Print ISSN: 2321-6379
Online ISSN: 2321-595X
DOI: 10.17354/ijss/2018/9

Original Article

Mandibular Ramus: An Indicator for Gender Determination - A Digital Radiographic Study

Neeru Pangotra[1], Altaf Hussain Chalkoo[2], Nahida Dar[3]

[1]PG Scholar Department of Oral Medicine and Radiology, Government Dental College, Srinagar, Jammu and Kashmir, India, [2]Professor and Head, Department of Oral Medicine and Radiology, Government Dental College, Srinagar, Jammu and Kashmir, India, [3]Registrar, Department of Oral and Maxillofacial Surgery, Government Dental College, Srinagar, Jammu and Kashmir, India

Abstract

Aims and Objectives: The objectives of this study were as follows: (1) To measure, compare, and evaluate the various measurements of mandibular ramus as observed on orthopantomographs and (2) to assess the usefulness of mandibular ramus as an aid in gender determination.

Materials and Methods: A retrospective study was conducted on 50 males and 50 females using standard digital panoramic radiographs with age ranging from 18 to 58 years. The following five mandibular linear measurements were performed in cm such as maximum ramus breadth, minimum ramus breadth, condylar ramus height, projective ramus height, and coronoid ramus height. The obtained data were analyzed with the software SPSS (version 20.0) and Microsoft Excelled (version 5.00) for statistical analysis using discriminant methods.

Results: Mean measurements descriptive statistic shows that mean values were significantly higher in males compared to females (P < 0.05). Fisher-statistic values indicated that highest sexual dimorphism was seen with condylar ramus height and least with minimum ramus breadth, maximum ramus breadth, condylar height, condylar ramus height, coronoid height, and minimum ramus breadth. Sex was accurately determined in 44 cases of 50 male mandibular measurements with prediction accuracy rate of 88% and sex was accurately determined in 46 cases of 50 female mandibular measurements with an accuracy rate of 92%.

Conclusion: The result of the present study proved that the mandibular ramus plays a major role in gender determination due to its unique high sexual dimorphism and also possesses resistance to damage and disintegration processes. Hence, we conclude that the use of mandibular ramus is recommended as an aid for sex determination in forensic science.

Key words: Discriminant function analysis, Mandibular ramus, Orthopantomograph, Sexual dimorphism

INTRODUCTION

- 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.[1] The determination of gender is important aspect of forensic anthropology and vital in medicolegal investigations.
- Among various measures, mandibular ramus can be used to differentiate between male and female strongly expresses univariate sexual dimorphism. Determination of sex becomes more accurate after attainment of puberty. The differences are well marked in bony pelvis and skull.
- After both of these bony areas, mandible remains next in the human which will also help us in the identification of age, gender, and race.[2] Humphrey *et al.*[3] emphasized that almost any site of mandibular bone deposition, or resorption, or remodeling for that matter, seems to have a potential for becoming sexually dimorphic.
- 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 remodeling during growth.
- Among various radiographic technique, the orthopantomography (OPG) is still used as one of

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www.ijss-sn.com

Month of Submission : 08-2018
Month of Peer Review : 09-2018
Month of Acceptance : 09-2018
Month of Publishing : 10-2018

Corresponding Author: Dr. Neeru Pangotra ,Department of Oral Medicine and Radiology ,Government Dental College, Srinagar, Jammu and Kashmir, India. E-mail:drneerupangotra05@gmail.com

the measures in the determination of sex, wherein the morphology of mandibular ramus is studied.[4] Hence, this study was taken to understand the sexual dimorphism, using digital OPG.

Aims and Objectives

This study aims to determine the usefulness of mandibular ramus as an aid in gender determination.

MATERIALS AND METHODS

- A retrospective study was conducted
- Using digital panoramic radiographs
- 100 subjects (50 males and 50 females)
- Age ranging from 18 to 58 years.
- After obtaining ethical clearance, standardized digital panoramic radiographs of patients taken as part of pretreatment planning for implants, extractions of third molars and for periodontal diseases were selected from the archives of the radiology department.
- Good quality standard digital panoramic radiographs (Sirona, ORTHOPHOS XG 5) of completely dentate and partially edentulous patients were selected for the study.
- Poor quality with any pathological lesions, fracture, or developmental disturbances of the mandible and edentulous mandibles were excluded from the study. The standardized exposure parameters 66 kVp, 8 mA, and 14 s were employed for every panoramic radiograph and assessed by taking measurements unilaterally (on the left side).
- The digital panoramic images were saved in a JPEG file format and exported to the SIDEX 2.5 software (Sirona Dental Systems, USA) where mandibular ramus linear measurements were performed.
- This study was conducted in the department of oral medicine and radiology. The following mandibular ramus linear parameters were measured after image calibration using mouse-driven method in cm [Figures 1 and 2]:

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.[5,6]
2. *Minimum ramus breadth:* Smallest anterior–posterior diameter of the ramus.[6]
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.[6]
4. *Projective height of ramus:* Projective height of ramus between the highest point of the mandibular condyle and lower margin of the bone.[6]

