Mandibular ramus: An indicator for sex determination-A digital radiographic study

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Abstract

Objective: To measure, compare and evaluate the various measurements of mandibular ramus as observed on digital OPG and to assess the usefulness of mandibular ramus as an aid in sex determination. Materials and method: Ideal OPG of complete dentate 50 males and 50 females were selected which was taken by carestream 8000C. OPG was traced and mandibular ramus measurements were carried out manually. Mandibular ramus measurements were subjected to linear discriminant analysis. Result: Maximum ramus breadth, Minimum ramus breadth, Condylar height, Projective height of ramus Coronoid height were calculated for both the sexes differently with the formula & analysed with Discriminant function analysis using Fischer exact test. the mean combined (right and left combined) Min. ramus breadth, Max. ramus breadth, coronoid height, condylar height and projective height did not differ significantly between male and female subjects (P value>0.05 for all) with overall accuracy of 55%. Conclusion: Sex determination can be done by using mandibular ramus as overall accuracy is 55% but it is not well significant.

Keywords: Mandibular ramus, orthopantomography, sex

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INTRODUCTION

Determination of sex in skeletal remains is an important part of archaeological and many medico-legal cases. Therefore, identification of human skeletal remains is considered an initial step in diagnosis in forensic practice, investigation and anthropology. This is particularly done when bodies are damaged beyond recognition as in mass disaster, explosions, air hurricanes from decayed and damaged dead bodies and it depends largely on fragmented and available parts of skeleton.(1)

Skeletal characteristics differ in each population emphasizing the need for population specific osteometric standards for sex examination. (2, 3, 4).Next to pelvis, skull with mandible plays a vital role in identification of age, sex and race. (5).By radiological examination, sex determination of skull is possible as radiography is common accessible, less invasive and is used in routine procedures in clinics.

In cases where intact skull is not found, mandible may play a vital role in sex determination as it is dimorphic, largest and strongest bone of the skull that is often recovered largely intact as it is considered as most durable facial bone that retains its shape and is extremely durable in fire too. Presence of a dense layer of compact bone makes it durable.

Mandibular ramus can differentiate between sexes as the stages of mandibular development, growth rate and duration are distinctly different in both sexes. Also masticatory forces exerted are different for males and females which influence the shape and size of mandibular ramus. Moreover, the morphological changes of the mandible are thought to be influenced by occlusal status and age of the subject where longitudinal studies have shown that remodelling of mandibular bone occurs with age.

In forensic anthropology comparison of antemortem and post-mortem radiographs is one of the cornerstones of positive identification of human remains. So, antemortem OPG may be of great value in the identification of human remains. The presence of plenty of panoramic radiographs provides a great opportunity to study the sexual dimorphism.

Hence this present study was being aimed to evaluate various measurement of ramus with the help of OPG and the role in sex dimorphism and propose the use of same in forensic analysis.

Aims and objectives

1. To measure, compare and evaluate the various measurements of mandibular ramus as observed on digital OPG.
2. To assess the usefulness of mandibular ramus as an aid in sex determination.

Materials and methods

- A retrospective study was conducted using OPG of 50 males and 50 females. OPG showing pathologies, fractures, developmental disturbances of the mandible and edentulous mandible were excluded from the study. Ideal OPG of complete dentate patients were selected which was taken by carestream 8000C. the OPG was traced and the mandibular ramus measurements were carried out manually.

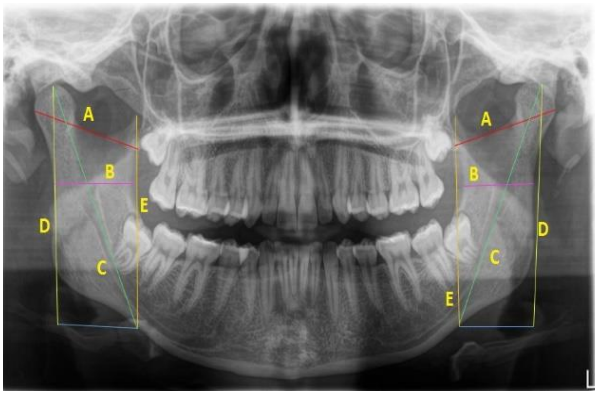


Figure 1: Measurements of mandibular ramus on orthopantomograph.

