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Gender Determination Using Linear Measurements of Mandible on Orthopantamographs: A Discriminative Functional Analysis

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Abstract: ***Introduction: Identification of human remains carried out for various purposes. Most popular methods for identification are DNA analysis, fingerprint analysis, and forensic dental identification. These methods depend on the availability of the antemortem data for comparison. Dental profiling is a method of obtaining information from human skeletal remains which got no antemortem data. Most commonly used skeletal components for sex determination is the pelvis followed by the skull. In the present study, mandibular body and ramus calculations were carried out to determine sex. Aims & Objectives: To measure and compare various measurements of mandibular body and ramus on Orthopantomography. To assess the usefulness of mandibular ramus in sex determination. Materials & Methods: A retrospective study was conducted using orthopantamographs of 100 subjects obtained from the Department of Oral medicine and radiology, Panineeya dental college. All the OPGs were taken using Diamaxis Planmeca 550 OPG machine with exposure parameters - 72mkv voltage and 12mA current. Measurements were carried out using Adobe photoshop CS5 extended software and were subjected to Discriminative Functional Analysis. Results: We evaluated 6 variables in mandibular ramus and body in which we got significance for 2 variables. Conclusion: This study concluded that mandibular ramus is sexually more dimorphic than the mandibular body.***

Keywords: Gender determination, Linear measurements, OPGs, Discriminative Functional Analysis.

1. Introduction

As we are living in a world which hegemonies by crime, murders and mass disasters and in such incidents, identification of deceased from human skeletal remains is the first step in victim identification protocol.[1,2] Correct determination of sex immediately eliminates half of the population from view of the examiner and is crucial for further analysis of age and stature which in turn are sex dependent.[3-5] Unavailability of soft parts representing sexual characteristics leads to rely on hard tissue components for determining sex. The most commonly used sex determining skeletal components are pelvis, followed by the skull.[1, 2]

In situation where the intact skull can't be retrieved, the mandible is the most dimorphic bone among skull which serves the purpose of sex determination.[6] It is the most durable bone of skull due to presence of a dense layer of compact bone that retains its shape better than others.[4] Male and female mandibles are distinguished by general size, chin shape, gonial angle and gonial flare and its morphology is thought to be influenced by age and occlusal status of the subject.[7, 8]

Radiographs play an important role in victim identification showing postmortem significance. The most commonly preferred extra-oral dental radiograph in the dental scenario is Orthopantomograph (OPG) or panoramic radiograph. It provides a wide coverage of both the jaws and teeth, offers a bilateral view and used as a clinical routine to assess various pathologies of jaws.[8,9] Use of panoramic radiographs was first reported by Schwartz S *et al* in 1977 to serve for the purpose of forensic identification.[9] Our study further enlightens the fact that OPG has a definite advantage over IOPAs in the field of forensic identification as it provides more information, covers wide area of maxillofacial region and it is easier to store a single OPG than several IOPAs and less radiation exposure due to OPG when compared with IOPAs.[9]

2. Literature Search

Literature search revealed that there are studies conducted by Franklin D et al, Saini V et al and Vinay G et al, regarding sex determination using dried mandibles.[6, 7, 10] According to studies done by Humphrey et al [11] and Saini V et al[6] presented that mandibular ramus is more sexually dimorphic and Vodanovic et al[2] and Saini V et al[4] studies depicted that mandibular body is more sexually dimorphic whereas, studies carried out by Rosas A et al [12] suggested that both body and ramus of mandible will determine the sex.

3. Problem Definition

Due to the above conflicting points and availability of very few studies comparing sexual dimorphism expressed by mandibular body and ramus by measuring them on OPGs and, as there were numerous studies which have demonstrated that skeletal features vary by population.

Hence, there is a need for studies focusing on population-specific standards for sex determination.[13]

Hence, this paper tries to evaluate the usefulness of mandibular body and ramus measurements on OPGs in sex determination in our population which helps a lot in forensic analysis.

