Original Article

Mandibular ramus- An indicator for gender determination: A digital panoramic study in Bagalkot population

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Abstract

Background: In medico-legal investigations identification of skeletal remains is of utmost importance. The skeletal remains most commonly investigated are pelvic and skull bones with the mandible an important element to analyze sexual dimorphism. Mandibular ramus can differentiate between the two genders as the stages of mandibular development, growth rates, and duration are different in both genders. Metric analysis on the radiographs is found to be of higher values when skeletal sex determination is considered.

Aims and Objectives: 1) To compare and evaluate the various measurements of the mandibular ramus on digital OPG's. 2) To assess the usefulness of mandibular ramus as an aid in gender determination in the Bagalkot population.

Materials and Methods: A retrospective study was conducted on 80 patients (40 males & 40 females) using Kodak 8000 C digital panoramic radiographs of the Bagalkot population with ages ranging from 18 to 58 years. Five parameters namely coronoid ramus height, condyle ramus height, condyle coronoid breadth, maximum ramus breadth, and minimum ramus breadth were taken into consideration, the values were measured and data were analyzed. Statistical analysis was done using SPSS software.

Results: In the present study, all the measurements of the mandibular ramus on digital panoramic radiographs showed a statistically significant difference between both the genders except for minimum ramus breadth which was found to be insignificant.

Conclusion: Discriminant analysis of mandibular ramus using panoramic radiography can be used as an effective tool in gender determination and can be used as an aid in forensic sciences.

Keywords: Forensic science, mandibular ramus, sexual dimorphism, skeletal

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INTRODUCTION

Anthropology is the scientific study that deals with the origins and dead remains of human beings and how their morphological characteristics changed over the years and how they relate with each other, both who belong

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to our own culture and those who belong from other cultures. Gender identification of the unknown is of great significance in the field of forensic sciences.[1,2] Mandible is the largest, strongest, and most movable part of the skull. Among various measures, mandibular ramus can be used to differentiate between males and females strongly and express sexual dimorphism.[3] Dentofacial radiography has become a routine procedure in dental, medical, and hospital clinics. Where radiographs are taken at different periods during the lifetime of large segments of the population. When skeletal sex determination is considered, a metric analysis on the radiographs is often found to be of superior value because of its accuracy, objectivity, and reproducibility.[4] Skull is the most dimorphic and easily sexed portion of skeleton after pelvis, providing accuracy up to 92%.[5] But in cases where an intact skull is not found, the mandible may play a vital role in sex determination as it is the most dimorphic, largest, and strongest bone of the skull.[6,7] Presence of a dense layer of compact bone makes it very durable, and hence remains well preserved than many other bones. Dimorphism in the mandible is reflected in its shape and size. Male bones are generally bigger and more robust than female bones.[8]

The relative development (size, strength, and angulations) of the muscles of mastication is known to influence the expression of mandibular dimorphism as masticatory forces exerted are different for males and females.[9] The greatest morphological changes showing the sexual dimorphism in the mandible are particularly seen in the mandibular condyle and ramus than the body of the mandible.[10] Methods based on measurements and morphometry are accurate and can be used in the determination of gender.[11]

Hence this study aims at evaluating the usefulness of the mandibular ramus in determining the gender in the Bagalkot population and its use of it in forensic sciences.

AIMS AND OBJECTIVES

The present study was designed with the following aims and objectives:

1. To compare & evaluate the various measurements of the mandibular ramus on digital Orthopantomogram (OPG's).
2. To assess the usefulness of mandibular ramus as an aid in gender determination in the Bagalkot population.

MATERIALS AND METHODS

A retrospective study was conducted using orthopantomographs of 40 males and 40 females of the Bagalkot district population in the age group between 18 to 58 years. Ideal orthopantomography of completely dentate patients was selected for the study. Pathological, fractured, developmental disturbances of the mandible, deformed and edentulous mandible, and distorted radiographs were excluded from the study. Radiographs taken by Kodak 8000 C Digital Panoramic and Cephalometric system (73kvp, 12Ma, 13.9s) were used for the study. Since this study was conducted on radiographs stored in the system, ethical clearance was not applicable. Mandibular ramus measurements were carried out using masterview 3.0 software.

