Sex determination by using mandibular ramus: A digital radiographic study

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Keywords
Linear discriminant functional analysis, mandibular ramus, sex determination

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Received: 18 May 2017; Accepted: 19 June 2017
doi: 10.15713/ins.jmrps.99

Introduction
Identification of human skeletal remains is an important step during mass disasters, from decayed and damaged dead bodies. In forensic investigations and medicolegal cases, identification of sex is an important aspect, followed by age determination. It depends on availability of human skeletal remains. When the entire skeleton is present, identification of age and sex can be done accurately. However, in mass disasters, complete human skeletal remains cannot be available. Hence, it depends on availability of bony fragments.

In human remains, pelvis and skull are the important human skeletal remains for sex determination. When intact skull is absent and only fragments of skull bones are present, then mandible plays an important role in gender determination. Among all the bones of skull, mandible is the largest, strongest, and movable part of the skull.

Due to compact bone which is very dense, they are most durable and well preserved than many other bones. Masticatory forces exerted by males and females are different. These forces influence the sexual dimorphism in mandible.

To get an overview, currently, rotational panoramic radiography has become a routine procedure in dental and medical hospitals. To get an overview of maxillofacial complex, nowadays, rotational panoramic radiography is widely used. Identification of the human remains is done by comparing ante- and post-mortem radiographs.

The main aim of the study is to determine sex using mandibular ramus by considering all the parameters.

Aims and Objectives
The aim of this study is to measure and compare the various dimensions in the mandibular ramus as observed in orthopantomograph and to determine the gender using mandibular ramus measurements.

Materials and Methods
Retrospectively, a study was done by taking orthopantomograph of 50 males and 50 females. Orthopantomographs were taken using the Panoramic Machine (69 kVp 15 mA 14.1 s). The data were analyzed using linear discriminant analysis.

Results: In mandibular ramus, each and every variable was significant in classifying a given sample (P < 0.001).

Conclusion: Mandibular ramus can be used as an aid for sex determination.
Inclusion criteria
The participants with age group between 20 and 40 are included in the study.

Exclusion criteria
Pathological fractures and developmental disturbances of the jaws are excluded from the study.

By mouse driven method, the following parameters were measured as shown in Figure 1.
A. Maximum ramus breadth: Distance between anterior point on the mandibular ramus and a line connecting the posterior most point on the condyle and the angle of the mandible.
B. Minimum ramus breadth: Smallest anterior-posterior diameter of the ramus.
C. Projective height of ramus: Projective height of ramus between the highest point of the mandibular condyle and lower margin of the bone.
D. Condylar height: Height of the ramus from most superior point on the mandibular condyle to the tubercle or most protruded portion of the inferior border of the ramus.
E. Coronoid height: Distance between coronion and lower margin of the mandible.

Statistical analysis
In this study, discrimination between male and female was done using linear discriminant functional analysis and is used for gender determination from the parameters of mandibular ramus.

Descriptive statistics
Mean measurements and SD: Standard deviation were taken. Mean value for males was greater than females and SD for females was greater than males which was shown in Table 1 and Graph 1.

The F-statistics showed that condylar height and projective height of mandibular height showed the great sexual dimorphism in mandibular ramus as shown in Table 2.

Sex can be determined by equations given below as shown in Table 3.

To classify a sample as male or female, the higher/maximum value of the two equations is considered. In this study, the sectioning point was found to be −0.564. When sectioning point is more, it indicate as male and values lesser than this point indicate female.

By taking these variables into consideration, 71% of the taken subjects were classified correctly which was shown in Table 4.

Discussion
Identification of gender is an important step in forensic investigation to identify a missing persons as well as in criminal investigations. Males and females have different masticatory forces, and these forces play an important role in bone


remodeling. Hence, mandible can be used as an indicator for sex determination.

Nowadays, orthopantomographs are taken regularly for routine dental procedures. The advantages of orthopantomograph images are broad coverage, low-radiation dose to patient and require short time for image acquisition, and interference of the superimposed images is not encountered.\[5\] The brightness and contrast enhancement and enlargement of the images provide an reproducible method of measuring the chosen points.\[6,7\] The measurements taken from mandibular ramus are subjected to linear discriminant function.

Using orthopantomograph, all the variables measured using panoramic radiography showed statistically significant sex differences among the subjects included in the study, indicating that ramus expresses strong sexual dimorphism.

Earlier studies done on mandible by Humphrey et al mentioned about these authors in their article. had established the advantage of mandible for gender determination. According to their study, height of the ramus exhibited sexual differences, thus concluded that in mandibular ramus, sex differences are more pronounced than in any other part of the body.\[8\]

Saini et al. conducted a study on dry mandible in North Indian population. They also concluded that mandibular ramus expresses strong sexual dimorphism. The overall prediction rate is 80.2% for all five variables.\[5,9\]

Giles measured all the variables in mandibles of known gender using anthropometric measurements and concluded that mandibular ramus height, maximum ramus breadth, and minimum ramus breadth are more significant, with an accuracy of 85% in American Whites and Negroes.\[1,2,5,10\] Steyn and Iscan reported that five mandibular parameters (i.e. bigonial breadth, total mandibular length, bicondylar breadth, minimum ramus breadth, and gonion-gnathion) and achieved an accuracy of 81.5% in South African Whites, which is comparable with the present study results.\[5,11\] According to Dayal et al., mandibular ramus was considered to be the best parameter with 75.8% accuracy.\[12\]

**Limitations**

Gender cannot be determined in subadult age group and edentulous patients.

**Conclusion**

In forensic study, mandibular ramus can be used as an indicator for gender determination as it is found intact and it is very durable and shows resistance to disintegration process. Using orthopantomographs, mandibular ramus was found to be a reliable indicator for gender determination.

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**Table 2: Descriptive statistics**

| Variable                        | Wilks’ lambda | F    | Df1 | Df2 | Significance |
|---------------------------------|---------------|------|-----|-----|--------------|
| Maximum ramus breadth           | 0.982         | 1.751| 1   | 98  | 0.189        |
| Minimum ramus breadth           | 0.993         | 0.685| 1   | 98  | 0.410        |
| Condylar height                 | 0.846         | 17.890| 1   | 98  | 0.000        |
| Coronoid height                 | 0.926         | 7.884| 1   | 98  | 0.006        |
| Projective height of ramus      | 0.853         | 16.855| 1   | 98  | 0.000        |

**Table 3: Linear discriminant function**

| Variable                        | Male          | Female         |
|---------------------------------|---------------|----------------|
| Maximum ramus breadth           | 3.169         | 3.016          |
| Minimum ramus breadth           | −0.921        | −0.838         |
| Condylar height                 | 1.966         | 1.800          |
| Coronoid height                 | 0.376         | 0.429          |
| Projective height of ramus      | 0.445         | 0.382          |
| Constant                        | −154.573      | −137.708       |

**Table 4: Classification results**

| Gender | Predicted group membership | Total |
|--------|----------------------------|-------|
|        | Male | Female |       |
| Original Count (%) | 36 (72.0) | 14 (28.0) | 50 (100.0) |
| Female | 15 (30.0) | 35 (70.0) | 50 (100.0) |
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How to cite this article: Nagaraj T, James L, Gogula S, Ghouse N, Nigam H, Sumana CK. Sex determination by using mandibular ramus: A digital radiographic study. J Med Radiol Pathol Surg 2017;4:5-8.