4. Materials and Methods

a) Sample

A retrospective study was conducted using 100 OPGs of patients who were advised as a part of the diagnostic routine, from the department of Oral Medicine and Radiology, Panineeya Mahavidyalaya Institute of Dental Sciences and Research Centre, Hyderabad. All the OPGs were taken using Diamaxis Planmeca 550 OPG machine with exposure parameters being 72mkv voltage and 12mA current. Based on the age, these OPGs are divided into five groups as follows [Table 1]

Table 1: Age distribution of the sample

Group	*N*	*Age range (in years)*
I	20	20 - 30
II	20	30 - 40
III	20	40 - 50
IV	20	50 – 60
V	20	60 - 70

b) Measurements

Total of 6 parameters taken for the study. Of these 2 are of the mandibular body and 4 are from mandibular ramus.
The parameters used in Mandibular Body are [Figure 1]:

1) Infradentale to Gnathion which represents the height of mandibular body
2) Gonion to Gnathion which represents the width of mandibular body

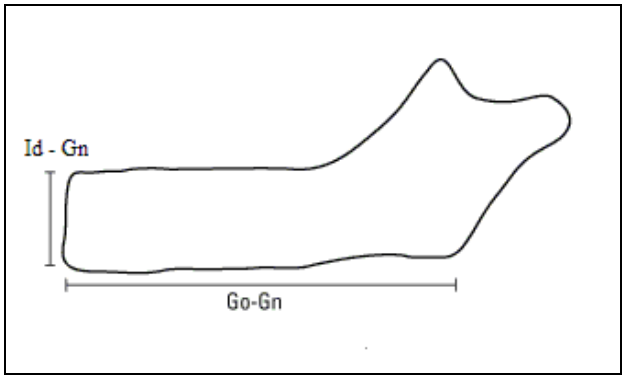

Figure 1: Various measurements on the mandibular body

The parameters used in Mandibular Ramus are [Figure 2]:

1) O1 to O2 – Mandibular ramal height
2) O2 to Tangent – Mandibular condylar height
3) Minimum Ramus Width and
4) Maximum Ramus Width

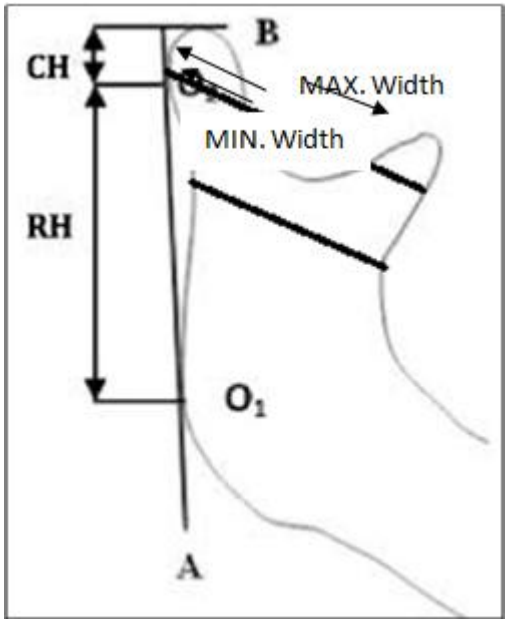

Figure 2: Various measurements on mandibular ramus

O1 to O2 & O2 to Tangent represents the height of mandibular ramus. Minimum and Maximum ramus width represent the width of the mandibular ramus.

All the parameters are measured by moving the mouse and marking the points at predetermined points and by drawing the lines connecting those points on the digital OPG. The predetermined points are as follows:

1) Infradentale: The mid-point of a line tangent to the outer margins of the cavities of the two mandibular central incisor teeth.
2) Gnathion: The middle point on the lower border of the mandible in the sagittal plane
3) Gonion: The most lateral external point of junction of the horizontal and ascending rami of the lower jaw
4) O1: The most lateral point of mandibular ramus
5) O2: The most lateral point of mandibular condyle
6) Tangent: Tangent to the highest point of the condyle
7) Maximum Ramus width: Distance between most anterior point and most posterior point on the mandibular ramus
8) Minimum Ramus width: Smallest anteroposterior diameter of mandibular ramus.

Since this study was carried over on OPGs stored in the system, ethical clearance was not mandatory. All the measurements were carried over OPGs using Adobe photoshop CS5 extended software. Obtained data was subjected to statistical analysis using SPSS version 22.0 using the discriminant procedure. Discriminant function analysis was applied which is a powerful method of examining differences between two or more groups with several variables simultaneously. In our study, this analysis was used to determine sex from skeletal measurements by defining variables that discriminate between male and female.

5. Results & Discussion

5.1 Results

Descriptive statistics of all 6 parameters of the study showing their mean values, standard deviation along with their Wilks' lambda and p-values are presented in Table 2 which displays significance for two parameters. One is from mandibular body i.e., Infradentale-Gnathion representing the height of mandibular body with a p-value of 0.025 and the other is from mandibular ramus i.e., O1 – O2 representing the mandibular ramal height with a more significant p-value of 0.001 presenting that the mandibular ramus is a more reliable in predicting the sex compared to mandibular body. The same table also shows that the mean values of all the 6 parameters were higher for males when compared to females.

