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# AN ORTHOPANTOMOGRAPHIC STUDY FOR SEX DETERMINATION BY MANDIBULAR RAMUS IN WESTERN RAJASTHAN POPULATION

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**ABSTRACT**

**INTRODUCTION:** Bones are an important tool for determining the age, sex, and stature of an individual both in a forensic study and in a medico legal case. The mandible is considered a second most sexually dimorphic bone after pelvis. The orthopantomograph is widely used for obtaining a comprehensive overview of the maxillofacial complex.

**MATERIAL AND METHODS**: The present study was conducted on 50 males & 50 females orthopantomographs in the Department of Anatomy, Department of Radiology and in Department of Oral & Maxillo facial surgery, Dr. S. N. Medical College, Jodhpur (Rajasthan) with the aim to measure, compare, and evaluate the various measurements of mandibular ramus as observed on Digital Orthopantomographs. In the present study, direct discriminant analysis was employed, testing five variables i.e. Maximum ramus breadth, Minimum ramus breadth, Condylar height/maximum ramus height, Projective height of ramus and Coronoid height measured on mandibular ramus of the Western Rajasthan population.

**RESULT**: The 5 variables showed statistically significant sex differences between sexes, indicating that ramus expresses strong sexual dimorphism in Western Rajasthan population. The best parameters are coronoid height and condylar height for males and projective height for females.

**DISCUSSION**: It is well noted that discriminant function derived from one specific population cannot be applied to another as magnitude of sex-related differences vary significantly among regional populations. So, there is always a need to develop population-specific standards.

**CONCLUSION**: We found that mandibular ramus measurements using orthopantomographs were reliable for sex determination.

**KEYWORDS**: Mandible, Orthopantomograph, Sexual dimorphism, Discriminant functional analysis

**INTRODUCTION**: Identification and sex determination of human skeleton remains are a critical problem in a forensic study. Bones are an important tool for determining the age, sex, and stature of an individual. By sex determination the job of identification is reduced to half. If the gender of the human skeletal remains is assessed correctly then further investigation are likely to be more accurate. The pelvis exhibits the greatest sexual dimorphism[1]. However, a perfect pelvis is not present in most circumstances,in that case a mandible of skull becomes an important source for sex determination. As a component of skull, the mandible may be considered a second most sexually dimorphic bone[2]. The mandible is most durable facial bone that retains its shape better than other[3,4]. In mass disasters it can retain its shape better than other and commonly resist post mortem damages and form an important source of information about sexual dimorphism[5].Dimorphism in mandible is reflected in its shape and size[6]. Male bones are generally bigger and more robust than female bones[1].

Humphrey et al showed that the site associated with the greatest morphological changes in size and remodeling during growth, mandibular condyle, and ramus in particular are generally the most sexually dimorphic. Measurements of the mandibular ramus tend to show higher sexual dimorphism, and difference between the sexes is generally more marked in the mandibular ramus than in the mandibular body[7.]

Rotational panoramic radiography is widely used for obtaining a comprehensive overview of maxillofacial complex[8]. In forensic anthropology, comparison of antemortem and postmortem radiographs is of great importance in identification of human remains. Antemortem orthopantomograms may be of great value in identification of human remains[9]. Several studies have been conducted on dry adult mandibles for sex determination[3,6,10] but a few studies for measurements on ramus of mandible using a digital panoramic radiographs.

Panoramic imaging (pantomography) is technique for producing a single tomographic image of the facial structures that includes both the maxillary and mandibular dental arches and their supporting structures. It is based on the principle of the reciprocal movement of an x-ray source and an image receptor around a central point or plane, called the image layer, in which the object of interest is located.The principal advantages of panoramic images includes Broad coverage of facial bones and teeth, low patient radiation dose, convenience of the examination for the patient, use in patients unable to open their mouth, short time required to make a panoramic image[11].

## MATERIAL AND METHODS

The retrospective study was conducted using orthopantomographs of 50 males and 50 females of Western Rajasthan population in the age group ranging between 18 and 60 years. The orthopantomographs were collected from Department of Radiology and department of Oral & Maxillo facial surgery, Dr. S.N. Medical College, Jodhpur. The inclusion criteria for optimal radiographs involved were no pathologies, age>18-60 years, no magnification errors, no periodontal lesions, no missing teeth in the mandibular arch and completely dentate patients.

