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Radiographic evaluation of mandible for gender estimation by ramus and gonial angle measurements using Orthopantomographs - A Retrospective Study

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Abstract

Background: Forensics has been established as an indispensable science in medico-legal matters and in the identification of the dead person. The skeletal components most often investigated for gender determination are the pelvis and skull. Mandible may prove to be a feasible element to analyze sexual dimorphism in the fragmented bones as it is the most dimorphic, largest, and strongest bone of skull.

Aim &Objective: To measure, compare, and evaluate the various measurements of mandibular ramus and gonial angle as observed on digital orthopantomographs and to assess its usefulness as an aid in sex determination.

Material and methods: A retrospective study was conducted using orthopantomographs of 60 males and 60 females of age above 18 years. Two methods were used to determine the sexual dimorphism i. e Ramus Method and Gonial method. Data obtained was entered in Microsoft excel (2013). Statistical analysis was done using Statistical package of social sciences (SPSS) software (v.21.0). Descriptive statistics of the different parameters was performed with gonial method and ramus method. The inter-group comparison of the mean scores of D value was performed using Unpaired t-test; keeping 95% confidence intervals and considering p value <0.05 statistically significant.

Results: The mean ramus breadth, coronoid and condylar height and the projective height of ramus; all these parameters were found to be higher in males as compared to females. The gonial angle values when compared in males and females, were higher for females and the mean bigonial width was higher in males as compared to females. The mean accuracy of ramus method was found to be 92.5% whereas the mean accuracy of gonial angle method was 86.66%.

Conclusion: Mandibular Ramus may act as a valuable tool in the field of forensics and gender determination. According to this study, the accuracy of mandibular ramus method appears to be higher as compared to the gonial angle method. However, further studies with larger sample size need to be conducted to confirm the accuracy of these methods.

Keywords: Forensic odontology; gender determination; gonial angle; mandibular ramus; orthopantomograph.

Introduction

Forensics is has been established as an indispensable science in medico-legal matters and in the identification of the dead person. The determination of gender is important aspect of forensic anthropology and vital in medico legal investigations particularly where the bodies are damaged beyond recognition as in mass disasters. Various methods have been developed to determine age, sex, and ethnicity of the person, using dental tissues.

When the entire adult skeleton is available for analysis, gender can be determined up to 100% accuracy, but in cases of mass disasters where usually fragmented bones are found, sex determination with 100% accuracy is not possible and it depends largely on the parts of the skeleton available. Three basic criteria guide the choice of skeletal elements that may be useful indicators of sex determination. First, their morphology should clearly reflect anatomic or physiologic sex differences. Second, they should be able to withstand the rigors of skeletonization and fossilization and finally there should be easily recognizable traits through time and across paleo species

Next to pelvis, skull plays a vital role in the identification of age, sex and race.[1] But in cases where intact skull is not found, mandible may play a vital role in sex determination as it is the most dimorphic, largest, and strongest bone of skull. Presence of a dense layer of compact bone makes mandible very durable, and hence remains well preserved than many other bones. Dimorphism in mandible is reflected in its shape and size. Male bones are generally bigger and more robust than female bones.

The relative development (size, strength, and angulation) of the muscles of mastication is known to influence the expression of mandibular dimorphism as masticatory forces exerted are different for males and females.[2]b Mandibular condyle and ramus, in particular, are generally the most sexually dimorphic as they are the sites associated with the greatest morphological changes in size and remodelling during growth.

Measurements of the mandibular ramus tend to show higher sexual dimorphism, and differences between the sexes are generally more marked in the mandibular ramus than in the mandibular body. Methods based on measurements and morphometry have been found to be accurate and may be used in gender determiation.[3]

Dentofacial radiography has become a routine procedure in the dental, medical, and hospital clinics, wherein radiographs are taken at different periods during the lifetime of large segments of the population. By radiological examination, sex determination of skull is possible to an extent of 88%.[4] Panoramic radiographs are reproducible, gives accurate linear and angular measurements on mandibles. These radiographs can be made available whenever required and can act as a tool for identifying a person.

A number of studies have been conducted to test the efficiency of long bones of both upper and lower limbs in determining gender. However, there are limited data available regarding use of facial bones for gender determination. Hence, this study was undertaken to assess and compare the various parameters of mandibular ramus as well as the gonial angle in males and females and evaluate the ability of selected parameters in gender determination in forensic sample.

