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Sex determination by mandibular ramus - A digital orthopantomographic study

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Abstract

Background: Sex determination by morphological assessment has been used in forensic anthropology and medico-legal cases. The most commonly used sex determining skeletal components are pelvis, followed by the skull. In cases where intact skull is not found, mandible may play a vital role in sex determination, as it is the most dimorphic bone of skull.

Aims and Objectives: 1) To assess the usefulness of mandibular ramus as an aid in sex determination. 2) To measure various measurements of mandibular ramus as observed on orthopantamographs.

Materials and Methods: A Retrospective study was conducted using orthopantamographs of 250 subjects (125 males and 125 females) with age ranging from 11-60 years. Radiographs were taken by Planne ca Proline XC Di gital Panoramic S ystem (66KV,8 mA,18s). Using Mouse-driven method 5 Parameters were measured (Maximum ramus breadth(R1), Minimum ramus breadth(R2), Condylar height(AB), Projective height of ramus(A-D), Coronoid height(C-B). The measurements of the mandibular ramus were subjected to discriminant function analysis.

Results: Linear measurements of all the study parameters showed a significant increase in the mean values in males as compared to females and were considered as the significant predictor for gender prediction.

Conclusion: The results of this study showed that mandibular ramus measurements can be useful tool for sex determination as they possess sexual dimorphism and resistance to disintegration process. However further studies with large sample size is required to taken into future consideration.

Keywords: Mandibular ramus, orthopantomography, sexual dimorphism.

Introduction

Forensic is a Latin word meaning “before the forum” and Odontology refers to the study of teeth or dentistry. Federation Dentaire International (FDI) defined Forensic Odontology as “that branch of dentistry which, in the interest of justice, deals with the proper handling and examination of dental evidence, and with the proper evaluation and presentation of dental findings.1 One of the important aspect in forensic odontology is the sex determination; which is considered the initial step in identification of cases at mass disasters, explosions, air hurricanes where bodies are damaged beyond recognition.2 Sex can be determined based on the availability of human skeleton remains. When the entire skeleton is present, sex can be identified accurately.3 However in cases of mass disasters where fragmented bones are usually found, sex cannot be determined with an 100 percent accuracy. Wherein such situations pelvis and skull bones are used.4 The most dimorphic portion of skeleton after pelvis is the skull; which provides an accuracy up to 92 per cent. But in cases where intact skull is not found, mandible can be used as it is the most dimorphic, largest , and strongest bone of skull.5 Generally males have bigger and more robust mandible in contrast to females ; this is because of different masticatory forces exerted by males and females.2 In mandible sites associated with the greatest morphological changes in size and remodeling during growth are mandibular condyle and ramus.5 Radiographs can be used in forensic studies as they provide an inexpensive, simple, and less time consuming tool for sex and age identification compared to histological and biochemical methods. 7 OPG (orthopantamographs) has many advantage over IOPAs (intra oral periapical radiograph) in forensic identification where it gives more information, wide area of maxillofacial region can be covered and it is much easier to store a single OPG than several IOPAs and also less radiation exposure when compared with IOPAs.6 Owing to above advantages of OPG, it has been taken in this study compared to other imaging Techniques. Hence the aim of the present study is to evaluate the usefulness of various mandibular parameters for sex determination.

Material and Methods

A Retrospective study was conducted using orthopantamographs of 250 subjects (125 males and 125 females) with age ranging from 11-60 years. Ideal orthopantamographs of complete dentate and partially edentulous patients were taken for the study. Any Pathology, fracture, deformed and developmental disturbances of the mandible were excluded from the study. Radiographs were taken by Planneca Proline XC Digital Panoramic system (66 KV,8mA,18 s). Since it was retrospective study, data was available in the department. Therefore, no ethical clearance was required. The following parameters were measured using mouse-driven method (ie, by moving the mouse and drawing lines using chosen points on the digital panoramic radiograph).

1. Maximum ramus breadth (R1): The distance between the most anterior to the most posterior point of the ramus passing through sigmoid notch.

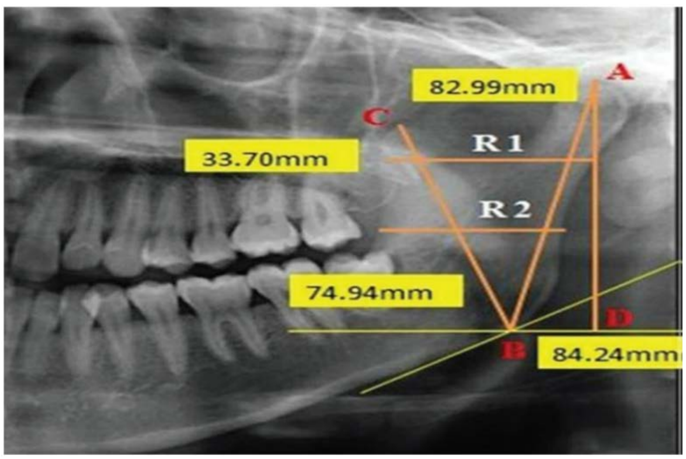
2. Minimum ramus breadth (R2): The distance between the most anterior to the most posterior point of the ramus at the level of the occlusal plane along a line parallel to the previous one.