Following parameters were measured:

1. *__Maximum Ramus Breadth (A):__* Distance between the most anterior point of mandibular ramus and a line connecting the most posterior point on the condyle and angle of jaw.[6]
2. *__Minimum Ramus Breadth (B):__* Smallest anterior-posterior diameter of the ramus.[6]
3. *__Projective Height Of Ramus (C):__* Projective height of ramus is between the highest point of the mandibular condyle and lower margin of the bone.[6]
4. *__Condylar Height/ Maximum Ramus Height (D):__* Height of the ramus of the mandible from the most superior point on the mandibular condyle to the tubercle, or most protruding portion of the inferior border of the ramus.[6]
5. *__Coronoid Height (E):__* Projective distance between coronion and lower border of the bone.[6]

Statistical analysis

Descriptive statistics were expressed as means and standard deviation for each group. Between groups comparison (males v/s females) was done using Student t test. In the above tests, p value less than or equal to 0.05 ($p \leq 0.05$) was taken to be statistically significant. All analyses were performed using SPSS software version 17 and measurements were done in centimeters.

Table 1) The descriptive statistics of various mandibular ramus measurements according to sex and laterality.

	Male (n = 50)						Female (n = 50)					
	Right		Left		Combined		Right		Left		Combined	
Parameters	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Min. Ramus Breadth	4.14	0.38	4.29	0.37	4.22	0.33	4.15	0.40	4.15	0.36	4.15	0.34
Max. Ramus Breadth	3.14	0.27	3.24	0.29	3.19	0.24	3.14	0.37	3.11	0.39	3.13	0.34
Condylar Height	8.33	0.73	8.37	0.72	8.35	0.69	8.32	0.66	8.27	0.69	8.29	0.65
Projective Height	7.61	0.78	7.57	0.78	7.59	0.76	7.58	0.69	7.52	0.74	7.55	0.69
Coronoid Height	7.07	0.69	6.98	0.63	7.55	0.69	6.92	0.63	6.87	0.61	6.90	0.59

	Male (n = 50)					
	Right (n = 50)		**Left (n = 50)**		**T-value**	**P-value**
Parameters	**Mean**	**SD**	**Mean**	**SD**		
Min. Ramus Breadth	4.14	0.38	4.29	0.37	2.952	0.005**
Max. Ramus Breadth	3.14	0.27	3.24	0.29	2.326	0.024*
Condylar Height	8.33	0.73	8.37	0.72	0.520	0.605NS
Projective Height	7.61	0.78	7.57	0.78	-0.784	0.437NS
Coronoid Height	7.07	0.69	6.98	0.63	-1.678	0.100NS

Table 2a) The comparison of various mandibular ramus measurements between right and left side of male subjects studied.

P-value by paired t test, p-value<0.05 is considered to be statistically significant. *P-value<0.05, **P-value<0.01, ***P-value<0.001, NS- Statistically non-significant.

Ramus Breadth:

The mean left sided min. and max. Ramus breadth is significantly higher compared to the mean right sided.

min. and max. Ramus breadth in males (P-value<0.05 for both). As shown in table 2a.

Condylar Height:

The mean right and left sided Condylar Height, Projective Height and Coronoid Height did not differ significantly in males (P-value>0.05 for all). As shown in table 2a.