### Exclusion Criteria

The exclusion criteria involved was Pathological mandible, Fractured mandible, Developmental disturbances of mandible, Deformed mandibles, Edentulous mandibles, asymmetry in OPG images, unreadable and poor quality, presence of supernumerary teeth, orthodontic treatment, magnification and distortion.

## MATERIALS

1. 100 ideal OPGS, of which 50 are of males and 50 are of females.

2. Carestream (Kodak) opg dental machine (60-90kV , 2-15 mA) .It is used for extraoral radiography.
3. Kodak Dental imaging software 6.13.1.12- D. The KODAK dental imaging software is a user-friendly working interface that was designed and developed specifically for radiological diagnosis.

Since this study was conducted on radiographs stored in the system, ethical clearance was not applicable.


**Fig. 1- Digital unit of Dental Orthopantomograph machine**

**Fig. 2- Correct head position of the patient**

## 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)

1. **Maximum ramus breadth**: 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[30,4]
2. **Minimum ramus breadth:** Smallest anterior–posterior diameter of the ramus[30].
3. **Condylar height/maximum ramus height**: 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[30].
4. **Projective height of ramus:** Projective height of ramus between the highest point of the mandibular condyle and lower margin of the bone[30].
5. **Coronoid height**: Projective distance between coronion and lower wall of the bone[30].

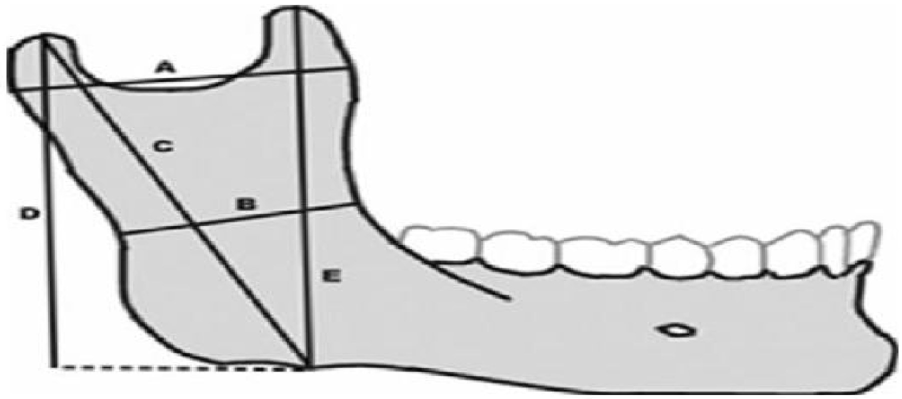


**Fig.3- Showing all the five measurements. (A) Maximum ramus breadth. (B) Minimum ramus breadth. (C) Condylar height ⁄maximum ramus height. (D) Projective height of ramus. (E) Coronoid height. Originally obtained from Vodanovic et al[10]**