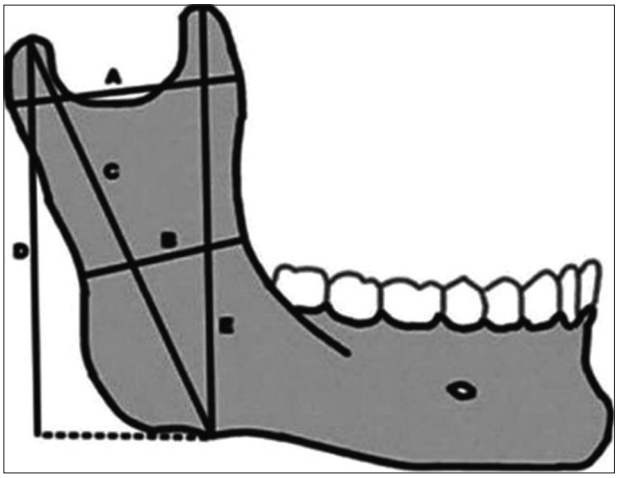


Figure 1: Diagram showing mandibular ramus measurements adapted from Saini *et al.*

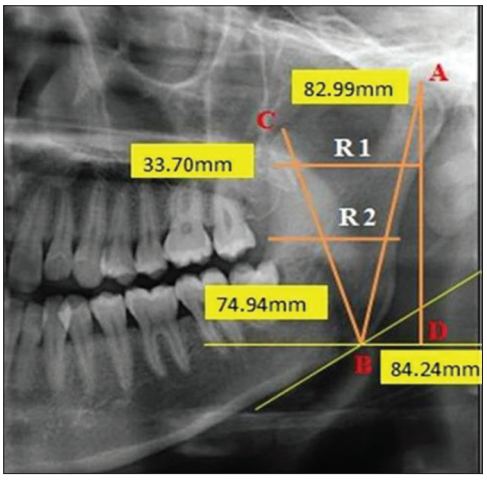


Figure 2: The five linear ramus measurements on digital panoramic radiograph. R1: Upper ramus breadth. R2: Lower ramus breadth. AB: Condylar ramus height. BC: Coronoid ramus height. AD: Projective ramus height

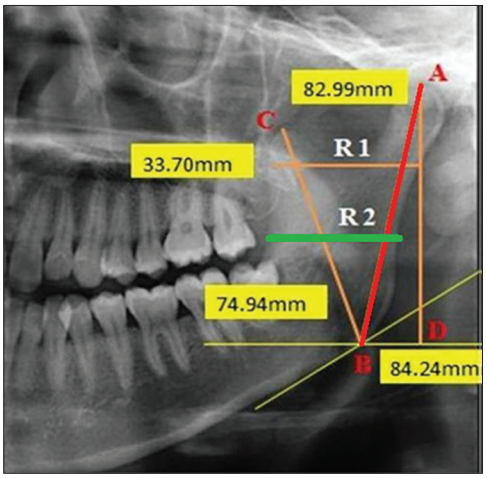
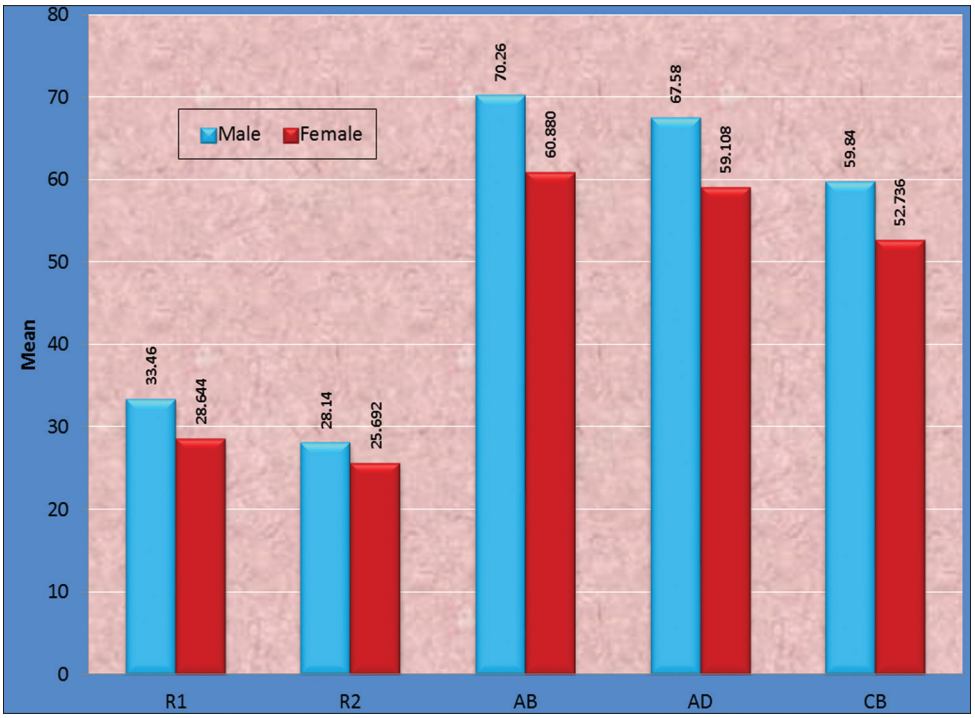