	Female (n = 50)					
	Right (n = 50)		Left (n = 50)		T-value	P-value
Parameters	Mean	SD	Mean	SD		
Min. Ramus Breadth	4.15	0.40	4.15	0.36	-0.177	0.860NS
Max. Ramus Breadth	3.14	0.37	3.11	0.39	-0.671	0.505NS
Condylar Height	8.32	0.66	8.27	0.69	-0.919	0.362NS
Projective Height	7.58	0.69	7.52	0.74	-1.087	0.282NS
Coronoid Height	6.92	0.63	6.87	0.61	-0.886	0.380NS

Table 2b) The comparison of various mandibular ramus measurements between right and left side of female subjects studied.

P-value by paired t test, p-value<0.05 is considered to be statistically significant. *P-value<0.05, **P-value<0.01, ***P-value<0.001, NS- Statistically non-significant.

The mean right and left sided Min. Ramus Breadth, Max. Ramus Breadth Condylar Height, Projective Height and Coronoid Height did not differ significantly in females (P-value>0.05 for all).

	Right Side (n = 100)					
	Male (n = 50)		Female (n = 50)		T-value	P-value
Parameters	Mean	SD	Mean	SD		
Min. Ramus Breadth	4.14	0.38	4.15	0.40	-0.155	0.877NS
Max. Ramus Breadth	3.14	0.27	3.14	0.37	0.000	0.999NS
Condylar Height	8.33	0.73	8.32	0.66	0.144	0.886NS
Projective Height	7.61	0.78	7.58	0.69	0.243	0.808NS
Coronoid Height	7.07	0.69	6.92	0.63	1.088	0.279NS

Table 3a) The comparison of various mandibular ramus right sided measurements between male and female subjects studied.

P-value by unpaired t test, p-value<0.05 is considered to be statistically significant. *P-value<0.05, **P-value<0.01, ***P-value<0.001, NS- Statistically non-significant.

The mean right sided Min. Ramus Breadth, Max. Ramus Breadth Condylar Height, Projective Height and Coronoid Height did not differ significantly between male and female subjects studied (P-value>0.05 for all).

	Left Side (n = 100)					
	Male (n = 50)		**Female (n = 50)**		**T-value**	**P-value**
Parameters	**Mean**	**SD**	**Mean**	**SD**		
Min. Ramus Breadth	4.29	0.37	4.15	0.36	2.009	0.047*
Max. Ramus Breadth	3.24	0.29	3.11	0.39	1.898	0.061NS
Condylar Height	8.37	0.72	8.27	0.69	0.719	0.474NS
Projective Height	7.57	0.78	7.52	0.74	0.275	0.784NS
Coronoid Height	6.98	0.63	6.87	0.61	0.821	0.414NS

Table 3b) The comparison of various mandibular ramus left sided measurements between male and female subjects studied.

P-value by unpaired t test, p-value<0.05 is considered to be statistically significant. *P-value<0.05, **P-value<0.01, ***P-value<0.001, NS- Statistically non-significant.

The mean left sided Min. Ramus Breadth is significantly higher in males compared to the females (P-value<0.05).

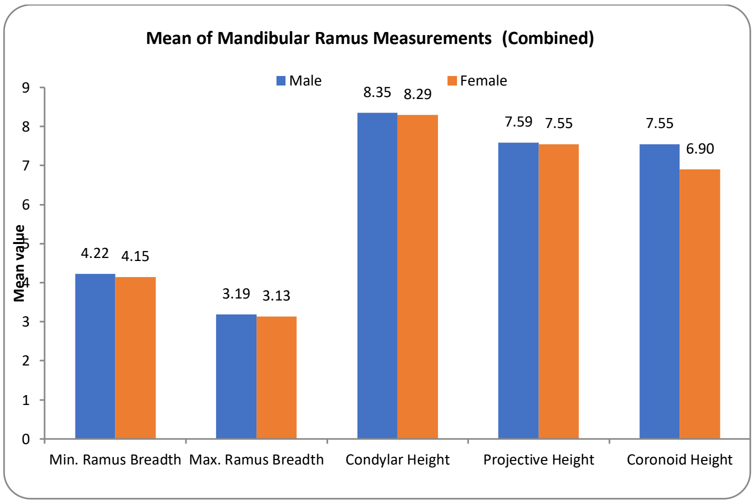
The mean left sided Max. Ramus Breadth Condylar Height, Projective Height and Coronoid Height did not differ significantly between male and female subjects studied (P-value>0.05 for all)