Table 2: Descriptive statistics

Parameter	*Sex*				*Wilks Lambda*	*p-value*
	Male		*Female*			
	Mean	*SD*	*Mean*	*SD*		
O1- O2	1.66	.17	1.47	.11	.722	**<0.001*; Sig**
O2-Tangent	.29	.08	.27	.07	.982	0.177
Min Width	1.22	.15	1.20	.12	.995	0.463
Max Width	1.60	.14	1.55	.15	.979	0.149
Infradentale-Gnathion	1.26	.11	1.21	.11	.950	**0.025*; Sig**
Gonion-Gnathion	3.66	.22	3.61	.22	.984	0.21

Table 3: Linear Discriminant function

	Male			*Female*	
	Unstandardized coefficient	*Mean*	*Product*	*Mean*	*Product*
O1-O2	6.681	1.66	11.09046	1.47	9.82107
O2-Tangent	5.609	0.29	1.62661	0.27	1.51443
Min Width	0.492	1.22	0.60024	1.2	0.5904
Max Width	0.054	1.6	0.0864	1.55	0.0837
Infradentale-Gnathion	0.856	1.26	1.07856	1.21	1.03576
Gonion-Gnathion	-0.611	3.66	-2.23626	3.61	-2.20571
(Constant)	-11.717		-11.717		-11.717
Total	For centeroids		0.529		-0.877

Table 3 shows Canonical Discriminant Function Coefficients using Linear Discriminant Function presenting the list of coefficients of the unstandardized discriminant equation and also the centroid value of 0.529 and -0.877 for males and females respectively. Hence, the sex determination can be evaluated by using the following equation:

D= -11.717 + 6.681(O1-O2) + 5.609(O2 – Tangent) + 0.492(Min. Width) + 0.054(Max. Width) + 0.856(Infradentale – Gnathion) -0.611(Gonion – Gnathion)

Table 4: Prediction accuracy

	Sex	*Predicted Group Membership*		*% accuracy*
		Male	*Female*	
Original	Male	51	12	78.2
	Female	10	28	

Table 4 shows a simple summary of a percent of subjects classified correctly. In our study, we procured an accuracy of 78.2%

6. Discussion

Disasters may involve explosions, earthquakes, floods, cyclones, wars etc., in which individuals are exposed to extreme forces causing severe disruption of their bodies. Disaster Victim Identification (DVI) involves many individuals posing a challenge for the forensic anthropologist and forensic pathologist who aim at exploring four biological indicators: sex, age, stature, and ancestry background. Out of these indicators, assessment of sex influences the others.[14, 15] As Crime and Disasters override the world, identification of deceased is pivotal.

Forensic odontological examination becomes chief method of identification in which we have to rely on skeletal components, where the other means of identification are impossible.[1, 9] Pelvis is the most sexually dimorphic bone, followed by the skull in which, the mandible is the one which acts as a prominent trait exhibiting sexual dimorphism. The present study aims to compare and determine which part is most sexually dimorphic among mandibular body and ramus by virtue of OPGs. According to the studies carried out by Kumar N et al (2013)[9] and Fuentes R et al (2011),[16] confirmed the utilization of OPGs in forensic odontology and measuring condylar asymmetry respectively.[9, 16]

Studies carried out by Rosas et al (2002)[11] observed that maximum length of the mandible which is the distance between gnathion and condyle is the most sexually dimorphic parameter followed by the length of basal border depicted by the distance between gnathion and gonion. By correlating their observations they hypothesized that both the body and ramus of the mandible are required for determination of sex which is in accordance with Vinay G et al (2013)[7] who studied on dried mandibles and opined that both body and ramus of the mandible are necessary for sex determination. The study performed by Al-Shamout R et al (2012)[8] on OPGs also suggested that bigonial width and ramal height are dimorphic features which reflected that sexual dimorphism depends on both mandibular body and ramus.

Vodanovic M et al (2006)[2] done a study to determine sex in which they used 18 measurements in the mandible and concluded that distance between the center of mental foramen and mental tubercle is the most sexually dimorphic parameter who opined that mandibular body is more sexually dimorphic than mandibular ramus. Recent study on North Indian population by Saini V et al (2013) [4] studied on dry adult mandibles and suggested that mandibular body height is most significant parameter in sexual dimorphism with an accuracy of 67.4%

Saini V et al (2011) [6] studied 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.