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

1. Coronoid ramus height (A): The distance between coronion and the inferior border of the ramus.[5]
2. Condyle ramus height (B): The distance between the condylion and the inferior border of the ramus.[5]
3. Condyle coronoid breadth (C): The distance between the most superior point on the condylion and coronion.[12]
4. Maximum ramus breadth (D): 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.[5-11]
5. Minimum ramus breadth (E): Smallest anterior-posterior diameter of the ramus.[5]

Statistical analysis

The data were analyzed using the discriminant procedure of the statistical package SPSS 20 software. Discriminant function analysis was used for the determination of variables that discriminate between males and females.

RESULTS

Comparison of all the linear measurements of the mandible in both males and females by applying an independent sample t test is shown in Table 1. We observed that each variable was a significant predictor in classifying a given sample ($P < 0.05$) except minimum ramus breadth which was found to be insignificant. The mean values showed that all dimensions were higher for males compared to females. Mean measurements between males and females are shown in Figure 2.

The sex could be determined from calculations using the equations given below [Table 2].

Table 1: Comparison of male and females with different parameters by *t* test

Parameters	Males		Female		*t*	*P*
	Mean	Std.Dev.	Mean	Std.Dev.		
Coronoid-ramus height	2.25	0.19	1.98	0.21	6.1072	0.0001*
Condyle-ramus height	2.51	0.21	2.18	0.18	7.6997	0.0001*
Coronoid-condyle breadth	1.18	0.11	1.11	0.19	2.0292	0.0458*
Maximum ramus breadth	1.20	0.21	1.11	0.13	2.3008	0.0241*
Minimum ramus breadth	1.04	0.11	0.98	0.21	1.8489	0.0683**

*$P<0.05$

Table 2: Linear discriminant function

Parameters	Male	Female
Constant	-127.73	-102.03
Coronoid-ramus height	37.49	34.44
Condyle-ramus height	36.19	29.58
Coronoid-condyle breadth	43.33	40.96
Maximum ramus breadth	14.09	13.43
Minimum ramus breadth	10.56	10.27

Table 3: Prediction accuracy

True group	Predicted group membership			
	Male	Female	Total	% of accuracy
Male	34	6	40	85.0
Female	6	34	40	
Total	40	40	80	

Dmale: -127.73 + 37.49 (coronoid-ramus height) + 36.19 (condyle-ramus height) + 43.33 (condyle-coronoid breadth) + 14.09 (maximum ramus breadth) + 10.56 (minimum ramus breadth)

Dfemale: -102.03 + 34.44 (coronoid-ramus height) + 29.58 (condyle-ramus height) + 40.96 (condyle-coronoid breadth) + 13.43 (maximum ramus breadth) + 10.27 (minimum ramus breadth)

For classifying a given sample as male or female, the higher/maximum value of the two equations is considered. With all the variables in consideration, 85% of the cases were classified correctly [Table 3]. In the present study, the sectioning point was found to be 0.9057. Values greater than this sectioning point indicate male and values lesser than this point indicate female [Table 4].

DISCUSSION

The growth changes in humans take place from the beginning of prenatal life to senility. Hard tissues (bones & teeth) also undergo changes with growth, which can be a change in shape or fusion of ossification centers or after death, these changes remain stable and help in estimation of age from hard tissue samples.[13-15] The identification of sex from human remains is of fundamental importance in forensic medicine and anthropology, especially in crime investigations & identification of missing persons & in attempts at reconstructing the lives of ancient populations.