	Combined (n = 100)					
	Male (n = 50)		Female (n = 50)		T-value	P-value
Parameters	Mean	SD	Mean	SD		
Min. Ramus Breadth	4.22	0.33	4.15	0.34	0.999	0.320NS
Max. Ramus Breadth	3.19	0.24	3.13	0.34	1.107	0.271NS
Condylar Height	8.35	0.69	8.29	0.65	0.454	0.651NS
Projective Height	7.59	0.76	7.55	0.69	0.268	0.789NS
Coronoid Height	7.55	0.69	6.90	0.59	1.004	0.318NS

Table 3c) The comparison of various mandibular ramus combined measurements between male and female subjects studied.

P-value by unpaired t test, p-value<0.05 is considered to be statistically significant. *P-value<0.05, **P-value<0.01, ***P-value<0.001, NS- Statistically non-significant.

The mean combined (right and left combined) Min. Ramus Breadth, Max. Ramus Breadth, Condylar Height, Projective Height and Coronoid Height did not differ significantly between male and female subjects studied



The sex could be determined from calculations using the equations given below (table4).

	Right Side		Left Side		Combined	
	Male	Female	Male	Female	Male	Female
Constant	-111.852	-110.691	-140.467	-133.587	-147.383	-142.927
Min. Ramus Breadth	16.002	15.926	20.354	19.688	23.593	23.072
Max. Ramus Breadth	11.263	11.365	18.738	18.029	18.333	18.051
Condylar Height	6.763	7.101	5.951	5.559	6.898	7.079
Projective Height	0.387	0.528	3.071	3.450	0.451	0.664
Coronoid Height	8.676	7.954	8.372	8.168	10.585	9.938

Table 4) The linear discriminant function based on various mandibular ramus measurements for each sex.

Values are Classification function coefficients (Fisher's linear discriminant function).

The sex could be determined from the calculations of discriminant analysis using the equations given below:

Measurement Side	Equation based on discriminant analysis
Right	D_{Male} = -111.852 + 16.002 (Min. Ramus Breadth) + 11.263 (Max. Ramus Breadth) + 6.763 (Condylar Height) + 0.387 (Projective Height) + 8.676 (Coronoid Height).
	D_{Female} = -110.691 + 15.926 (Min. Ramus Breadth) + 11.365 (Max. Ramus Breadth) + 7.101 (Condylar Height) + 0.528 (Projective Height) + 7.954 (Coronoid Height).
Left	D_{Male} = -140.467 + 20.354 (Min. Ramus Breadth) + 18.738 (Max. Ramus Breadth) + 5.951 (Condylar Height) + 3.071 (Projective Height) + 8.372 (Coronoid Height).

	D_{Female} = -133.587 + 19.688 (Min. Ramus Breadth) + 18.029 (Max. Ramus Breadth) + 5.559 (Condylar Height) + 3.450 (Projective Height) + 8.168 (Coronoid Height).
Combined	D_{Male} = -147.383 + 23.593 (Min. Ramus Breadth) + 18.333 (Max. Ramus Breadth) + 6.898 (Condylar Height) + 0.451 (Projective Height) + 10.585 (Coronoid Height).
	D_{Female} = -142.927 + 23.072 (Min. Ramus Breadth) + 18.051 (Max. Ramus Breadth) + 7.079 (Condylar Height) + 0.664 (Projective Height) + 9.938 (Coronoid Height).

For classifying a given sample as male or female, the higher/maximum value of the two equations given above is to be considered [Table 4].