3. Condylar height maximum ramus height(A-B): The distance from the condylion (The craniometric point at the tip of the mandibular condyle) (A) the intersection of the orientation line with the inferior border of ramus(B).

4.Projective height of ramus (A-D): Projective distance between the condylion (A) and the orientation line(D)

5. Coronoid height (C-B): The distance between coronion (the craniometric point at the tip of the coronoid process of the mandible(C) and the intersection of the orientation line with the inferior border of ramus(B). Obtained data was subjected to statistical analysis. Discriminant function analysis for the linear measurements of Mandibular ramus for gender discrimination was performed.

Figure 1: The five linear ramus measurements on digital panoramic radiograph. R1: Maximum ramus breadth. R2: Minimum ramus breadth. AB: Condylar ramus height. CB: Coronoid ramus height. AD: Projective ramus height.



Results

Table 1

Age and Gender distribution among study subjects			
Variable	Category	n	%
Age	11-20 yrs.	14	5.6%
	21-30 yrs.	104	41.6%
	31-40 yrs.	59	23.6%
	41-50 yrs.	36	14.4%
	51-60 yrs.	26	10.4%
	> 60 yrs.	11	4.4%
		Mean	SD
	Mean & SD	35.39	12.90
	Range	11 - 78	
Gender	Males	125	50.0%
	Females	125	50.0%

125 male and 125 female mandibular ramus measurements were taken; out of which majority of sample belong to age group of 21-30 yrs. overall mean age was (35.39±12.90 years).

Table 2

Gender wise comparison of mean values of different study parameters using Independent Student t Test						
Parameters	Gender	N	Mean	SD	Mean Diff	P-Value
R1(Maximum ramus breadth)	Males	125	40.19	3.91	2.49	<0.001*
	Females	125	37.70	3.38		
R2(Minimum ramus breadth	Males	125	33.47	3.74	2.11	<0.001*
	Females	125	31.36	3.26		
A-B(Condylar height)	Males	125	69.31	5.38	6.51	<0.001*
	Females	125	62.80	4.86		
C-B(Coronoid height)	Males	125	62.23	5.03	6.08	<0.001*
	Females	125	56.16	4.85		
A-D(Projective ramus height)	Males	125	67.54	5.45	6.80	<0.001*
	Females	125	60.74	5.13		

* - Statistically Significant Descriptive statistics of all five mandibular ramus measurements for both genders are shown in Table 2. It has been found that mean value was higher in males compared to females with statistically significant P<0.001*

Table 3

Determination of Wilk's Lambda among the significant parameters for Discrimination b/w genders			
Parameters	Wilks' Lambda	F	P-Value
R1(Maximum ramus breadth)	0.895	28.946	<0.001*
R2(Minimum ramus breadth	0.916	22.737	<0.001*
A-B(Condylar height)	0.711	100.964	<0.001*
C-B(Coronoid height)	0.724	94.527	<0.001*
A-D(Projective ramus height)	0.706	103.076	<0.001*

* Statistically Significant

Smaller values of Wilks' lambda indicate greater discriminatory ability of the function. In our study Projective ramus height has greater discriminatory ability. Wilks's lambda is significant by the F test for all independent variables, higher the F ratio more the variable will contribute for discrimination. Here in our study projective ramus height, followed by condylar height and coronoid height contribute discrimination.

Table 4

Linear Discriminant Function Coefficients		
Parameters	Males	Females
Constant	-112.401	-93.882
R1(Maximum ramus breadth)	1.800	1.709
R2(Minimum ramus breadth	-0.308	-0.224
A-B(Condylar height)	0.880	0.864
C-B(Coronoid height)	1.037	0.917
A-D(Projective ramus height)	0.531	0.381

The linear discriminate (D) function equation is as follows: -

D males = -112.401 + 1.800 (R1) - 0.308 (R2) + 0.880 (A-B) + 1.037 (C-B) + 0.531 (A-D)

D Females = -93.882 + 1.709 (R1) - 0.224 (R2) + 0.864 (A-B) + 0.917 (C-B) + 0.381 (A-D)

For classifying a given sample as male or female, the higher/maximum value of the two equations is considered.

Table 5

Group Membership model for Gender Prediction Accuracy					
			Predicted Group Membership		
Grouping Type	Expression	Gender	Males	Females	Total
Original	n	Males	98	27	125
		Females	28	97	125
	%	Males	78.4	21.6	100
		Females	22.4	77.6	100

Gender was accurately stated in 97 samples out of 125 female mandibular measurements with prediction accuracy rate of 77.6%, and 98 samples out of 125 males mandibular measurement with an accuracy rate of 78.4%.