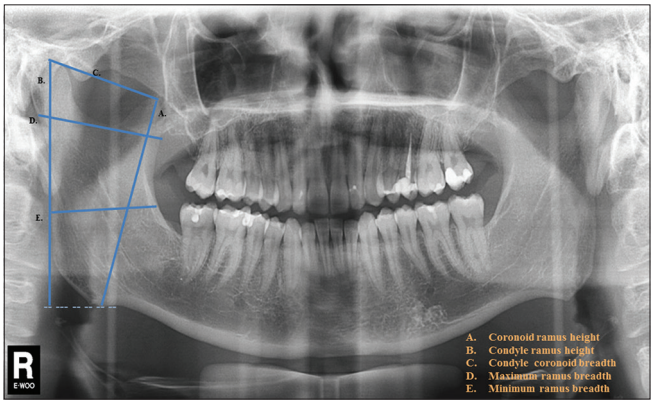

Figure 1: Measuements of mandibular ramus on orthopantomograph

One of the important aspects of forensics is to determine sex from fragmented jaws and dentition.[16] Identification of gender-based on measurements and morphometry is accurate & can be used in the determination of sex from the skull.[8] The accuracy of panoramic radiography in providing anatomic measurements has been established. Orthopantomograph has been advocated routinely and widely used by clinicians as an appropriate screening tool for the diagnosis of oral diseases. The principal advantages of panoramic images are their broad coverage, low patient radiation dose and the short time required for image acquisition.[17] Other advantages are the interference of superimposed images is not encountered. Also, the contrast and brightness enhancement and enlargement of images provide an accurate and reproducible method of measuring the chosen points.[18,19] The limitations of this technique are magnification and geometric distortion, however, the vertical dimension in contrast to the horizontal dimension is a little altered and this technique is quite sensitive to positioning errors because of the relatively narrow image layer.[17] However, in the present study, this limitation did not affect the results as all images were uniformly magnified.

Kambylafkas *et al*.[20] concluded that the use of the panoramic radiograph for evaluation of total ramal height is reliable and an asymmetry of more than 6% is an indication of a true asymmetry. Schulze *et al*.[21] found that the most reliable measurements were obtained for linear objects in

Table 4: Standardized and unstandardized coefficients in linear discriminant function of original samples

Parameters	Raw coefficients	Standardized coefficients	Structure coefficients	Sectioning point
Coronoid-ramus height	1.68	0.34	0.75	0.9057
Condyle-ramus height	3.65	0.71	0.95	
Coronoid-condyle breadth	1.31	0.21	0.25	
Maximum ramus breadth	0.36	0.06	0.28	
Minimum ramus breadth	0.16	0.03	0.23	
Constant	-14.19	-	-	

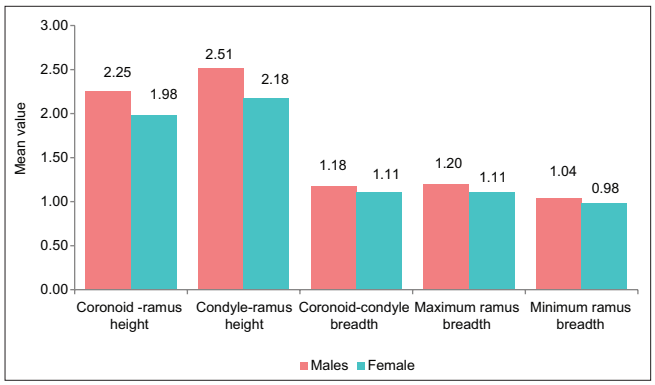

Figure 2: Mean measurements in males and females

the horizontal plane & digital measurements are sufficiently accurate for clinical use.

In this study, mandibular ramus measurements were subjected to discriminant function analysis. Each of the five variables measured on mandibular ramus using orthopantomography showed statistically significant sex differences between sexes except minimum ramus breadth which was found to be statistically insignificant. The mandibular ramus showed the greatest univariate sexual dimorphism in terms of condyle-ramus height followed by coronoid-ramus height and condyle-coronoid breadth. The overall prediction rate using all five variables was 85% and similar results were obtained by the studies conducted by Martin and Hrdlicka[22,23] who stated that measurements of the mandibular ramus height showed greater sexual dimorphism.

Giles concluded that the height of the symphysis, ramus, and body, mandibular body length and bigonial diameter were useful measurements with greater sexual dimorphism.[24]

A study conducted by Pokhrel and Bhatnagar[25] on dry mandibles of the Indian population concluded mandibular measurements to be highly significant in the prediction of sex in a defined population.

Saini *et al*.[5] studied mandibular ramus in the dry adult mandible and found that mandibular ramus expresses strong sexual dimorphism. The overall prediction rate using five variables was 80.2%. the best parameters were coronoid height, condylar height, and projective height of ramus and breadth measurements were not very dimorphic in their sample. In the present study, the mean values of all the parameters were found high in males in comparison to females which is in accordance with a study conducted by Maloth *et al*.[26]

Limitations of this study are its inability to reliably determine the gender in both pediatric and geriatric age groups and also in patients with edentulous mouths and osseous disorders affecting mandible.

CONCLUSION

Sex determination is of extraordinary significance in anthropological and medicolegal perspective. The mandibular ramus parameters must be considered for anthropological and forensic purposes as it possesses resistance to damage and the disintegration process. The present study found that discriminant analysis of mandibular ramus using panoramic radiography is an available tool for gender determination and can be used as an aid in forensic sciences. Further studies on more diverse populations to assess the significance of these parameters are recommended.

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Conflicts of interest
There are no conflicts of interest.

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