Material and Methods

After obtaining necessary permissions from the institutional scientific committee, a retrospective study was conducted using orthopantomographs of 60 males and 60 females of age above 18 years. Sample size calculation was done using simple random samplingmethod.Ideal digital radiographs of completely dentate patients were selected for the study. All these radiographs had been made using Planmeca Proline-EC/XC ® digital machine with exposure parameters of 80kVp, 12mA and 14s.Pathological, fractured, developmental disturbances of the mandible, deformed and edentulous mandibles were excluded from the study. Two methods were used to determine the sexual dimorphism:

Ramus Method

The height and breadth of the Ramus were measured by this method.

The following parameters were measured using mouse - driven method (by moving the mouse and drawing lines using chosen points on the digital panoramic radiograph) (Figure 1).

1. Maximum ramus breadth (A): The distance between the most anterior point on the mandibular ramus and a line connecting the most posterior point on the condyle and the angle of jaw.
2. Minimum ramus breadth(B): Smallest anterior–posterior diameter of the ramus.
3. Condylar height/maximum ramus height(C): 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
4. Projective height of ramus (D): Projective height of ramus between the highest point of the mandibular condyle and lower border of mandible.
5. Coronoid height (E): Projective distance between coronoid and lower border of the mandible.

Gonial Method

Bigonial width and gonial angle were recorded using this method. (Figure 2)

- Gonial angle: The gonial angles were measured using a method described by Mattila et al. A line was digitally traced on the panoramic radiographs tangential to the most inferior points at the gonial angle and the lower border of the mandibular body and another line tangential to the posterior borders of the ramus and the condyle. The intersection of these two lines formed the

gonial angle, which was measured either on right or left side depending upon the accuracy of the image.

- Bigonial width: The bigonial width is the distance between both Gonion (Go). Gonion is the most inferior, posterior and lateral point on the external angle of the mandible. It was measured horizontally from the right to left gonia.

All the above measurements were done using MASTERVIEW software by a single, calibrated radiologist, under the guidance of a senior Radiologist.

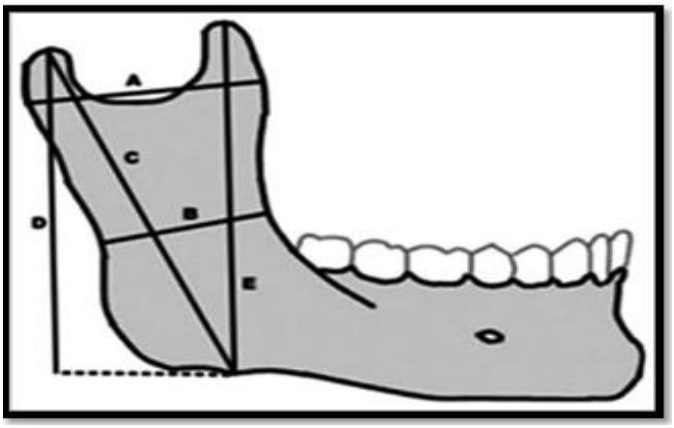

Figure 1: Ramus Method: The height and breadth of the Ramus were measured by this method

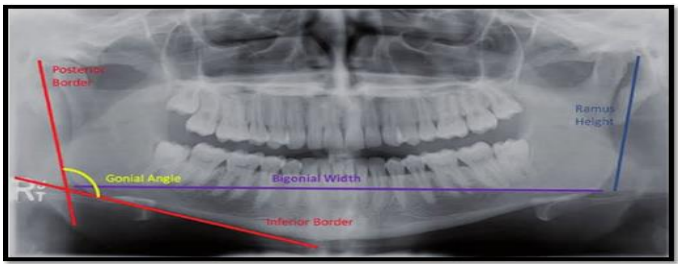

Figure 2: Gonial Method: Bigonial width and gonial angle were recorded using this method.

Figure 3: The mean ramus breadth, coronoid and condylar height and the projective height of ramus all the parameters where higher in males as compared to females

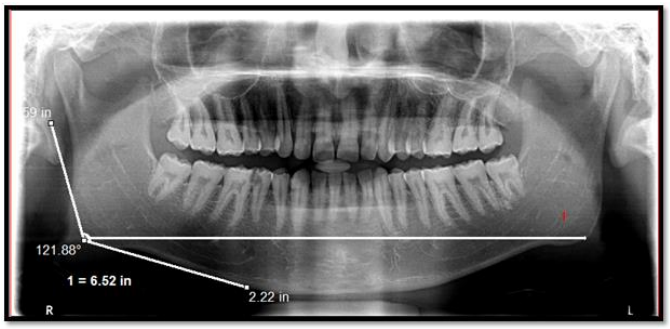

Figure 4: The mean bigonial width was higher in males as compared to females.