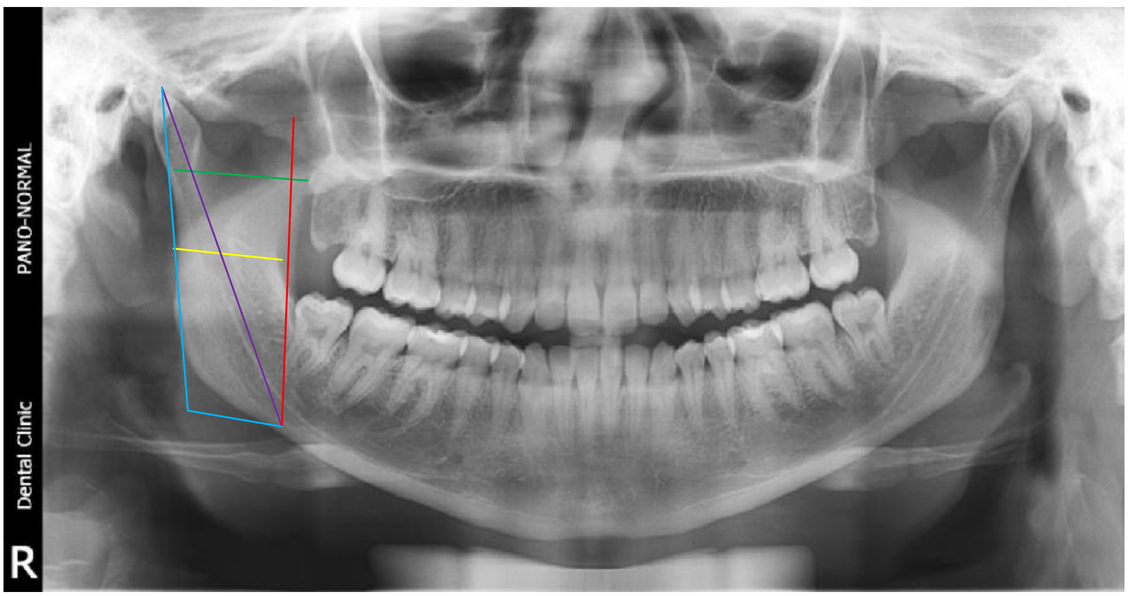


**Fig.4– Representation of the Measurements**

| | | |
|---|---|---|
| **Green line** | **:** | **Maximum ramus breadth.** |
| **Yellow line** | **:** | **Minimum ramus breadth** |
| **Purple line** | **:** | **Condylar height** |
| **Blue line** | **:** | **Projective height of ramus** |
| **Red line** | **:** | **Coronoid height** |

## DISCUSSION

Human beings growth changes take place from the beginning of the prenatal life to senility. Hard tissues (bones and teeth) also undergo changes with growth, which can be a change in shape and/or fusion of ossification centres or after death, these changes remain stable and facilitate ease in estimation of age from hard tissue samples[12,13,14.] Consistent differences have been found between male and female mandibles from diverse range of human groups by Hrdlicka· Statistically significant differences between male and female mandibles are well established, and these differences can be used to predict sex in unidentified mandible. It is well established that discriminant function derived from one specific population cannot be applied to another as magnitude of sex-related differences vary significantly among regional populations[3,15,16]. So, there is always a need to develop population-specific standards for accurate sex determination from a skeleton deriving from that population. Hence, standards have been developed for different populations worldwide.

In the present study, direct discriminant analysis was employed,testing each combination of variables. Each of the five variables measured on mandibular ramus of the Western Rajasthan population showed statistically significant sex differences between sexes, indicating that ramus expresses strong sexual dimorphism in this population. The ramus shows greatest univariate sexual dimorphism in terms of coronoid height followed by condylar height. The best parameters are coronoid height and condylar height for males and projective height for females. The variables of least use for discrimination are maximum and minimum ramus breadth.

In this study, mandibular ramus measurements were subjected to discriminant function analysis. Each of the five variables measured on mandibular ramus using orthopantomograph showed statistically significant sex differences between sexes, indicating that ramus expresses strong sexual dimorphism. The p-values indicated that mandibular measurements expressing the greatest sexual dimorphism were Condylar height, projective height of ramus, coronoid height followed by maximum ramus breadth and minimum ramus breadth. The mean values showed that all dimensions were higher for males compared to females. ROC curve for cut off Values of each variable were calucalted and values greater than the cut off values indicate male and values lesser than or equal to cut off values indicate female.

Earliest studies on mandible by Morant et al. (1936), Martin (1936), and Hrdlicka (1940) (cited in Humphrey et al.[7]), have established the usefulness of mandible for determination of sex. They found that the sexual differences were highest in height of the ramus. This has been confirmed in subsequent studies by De Villiers[17] and Humphrey et al.[7]. Measurements of the height of mandibular ramus tend to show higher sexual dimorphism than measurements of body height and breadth. Thus, emphasizing that sex differences are more pronounced in mandibular ramus than body. Mandibular ramus flexure, though contentious, was proved to be very useful in the determination of sex up to an accuracy of 94–99% in combined African and Americans samples by Loth and Henneberg[18]. A number of metric studies performed on mandible have also confirmed that the ramus of mandible is most dimorphic. Giles[2] reported mandibular ramus height, maximum ramus breadth, and minimum ramus breadth as highly significant with classification accuracy of 85% in American white and Negro. Steyn and Iscan[19] achieved an accuracy of 81.5% with five mandibular parameters (i.e., bigonial breadth, total mandibular length, bicondylar breadth, minimum ramus breadth, and gonion-gnathion) in South African whites that is comparable with the current study. Dayal et al.[15] found mandibular ramus height the best parameter in their study with 75.8% accuracy. Previously, Franklin et al. [20] reported a very high accuracy of 95% with 10 variables employing geometric morphometric technique on South African population. They reported that in South African blacks, the regions of mandible. expressing the greatest sexual dimorphism are condyle and ramus. In their study, both ramus height and coronoid height showed an average accuracy of 87.5%, which is higher than the present study. It has been established that socio-environmental factors (e.g., malnutrition, climate, pathologies, occupation etc.), influences the development and the appearance of bones. The studies have been conducted on Asian (Indians)[13,14,21] subjects where malnutrition was prominently found contributing to the lower degree of dimorphism that may result in false identification of males as demonstrated by Galdames et al[16] who studied the effect of severe malnutrition on morphological determinants of sexual dimorphism in skull. Saini et al[6] conducted a study on dry adult mandibles of northern part of India and found that ramus expresses strong sexual dimorphism in this population. 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