Table 6

Discriminant function coefficients for Gender Determination among the study parameters				
Variables	Unstd. Coefficient	Std. Coefficient	Str. Matrix	Sectioning Point
R1(Maximum ramus breadth)	0.066	0.242	0.495	-0.688
R2(Minimum ramus breadth	-0.062	-0.216	0.438	
A-B(Condylar height)	0.011	0.058	0.924	
C-B(Coronoid height)	0.087	0.431	0.894	
A-D(Projective ramus height)	0.109	0.575	0.933	
Constant	-13.458			

The Gender Prediction equation from the study sample can be quoted as follows: Discriminant value: 0.066 x R1 – 0.062 x R2 + 0.011 x (A-B) + 0.087 (C-B) + 0.109 (A-D) – 13.458.

If the obtained discriminant score is more than Sectioning Point (- 0.688) is categorized as Males, less than sectioning point is considered as Females. The study revealed higher identification rates for males (78.4%) and females (77.6%) with a total accuracy rate of 78%.

Figure 2

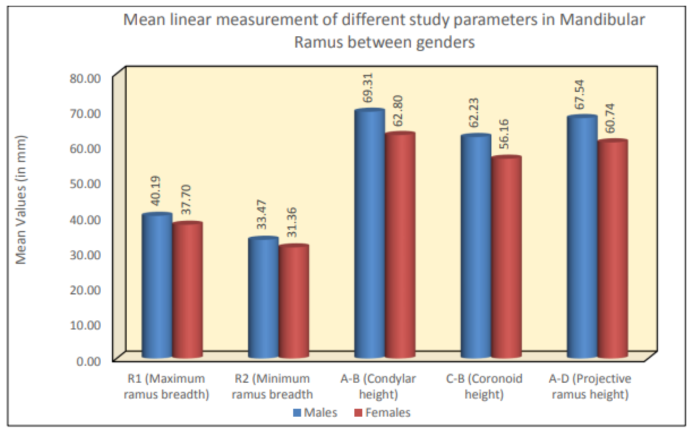


Fig 2: Depicts mean linear measurements of different study parameters. All 5 parameters were higher in males compared to females.

Discussion

Forensic experts sought dentist most often in case of mass fatalities where obscurity over personal identification arises mainly related to the age and gender discrimination.[12] Antemortem radiographs has greater role in identification of human remains. Panoramic radiographs are the extra oral radiographs that provide overall hard tissue details of maxilla and mandible and can be saved and stored for years.[13]

In the present study majority of population belong to age group of 21-30 (41.6%). Their overall mean age was (35.39±12.90 years). Which is not consistent with the study conducted by Pangotra et al and Chalkoo et al.[(11,14)]The mean value of maximum ramus breadth (2.49), minimum ramus breadth (2.11), condylar height (6.51), coronoid height (6.08), Projective ramus height (6.80) were higher in males compared to females which is consistent with the study conducted by Samatha et al and Tejashree et al and chalkoo et al.[(8,9,14)] The differences in male and female measurements is due to genetically determined factors, local factors, like muscle forces, Chewing habits, nutritional factors etc.[10]

Dayal et al. found mandibular ramus height to be the best parameter in their study, with 75.8% accuracy. In our study, mandibular ramus height found to be the best parameter with statistically significant with P = 0.001.[8]

The F-statistic values shows Projective ramus height contribute greatest sexual dimorphism followed by condylar height and coronoid height which is similar to study conducted by Saini V et al on dry adult mandibles and suggested that coronoid, condylar height for males and projective height for females are the most sexually dimorphic features and mandibular ramus is sexually dimorphic portion.[6] whereas Indira et al conducted a study where minimum ramus breadth express greatest sexual dimorphism followed by condylar height and projective height of ramus.[5] Also Pangotra et al conducted a study where highest sexual dimorphism was seen with Condylar ramus height and least with minimum ramus breadth.[11] All these due to fact that sexual dimorphism occur on those sites of mandible where there is bone remodeling. So, Ramus and condyle are usually the most sexually dimorphic because of consistent morphological changes in size and remodeling during the growth.[4]

In our study gender was accurately stated in 97 samples out of 125 female mandibular measurements with prediction accuracy rate of 77.6%, and 98 samples out of 125 male mandibular measurement with an accuracy rate of 78.4%, which is in accordance with the study conducted by Saloni et al where 76.8% females and 78.4% males were successfully identified by mandibular ramus morphological analysis on OPG with overall accuracy of 77.6%. [4] This results was not consistent with the study conducted by Shivaprakash and Vijaykumar in diagnosing the gender by observing the mandibular ramus posterior flexure where gender was accurately determined in 44 cases out of 55 male mandibles with an accuracy rate of 80%, and gender was accurately determined in 35 cases out of 49 female mandibles with accuracy rate of 71%.11 The reason might be due to difference in sample size and also due to different populations considered for different studies.[4]

Conclusion

Mandibular ramus measurements using orthopantamographs can be reliable for sex determination when compared to a known population standard.

The limitations of the study are small sample size, inability to determine the sex if the age range is below the age of complete development of mandible, and inability to assess the gender in case of completely edentulous patients. Hence further research is recommended on a larger sample from different geographic regions to improve the effectiveness of these measurements.

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