With all the variables in consideration, 55% of the cases were classified correctly [Table 5] and the accuracy can be increased by repeated iterations. The 95%CI of the accuracy of the prediction exercise was [45.2% - 64.7%]. In this study, the sectioning point was found to be −0.168, values greater than this sectioning point indicate male and values lesser than this point indicate female [Table 6].

True Group	Predicted Group Membership		Total	% Accuracy
	Male	Female		
Male	28	22	50	55%
Female	23	27	50	
Total	**51**	**49**	**100**	

Table 5) The distribution of accuracy of prediction of sex based on various mandibular ramus measurements (combined measurements).

Variable	Unstandardized coefficient	Standardized coefficient	Structure coefficient	Sectioning Point	
				Male	Female
Constant	-13.227	--	--	0.168	-0.168
Min. Ramus Breadth	1.547	0.519	0.657		
Max. Ramus Breadth	0.839	0.246	0.596		
Condylar Height	-0.536	-0.360	0.593		
Projective Height	-0.633	-0.461	0.270		
Coronoid Height	1.920	1.176	0.159		

Table 6) The distribution of standardized, unstandardized and structure coefficients along with sectioning points in the original samples (combined measurements).

For classifying the given sample as male or female, the higher/maximum value of the two equations given above is to be considered [Table4]. With all the variables in consideration, 55% of the cases were classified correctly [Table5] and the accuracy can be increased by repeated iterations. The 95%CI of the accuracy of the prediction exercise was [42.5%-64.7%]. In this study the sectioning point was found to be -0.168, values greater than this sectioning point indicate male and values lesser than this point indicate female[Table6].

Discussion

Determination of sex holds a major importance in forensic medicine and anthropology, especially in cases of explosions, warfare, and identification of missingpeople and in order to reconstruct the ancient lives. The main information of biological identity includes sex, age, stature and ethnic background of an individual which are also known as the 'BIG FOUR' in forensic context.

Morphological aspects of bone of jaw is used for sex determination but it is likely to be inaccurate because of its subjectivitybut methods based on measurements and morphometry are accurate and can be used in determination of sex from the skull.[8,9,10]. Mandible were used for analysis for 2 reasons; firstly, there appears to be a paucity of standards utilizing this element, and secondly, the bone is often recovered largely intact. [11]

Orthopantomograph is widely and routinely used by clinicians for diagnosis of oral diseases. The main advantages of panaromic image is its broad coverage, low patient radiation dose, short time required for image acquisition and has been very good source for retrospective studies. [12] Other advantages are that interference of superimposed images are not encountered, also the contrast and brightness enhancement and enlargement of images provide an accurate and reproducible method of measuring the chosen points.[13,14] The disadvantages of this technique are magnification and geometric distortion, the vertical dimension in contrast to the horizontal dimension is little altered, and this technique is quite sensitive to positioning errors because of relatively narrow image layer. [15]

In present study, mandibular ramus measurements were subjected to linear discriminant analysis. Therefore, reference points and planes for the ramus linear measurements were taken from. For ramus breadth, the transverse plane was taken as a reference plane and two measurements were performed (the maximum and minimum ramus breadths). Inferior border of ramus was used as a reference point in measuring the condylar and coronoid ramus heights, and the projective distance from the condyle to the lower margin of bone was used in measuring the projective height of ramus.

There is statistical difference found between left and right sides of males regarding the linear measurements, but in females, difference is found in all the linear measurements except in Min. ramus breadth. Subsequently, the mean of the 2 sides was taken for the further statistical analysis. The present study results reveal that statistically there is significantly higher mean values regarding all the mandibular measurements in males than in females (Max. ramus breadth 4.22(0.33) and 4.15(0.34), Min. ramus breadth 3.19(0.24) and 3.13(0.34), Condylar height 8.35(0.69) and 8.29(6.25), Projective height 7.59(0.76) and 7.55(0.69), Coronoid height 7.55(0.69) and 6.90(0.59) in males and females respectively. In the present study the mean combined (right and left combined) Min. ramus breadth, Max. ramus breadth, coronoid height, condylar height and projective height did not differ significantly between male and female subjects (P value>0.05 for all) with overall accuracy of 55%. Saini et al. conducted a studyon dry adult mandibles of north part of India and found an overall prediction rate of 80.2%.