Figure 3: Highest sexual dimorphism was seen with condylar ramus height and least with minimum ramus breadth



Graph 1: Mean measurements in males and females

Table 1: Descriptive statistics of mandibular ramus linear measurements

Variable	Male	Female	Wilk's Lambda	F-value	*P*-value
	Mean±SD	Mean±SD			
R1	33.46±3.942	28.644±7.0187	0.843	8.93	0.004*
R2	28.14±2.955	25.692±3.6940	0.877	6.72	0.013*
AB	70.26±3.908	60.880±3.4713	0.373	80.58	<0.001*
AD	67.58±4.834	59.108±3.4054	0.483	51.32	<0.001*
CB	59.84±5.010	52.736±3.3197	0.579	34.97	<0.001*

*Statistically significant difference (P<0.05)

5. *Coronoid height:* Projective distance between coronion and lower wall of the bone.[6]

RESULTS

- Mean measurements descriptive statistic shows mean values ware significantly higher in males compared to females ($P < 0.05$) [Table 1 and Graph1].
- Fisher-statistic values indicated that highest sexual dimorphism was seen with condylar ramus height and least with minimum ramus breadth [Table 2 and Figure 3].
- Gender was accurately determined in 44 cases of 50 male mandibular measurements with prediction accuracy rate of 88% [Table 3].
- Gender was accurately determined in 46 cases of 50 female mandibular measurements with an accuracy rate of 92% [Table 3].

The linear discriminate (D) function equation is as follows:

Table 2: Linear discriminate function variables

Variable	Male	Female
Constant	−204.6	−154.2
R1	−0.76	−0.72
R2	0.33	0.49
AB	7.78	6.38
AD	−3.06	−2.41
CB	1.42	1.31

Table 3: Prediction accuracy

True Group	Predicted Group		Total	Accuracy
	Male	Female		
Male	44	6	50	88%
Female	4	46	50	92%
Overall Accuracy=90%				

D_{Female} = −154.2–0.72 (R1)+0.49 (R2)+6.38 (AB)–2.41 (AD)+ 1.31(CB)

D_{male} = −204.6–0.76 (R1)+0.33 (R2)+7.78 (AB)–3.06 (AD)+1.42 (CB)

DISCUSSION

- Determination of gender by morphological assessment has remained as one of the oldest approaches in forensic anthropology and medicolegal examinations.
- When entire adult skeleton is available for analysis,

gender can be determined up to 100% accuracy (pelvis).

- However, 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 available parts of skeleton.[7] Skull is the most dimorphic and easily remarked portion of skeleton after pelvis.
- However, in cases where intact skull is not found, mandible may play a key role in gender determination as it is the most dimorphic bone of skull.[8]
- The disadvantages OPG technique is unequal magnification and geometric distortion, which causes many problems.The vertical dimension as compared to the horizontal dimension is little altered. These distortions are the resultof the horizontal movement of the film and X-ray source.[9,10]
- Panoramic radiographic technique remains as quite sensitive to positioning errors because of relatively narrow image layer.[11]
- A study conducted by Kambylafkas *et al.*[12] concluded that the evaluation of total ramal height is reliable, andan asymmetry of more than 6% is an indication of a true asymmetry using panoramic radiograph.
- Dayal *et al.*[13] found mandibular ramus height to be the best parameter in their study, with 75.8% accuracy.
- Another study conducted by Indira et al.[14] on mandibular ramus measurements were subjected to discriminantfunction analysis. Each of the five variables measured on mandibular ramus using orthopantomograph . showed statistically significant sex differences between sexes, indicating that ramus expresses strong sexualdimorphism. The mandibular ramus demonstrated greatest univariate sexual dimorphism in terms of minimum ramus breadth, condylar height, followed byprojective height of ramus. Overall prediction rate using all five variables was 76%.
- Shivaprakash and Vijaykumar[15] conducted a study in diagnosing in the sex by observing the mandibular ramus posterior flexure. Sex was accurately determined in 44 cases out of 55 male mandibles with an accuracy rate of 80%, and sex was accurately determined in 35 cases out of 49 female mandibles with accuracy rate of 71%.
- In our study, highest sexual dimorphism was seen with Condylar ramus height and least with minimum ramus breadth.
- Condylar ramus height and least with minimum ramus breadth.
- Maximum ramus breadth, condylar height, projective height of ramus, coronoid height, and minimum ramus breadth were statistically significant with $P < 0.05$.

CONCLUSION

- The result of the present study proved that the mandibular ramus plays a major role in gender determination due to its unique high sexual dimorphism and also possesses resistance to damage and disintegration processes.
- Hence, we conclude that the use of mandibular ramus is recommended as an aid for determination in forensic science.

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How to cite this article: Pangotra N, Chalkoo AH, Dar N. Mandibular Ramus: An Indicator for Gender Determination - A Digital Radiographic Study. Int J Sci Stud 2018;6(7):42-45.

Source of Support: Nil, **Conflict of Interest:** None declared.