## RESULT

**Statistical analysis**:

The data were analyzed using the discriminant procedure of the statistical package SPSS 18. Discriminant function analysis was used to determine mean, standard deviation (SD) ,linear regression coefficient by regression equation to determine predictive value; multiple linear regression analysis by fitted model equation to arrive at gender. It is increasingly utilized for sex diagnosis from skeletal measurements.

**Results**:

Three descriptive tests namely Unpaired student t-test, Linear regression analysis with equation & ROC curve for cut-off value sensitivity & other etc. were applied. Descriptive statistics of five mandibular ramus measurements and associated unpaired t- test values for both sexes are shown in Table 1 to 5. Mean measurements between males and females are also shown in Table 1 to 5. The mean values showed that all dimensions were higher for males compared to females. We noticed that each variable was a significant predictor in classifying a given sample ($p < 0.001$) except Minimum Ramus Breadth. The p-values indicated that mandibular measurements expressing the greatest sexual dimorphism were Condylar height, projective height of ramus, coronoid height followed by maximum ramus breadth and minimum ramus breadth.

**Receiver Operating Characteristic (ROC**) curves were plotted for all the five variables. ROC curve plots the true positive rate in function of the false positive rate at different cut-off points. The variables were classified and filtered. To know the Sex prevalence, positive and negative predictive values were calculated. 95% Confidence Interval for sensitivity/specificity, likelihood ratio and predictive values were calculated. Optimal criterion value was calculated to account the sex prevalence, cost of false and true positive and negative decisions (Zweig & Campbell, 1993). This option is only available if sex prevalence is known.

**Table: 1 Maximus ramus breadth in Male and Female**

| **Maximum ramus breadth** | **Mean±SD** | **p value** |
|---|---|---|
| Male | 33.45±3.48 | t= 2.11<br>p=0.03 (S) |
| Female | 32.21±3.80 | |

**Table: 2 Minimum ramus breadth in Male and Female**

| **Minimum ramus breadth** | **Mean±SD** | **p value** |
|---|---|---|
| Male | 29.11±3.86 | t= 1.94<br>p=0.054 (NS) |
| Female | 27.67±3.53 | |

**Table: 3 Condylar height in Male and Female**

| **Condylar height** | **Mean±SD** | **p value** |
|---|---|---|
| Male | 66.78±5.47 | t= 6.42<br>p < 0.0001 (S) |
| Female | 59.99±5.07 | |

**Table: 4 Projective height of ramus in Male & Female**

| **Projective height of ramus** | **Mean±SD** | **p value** |
|---|---|---|
| Male | 58.55±5.76 | t= 5.57<br>p < 0.0001 (S) |
| Female | 52.63±4.81 | |

**Table: 5 Coronoid height in Male & female**

| **Coronoid height** | **Mean±SD** | **p value** |
|---|---|---|
| Male | 62.28±5.41 | t= 5.27<br>p < 0.0001 (S) |
| Female | 56.88±4.80 | |

ROC curve for cut off Values of each variable is shown in Table no.- 6 indicating values greater than the cut off values indicate male and values lesser than or equal to cut off values indicate female.

**Table no. 6 – Cut off values for sex prediction.**

| VARIABLES | CUT OFF VALUES |
|---|---|
| Maximus ramus breadth | 31.3 |
| Minimus ramus breadth | 24 |
| Condylar height | 61.8 |
| Projective height of ramus | 55.5 |
| Coronoid height | 61.7 |

## CONCLUSION

This preliminary radiographic study on mandible from Western Rajasthan population can be considered as a valuable tool in gender determination as the mandibular ramus possesses resistance to damage and disintegration processes. We found that mandibular ramus measurements using orthopantomographs were reliable for sex determination. Hence, we strongly suggest the use of mandibular ramus as an aid for gender determination in forensic analysis. In view of these findings, further studies on more diverse populations to assess the significance of these parameters are recommended. Numerous studies have demonstrated that skeletal characteristics differ in each population and have emphasized the need for population-specific radiographic standards for sex determination future direction toward by taking larger sample size and driving regression equation to predict the gender from dental records.

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