The difference in results can be because of difference in the sample selected. Generally, the overall size and bone thickness of the male is greater than that of female; however, this is not universal, since bone and thickness depends on many things other than sex; better nutrition and heavy activity. (16) On an average, males have greater masticatory force than females (17) that influences the bone size.

Conclusion

From the present study, it can be concluded that sex determination can be done by using mandibular ramus as overall accuracy is 55% but it is not well significant. There is a need of further study with a larger sample as determination of sex can be affected by growth spurts. So to check the accuracy of the formula obtained by present study, further studies has to be done in adult age group.

REFERENCES

1. Srivastava PC. Correlation of odontometric measures in sex determination. J Indian Acad Forensic Med. 2011;32:56-61.
2. Saini V, Srivastava R, Rai RK, Shamal SN, Singh TB, et al. Mandibular ramus: an

indicator for sex in fragmentary mandible. J Forensic Sci 56 Suppl. 2011; 1: S13-16.
3. Scheuer L. Application of osteology to forensic medicine. Clin Anat. 2002; 15:297-312.
4. Giles E. Sex determination by discriminant function analysis of the mandible. Am J Phys Anthropol 1964; 22: 129-135.
5. Williams PL, Bannister LG, Berry MM.Gray's Anatomy.38th Ed, New York, Churchill Livingstone. 2000: 409-19.
6. 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(Suppl1):S13–6.
7. Vodanovic M, Dumancic J, Demo Z, Mihelic D. Determination of sex by discriminant function analysis of mandibles from two Croatian archaeological sites. Acta Stomatol Croat. 2006;40:263–77.
8. Humphrey LT, Dean MC, Stringer CB. Morphological variation in great ape and modern human mandibles. J Anat. 1999;195:491–513.
9. Franklin D, Oxnard CE, O'Higgins P, Dadour I. Sexual dimorphism in the subadult mandible: Quantification using geometric morphometrics. J Forensic Sci. 2007;52:6–10.
10. Franklin D, O'Higgins P, Oxnard CE. Sexual dimorphism in the mandible of indigenous South Africans: A geometric morphometric approach. South Afr J Sci. 2008;104:101–6.
11. Franklin D, O'Higgins P, Oxnard CE, Dadour I. Discriminant function sexing of the mandible of Indigenous South Africans. Forensic Sci Int. 2008;179:84.e1–5.
12. Indira AP, Markande A, David MP. Mandibular ramus: An indicator for sex determination - A digital radiographic study. J Forensic Dent Sci. 2012;4:58–62.
13. Shahabi M, Ramazanzadeh BA, Mokhber N. Comparison between the external gonial angle in panoramic radiographs and lateral cephalograms of adult patients with Class I malocclusion. J Oral Sci. 2009;51:425–9.
14. Laster WS, Ludlow JB, Bailey LJ, Hershey HG. Accuracy of measurements of mandibular anatomy and prediction of asymmetry in panoramic radiographic images. DentomaxillofacRadiol. 2005;34:343–9.
15. Razi T, Moslemzade SH, Razi S. Comparison of linear dimensions and angular measurements on panoramic images taken with two machines. J Dent Res. 2009;3:7–10.
16. Kumar MP, Lokhanadham S, Sex determination & morphometric parameters of human mandible. Int J. Res Med Sci. 2013; 1:93-96.
17. Al-Shamout R, Ammoush M, Alrbata R, Al-Habahbah A. Age and gender differences in gonial angle, ramus height and bigonial width in dentate subjects Pakistan Oral Dent J. 2012, 32: 81-87.