Indira AP et al (2012) [5] conducted a study on OPGs to determine the sexually dimorphic parameter in mandibular ramus and suggested that minimum ramus breadth is a most significant parameter with an accuracy of 76%.

In a recent publication by Damera A et al (2016) [17] on the usefulness of mandibular ramus in sex determination also observed that height of mandibular ramus is the most sexually dimorphic parameter and obtained an accuracy of 83.3%. In their study, they didn't compare between mandibular body and ramus.

By correlating the above studies, few states that both the mandibular body and ramus, few describes that mandibular body whereas, few emphasizes that mandibular ramus is crucial in sex determination and very few studies were performed on OPGs in south Indian population. So, in our study, we aimed to explore the sexual dimorphic capability of two parts of mandible i.e., body and ramus by taking the measurements on OPGs.

In the present study, out of 6 parameters in mandibular body and ramus, we procured significance for 2 parameters including mandibular ramal height (O1 – O2) with a p-value of <0.001* and mandibular body height (Infradentale – Gnathion) with a p-value of 0.025* in mandibular ramus and mandibular body respectively with an accuracy of 78.2%. Of these 2 parameters, mandibular ramal height was more significant than body height which reflected that ramus is more sexually dimorphic than the body of the mandible.

Our results were in correlation with Al-Shamout R et al (2012),[8] Damera A et al (2016)[17] who also suggested that ramal height is one of the most sexually dimorphic features and These results were in contrast with the studies carried out by Saini V et al (2011)[6] and Indira AP et al (2012)[5].

7. Conclusion

Hence, the present study attained its aim by suggesting that ramal height was more significant than body height depicting that mandibular ramus is more sexually dimorphic than the mandibular body.

8. Future Scope

Future studies can be planned to compare the measurements between right and left sides of the mandible and including angular measurements along with linear measurements may aid in determining sexual dimorphism of the mandible.

References

[1] Patil KR, Mody RN. Determination of sex by discriminant function analysis and stature by regression analysis: a lateral cephalometric study. Forensic Science International.2005; 147: 175 – 80.
[2] Vodanovic M, Dumancic J, Demo Z, Mihelic D. Determination of sex by discriminant function analysis of mandibles from two Croatian archaeological sites. Acta Somatica Croat 2006; 40: 263-77.
[3] Kanchankumar P, Wankhede, Bardale RV, Chaudhari GR, Kamdi NY. Determination of sex by discriminant function analysis of mandibles from a central Indian population. Journal of Forensic Dental Sciences. 2015;7(1): 37 – 43
[4] Saini V. Metric study of fragmentary mandibles in a north Indian population. Bull Int Assoc Paleodont.2013; 7(2)
[5] 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.
[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: S13-S16.
[7] Vinay G, Mangala Gowri SR, Anbalagan J. Sex determination of human mandible using metrical parameters. JCDR. 2013
[8] 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 & dental journal.2012; 32(1): 81 – 87.
[9] Kumar N, Sreenivasan V, Patil P, Vashishth S. Panoramic imaging as a tool of identification in forensic odontology. Indian journal of forensic odontology. 2013; 6(2): 51-58.
[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] Humphrey LT, Dean MC, Stringer CB. Morphological variation in great ape and modern human mandibles. J. Anat. 1999; 195:491-513.
[12] Rosas A, Bastir M, Martinez-Maza C, Bermudez de Castro JM. Sexual dimorphism in the Atapuerca-SH hominids: the evidence from the mandibles. J Hum Evol. 2002; 42(4): 451-74.
[13] Steyn M, Iscan MY. Sexual dimorphism in the crania and mandibles of South African whites. Forensic Sci Int.1998; 98(1-2): 9-16.
[14] Blau S, Robertson S, Johnstone M. Disaster Victim Identification: New applications for post-mortem computed tomography. J Forensic Sci. 2008; 53(4): 956-61.
[15] Gupta S. A study on the reliability of gender and stature estimation from head circumference, inner canthal distance, inter-canine & inter-alar width in north Indian populations. JFOS. 2013; 31(1): 153-54.
[16] Fuentes R, Engelke W, Bustos L, Oporto G, Borie E, Sandoval P. Reliability of two techniques for measuring condylar asymmetry with X- rays. Int. J. Morphol. 2011; 29(3): 694 – 701.
[17] Damera A, Mohanalakshmi J, Yellarthi PK, Rezwana BM. Radiographic evaluation of mandibular ramus for gender estimation: a retrospective study. J Forensic Dent Sci. 2016; 8: 74-8.

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