Statistical Analysis

Data obtained was entered in Microsoft excel (2013). Statistical analysis was done using Statistical package of social sciences (SPSS) software (v.21.0). Descriptive statistics of the different parameters was performed was gonial method and ramus method.

D value was calculated using the appropriate formulae. The descriptive statistics of the D value was derived for both the groups. The inter-group comparison of the mean scores of D value was performed using Unpaired t-test; keeping 95% confidence intervals and considering p value <0.05 statistically significant.

In our study, the intergroup comparison of the mean scores of D value for different parameters was assessed using Unpaired t-test, amongst the gonial method and ramus method.

Results

The total number of OPGs included in this study was 120. There were 60 males and 60 females. The male: female ratio was 1:1.

Descriptive statistics of the ramus parameters on the OPG are shown in the Table 1.The mean ramus breadth was 36.43 in males and 34.98 in females. The mean

condylar height was 71.21 in males and 61.52 in females. The mean projective height of ramus was 66.88 in males and 57.91 in females. The mean coronoid height was 67.45 and 58.31 in females. Thus, the mean ramus breadth, coronoid and condylar height and the projective height of ramus all the parameters where higher in males as compared to females. Descriptive parameters for all the fives parameters measured on the OPG are shown in (Figure 3)

The gender was determined using ramus measurements from calculations using the equation

D = -0.074 (ramus breadth) + 0.257 (condylar height) - 0.229 (projection height of ramus) + 0.132 (coronoid height) - 8.430

The sectioning point was found to be −0.659. Values greater than this sectioning point indicate male and values lesser than this point indicate female.

The accuracy of ramus method was 95% in males and 90% in females. Thus the mean accuracy was 92.5%.

Descriptive statistics of the gonial angle parameters on the OPG are shown in the Table 2. Both the measurements were found to be statistically significant and thus each variable was a significant predictor in classifying the gender. The minimum gonial angle in males was 118.60 and 115.79 in females. The maximum gonial angle was 133.25 in males and 139.10 in females. The mean of gonial angle was 124.74 in males and 127.88 in females. The gonial angle values when compared in males and females, the values were higher for females. The minimum and maximum bigonial width were 168.60 and 255.50, 134.51 and 247.65 in males and females respectively. The mean bigonial width was 196.18 in males and 189.50 in females. Thus, the mean bigonial width was higher in males as compared to females.

Descriptive parameters of the gonial angle are measured on the OPG are shown in (Figure 2). All the measurements were found to be statistically significant and thus each variable was a significant predictor in classifying the gender.

The gender using gonial angle and bigonial width was assessed from calculations using the equation

D=0.167(Gonial angle) - 0.023 (Bigonial width) -16.881

The sectioning point was found to be -0.417**.** Values greater than this sectioning point indicate female and values lesser than this point indicate male.

The mean D values were higher in females and as compared to males according to the gonial method and they were higher in males according to the ramus method.

The accuracy of gonial angle method was 90% in females and 83.33% in males. Thus the mean accuracy of the method was 86.66%. (Table 3).

The intergroup comparison of D value between gonial method and ramus method is given in Table 4. The ‘t’ values for males is -16.333 and for females is 10.752. All the values are statistically significant.

Discussion

The gender determination from human remains is of fundamental importance in forensic medicine and anthropology. Sex determination based on morphological marks is subjective and is most likely to be inaccurate, but methods based on measurements and morphometry are accurate and can be used in the determination of gender from the skull. When the entire adult skeleton is available for analysis, sex can be determined up to 100% accuracy but in cases of mass disasters where usually fragmented bones are found, sex determination with 100% accuracy is not possible and it depends largely on the parts of the skeleton available.[2]. In cases where intact skull is not found, mandible may

play a vital role in sex determination as it is the most dimorphic, largest, and strongest bone of skull. Presence of a dense layer of compact bone makes it very durable, and hence remains well preserved than many other bones. Dimorphism in mandible is reflected in its shape and size. Male bones are generally bigger and more robust than female bones.

