoramic Radiographs: A Retrospective Study. Contemp Clin Dent. 2018 Sep;9(3):343–8.
21. Bhuyan R, Mohanty S, Bhuyan S, Pati A, Priyadarshini S, Das P. Panoramic radiograph as a forensic aid in age and gender

estimation: Preliminary retrospective study. J Oral Maxillofac Pathol. 2018;22(2):266-70.

22. Shah P, Venkatesh R, More C, Vaishnavee V. Age- and sex-related mandibular dimensional changes: A radiomorphometric analysis on panoramic radiographs. *Indian J Dent Res.* 2020;31(1):113-7. DOI: 10.4103/ijdr.IJDR_327_18.
23. Muskaan athiyaa. Mandible-An Indicator for age and sex determination using digital Orthopantomogram. *Sch J Dent Sci.* 2015;2((1)):82–95.
24. Kumar B, S. A Digital Radiographic Study for Gender Prediction Using Mandibular Indices - Count Search. *International Journal of Science and Research* (IJSR) [Internet]. Available from: https://www.ijsr.net/
25. Kartheeki B, Nayyar A, Sindhu Yu, Lakshmana N. Accuracy of mandibular rami measurements in prediction of sex. Arch Med Health Sci. 2017;5(1):50-4.
26. Shaminey DSA. Gender Based Variations in Morphological Features of Mandible in Digital Panoramic Radiographs - A Comparative Study. Saudi J Oral Dent Res, January 2019; 4(1): 31-47
27. Nagaraj T, James L, Gogula S, Ghouse N, Nigam H, Sumana CK. Sex determination by using mandibular ramus: A digital radiographic study. Nagaraj T, editor. JMRPS. 2017;4(4):5–8.
28. Behl A, Grewal S, Bajaj K, Baweja P, Kaur G, Kataria P. Mandibular ramus and gonial angle—Identification tool in age estimation and sex determination: A digital panoramic radiographic study in north indian population. *J Indian Acad Oral Med Radiol.* 2020; 32(1):31-6.
29. Okşayan R, Asarkaya B, Palta N, Şimşek İ, Sökücü O, İşman E. Effects of Edentulism on Mandibular Morphology: Evaluation of Panoramic Radiographs. Sci World J. 2014;2014:1–5. http://dx.doi.org/10.1155/2014/254932
30. Nor Syakirah Binti Shahroom1 GS. Relationship between Radiographic Evaluation with Age and Gender – A Radiographic Study. Indian Journal of Forensic Medicine & Toxicology. 2020 Jan 16;14(1):346–50.
31. Chole RH, Patil RN, Balsaraf Chole S, Gondivkar S, Gadbail AR, Yuwanati MB. Association of Mandible Anatomy with Age, Gender, and Dental Status: A Radiographic Study. ISRN Radiology. 2013 Dec 18;2013:1–4.
32. Upadhyay R, Upadhyay J, Agrawal P, Rao N. Analysis of gonial angle in relation to age, gender, and dentition status by radiological and anthropometric methods. J Forensic Dent Sci. 2012;4(1):29-33. DOI: 10.4103/0975-1475.99160
33. Dutra V, Yang J, Devlin H, Susin C. Mandibular bone remodelling in adults: evaluation of panoramic radiographs. Dentomaxillofacial Radiology. 2004 Sep;33(5):323–8.
34. Sahni P, Patel RJ, Shylaja, M JH, Patel A. gender determination by pantomographic (opg) analysis of mental foramen in north gujarat population- a retrospective study. Medico Research Chronicles. 2015 Nov 10;2(6):701–6.
35. Suragimath G, Ashwinirani SR, Christopher V, Bijjargi S, Pawar R, Nayak A. Gender determination by radiographic analysis of mental foramen in the Maharashtra population of India. J Forensic Dent Sci. 2016;8(3):176. DOI: 10.4103/0975-1475.195114
36. Vodanović M., Dmancic J, Demo, Z Mihelic D. Determination of Sex by Discriminant Function Analysis of Mandibles From two Croatian Archaeological Sites. *Acta Stomatol Croat.* 2006; 40(3):263-77
37. Karmarkar PH, Mhapuskar A, Prasad Hiremutt DR, Kale IP, Tepan M, Rao P. Mandibular Ramus: An Indicator for Gender Determination. Cureus [Internet]. 2023 Jan 25. Available from: https://www.cureus.com/articles/122332-mandibular-ramus-an-indicator-for-gender-determination

****