Orthopantomogram is considered as an adjuvant radiographic method to differentiate gender as it provides ground for the measurements of various landmarks from skeletal remains. The principal advantages of panoramic images are their broad coverage, low patient radiation dose, and the short time required for image acquisition. Considering these, we selected it as imaging modality for our study.[5]

Our study results indicated that the ramus and gonial angle measurements can prove to be useful in gender determination. This was in sync with various other studies done in the past.

Various studies conducted in the past measuring mandibular ramus using orthopantomographs showed statistically significant gender differences with variable accuracies. [1,2,4,6] Compared to them, our study showed better accuracy of measurement.

Also, in the study conducted by Damera et al in year 2016 showed greatest sexual dimorphism, with an accuracy of 83.8% in consideration to the maximum ramus height, the mean of which was 66.94 with a standard deviation of 4.556 in males and 60.5075 with a standard deviation of 4.09561 in females, which was significant ($P = 0.00$).[5]

Similar contributions by Morant et al(1936), Martin(1936), and Hrdlicka(1940) and Rajalakshmi Rai et al (2007) have shown a mean of 63.5 in maximum ramus height depicting the highest sexual dimorphism, which is in accordance with the studies conducted by Kambylafkas et al [7] and Schulz et al[8]., which stated that differences between the sexes are marked in the mandibular ramus than in the mandibular body.

In one study conducted by Shivprakash et al out of 55 male mandibles, sex was accurately determined in 44 cases with accuracy rate of 80% and out of 49 female mandibles, sex was accurately determined in 35 cases with accuracy rate of 71% by using mandibular ramus posterior flexure.[9]A similar study by Giles has shown an accuracy of 85%, Steyn and Iscanin their study achieved an accuracy of 81.5% with five mandibular parameters, Dayal *et al*.[10] and Saini et al.

showed an accuracy of 80.2%.[11] Mandibular height, mandibular ramus projection, mandibular width, or mandibular gonial angle on an individual basis were the most important variables that were considered and included in many studies in the past. This fact was reinstituted by the results of our study.

Conclusion

Mandibular Ramus and gonial angle both can be used for gender determination. The accuracy of mandibular ramus method seems to be higher as compared to the gonial angle method.

Mandibular Ramus can thus act as a valuable tool in forensics. Further studies need to be done with a larger sample to confirm the accuracy of these methods.

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Legends Tables

Table 1: Descriptive statistics of the study participants according to Ramus method

Gender	Parameter	Minimum	Maximum	Mean	Std. Deviation
Male	Maximum Ramus Breadth	34.10	40.13	37.24	1.69
	Minimum Ramus Breadth	32.34	39.64	35.62	1.90
	Mean ramus breadth	33.35	39.89	36.43	1.76
	Condylar Height	68.46	74.46	71.21	1.63
	Projective Height of Ramus	63.01	72.03	66.88	2.15
	Coronoid Height	63.30	72.33	67.45	2.09
Female	Maximum Ramus Breadth	32.57	37.91	35.67	.99
	Minimum Ramus Breadth	30.22	35.94	34.28	1.20
	Mean ramus breadth	31.40	36.57	34.98	1.04
	Condylar Height	58.30	64.20	61.52	1.37
	Projective Height of Ramus	54.07	62.39	57.91	1.91
	Coronoid Height	55.37	62.42	58.31	1.67

Table 2: Descriptive statistics of the study participants according to Gonial method

Gender	Parameter	Minimum	Maximum	Mean	Std. Deviation
male	Gonial angle	118.60	133.25	124.74	4.30
	Bigonial width	168.60	255.50	196.18	20.46
female	Gonial angle	115.79	139.10	127.88	4.85
	Bigonial width	134.51	247.65	189.50	20.61

Table 3: Descriptive statistics of the D value according to two different methods

D value		Minimum	Maximum	Mean	Std. Deviation
Type of Method	Gender				
Gonial	Male	-1.00	0.71	-0.56	0.42
	Female	-0.64	0.92	0.11	0.44
Ramus	Male	0.45	0.96	0.76	0.11
	Female	-0.99	-0.66	-0.77	0.08

Table 4: Intergroup comparison of D value between gonial method and ramus method

D value		Mean Difference	Unpaired t test	
			t value	P value
Male	Gonial method	-1.32	-16.333	.000*
	Ramus method			
Female	Gonial method	0.88	10.752	.000*
	Ramus method			

*p value <0.05 statistically significant