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# Determination of Gender Dimorphism in Mandible and Crania -A Digital Radiographic Study

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## Abstract

Sexual dimorphism refers to the systemic difference in either shape or size between individuals of different sexes. Skull and mandible being composed of hard tissue are indestructible and most easily sexed portion of the skeleton after pelvis. Determination of sex by radiographic methods have proven in many studies to be more accurate than the anthropological methods. Hence this study was aimed at determining gender by obtaining and comparing the reliability of cranio-mandibular parameters using digital Orthopantomograph (OPG), Lateral cephalogram and Postero-anterior (PA) radiograph. The study included 100 male and female patients. Cranio-mandibular measurements were made on each digital radiograph and statistical analysis was done using one way Anova test and logistic regression analysis. The results revealed that all cranio-mandibular measurements showed higher values in males as compared to females. On application of logistic regression analysis all the variables were significant in determination of gender. The variables on OPG manifested higher accuracy (78%) in sex determination as compared to Lateral Cephalogram (75%) and Postero-anterior view (66%). The results of this study inferred that metric analysis of crania and mandible using digital radiographs can be a useful tool in determining gender dimorphism and thus beneficial to the field of forensic science.

**Keywords**: Crania, Mandible, Gender dimorphism, Digital radiographs, Logistic regression

## Introduction

Human identity is the mainstay of civilization and the identification of unknown individuals has been of paramount importance to the society.[1]Sex determination is the first step of the identification process as age and stature estimation are sex dependent.[2] Sexual dimorphism refers to difference in either shape or size between individuals of different sexes in the same species.[3] There are several methods for determination of gender using different parameters.[4]Skull and mandible are the most dimorphic and easily sexed portion of skeleton after pelvis.[5] The studies using anthropometric measurements of skull have claimed accuracy of 77 to 92%. However, methods with digital radiographs has shown an accuracy of 80–100%.[6,7] In view of above literature, this study intends to determine sexual dimorphism in different parameters of crania and mandible using Lateral Cephalogram, Postero-anterior radiograph and

Orthopantomograph and to compare the accuracy of these three radiographic views in the determination of sex.

**Materials And Methods**

The study included 200 subjects with 100 male and female patients of age range between 20-50 years. Good quality radiographs of fully dentate patients were included in the study**.** Patients with history of orthognathic surgery, trauma, surgery of the skull and those with hereditary facial asymmetries, pathological, fractured, those with developmental abnormalities, deformed and edentulous mandibles were excluded from the study. The study was carried out in the department of Oral Radiology and ethical clearance was obtained. The Orthopantomograph (OPG) and Lateral Cephalogram were obtained from patients advised & willing to participate in study after obtaining the clinical data with informed consent and approval. The Postero-anterior Cephalogram were taken on later date (recall visit i.e after two months). The radiograph included in the study were taken on Kodak 8000C digital cephalometric and panoramic machine using all standard radiographic reference lines and exposure parameters as specified by the manufacturer. Cranio-mandibular measurements were made on each digital radiograph using Trophy Dicom and Master View 4.5.1 version software using digital ruler.

Cranio-mandibular measurements carried out in the study were

1.1 Measurements on Orthopantomograph [Figure 1]

1. Maximum ramus breadth (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)
2. Minimum ramus breadth (Smallest anterior–posterior diameter of the ramus)
3. Condylar 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)
4. Coronoid height (Projective distance between coronion and lower wall of the bone)

1.2 Measurements on Lateral Cephalometric radiograph [Figure 2]

1. Mandibular body length (distance between Gonion and Gnathion)
2. Mandibular length (distance between condyle and gnathion)
3. Mandibular height (distance between condyle and gonion)

1.3 Measurements on Postero-Anterior radiograph [Figure 3]

1. Bizygomatic width (distance from the right to left zygomaticus)
2. Bigonial distance (distance from the right to left gonion)

The statistical analysis included calculation of mean and standard deviation for each variable/parameter measured on each digital radiograph. The values obtained were compared between both the sexes using one way Anova test. Subsequently logistic regression analysis was performed for variables on each radiograph and further accuracy of these nine variables in sex determination was obtained. All the above mentioned calculations were carried out using SPSS 16.0 version software. $P< 0.05$ was considered significant and $P<0.01$ as highly significant.

**Results**

The means and standard deviation of variables on each radiograph were compared using one way anova test. The results revealed higher mean values of all cranio-mandibular parameters in males as compared to females. On OPG condylar height and coronoid height showed highly significant sexual dimorphism followed by minimum and maximum ramus breadth [Table 1 & Graph

1]. All the three parameters on lateral cephalogram demonstrated highly significant gender dimorphism [Table 2 & Graph 2]. Bigonial distance and bizygomatic width on PA cephalogram also showed highly significant difference in both the genders [Table 3 & Graph 3]. Logistic regression analysis was performed to determine the accuracy of sex determination. The constant and regression coefficient values of each variable were obtained. Regression equations for each radiograph were derived and subsequently sex was determined using these equations [Table 4]. In our study the sectioning point was found to be 1.5, the values greater than this sectioning point indicate male and values lesser than this point were considered female.

The derived regression equations for each radiograph are as follows

**OPG**

$D_{SEX\ (male\ or\ female)}$ = -1.917-0.013(MAX.RB) +0.018(MIN.RB) +0.043(COND.H) +0.014 (CORO.H])

**Lateral Cephalogram**

$D_{SEX\ (male\ or\ female)}$ = -1.371-0.009(MAN.BL) +0.024(MAN.L) +0.018(MAN.H)

**Postero-Anterior Radiograph**

$D_{SEX\ (male\ or\ female)}$ = -0.918+0.018(BIGONIAL DISTANCE) +0.011(BIZYGOMATIC WIDTH)

Logistic regression analysis demonstrated significant accuracy of all the variables in the determination of sex. Among all the variables, most significant gender dimorphism was demonstrated by condylar height, coronoid height and mandibular length with accuracy of 85%, 82% and 83% respectively [Table 4]. On comparing the three radiographic techniques, OPG showed higher prediction accuracy of 78% followed by Lateral Cephalogram and PA radiograph with 76% and 66% accuracy respectively [Graph 4].

**Discussion**

Human identification is one of the major and most important tasks of Forensic sciences.[8] 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.[9] Sexual dimorphism represents a group of morphologic characteristics that differentiate males from females.[10] The most reliable bone structures for sex determination are the pelvis and the skull.[8] The mandible is commonly available and remains intact, even in scenarios of mass disaster or severe decomposition as it is made up of a dense layer of compact bone which makes it durable and well preserved.[10]

The results of our study showed that all the variables on OPG had higher mean values in males than females and the difference among both the genders was highly significant demonstrating that mandibular ramus is highly dimorphic [Table 1 & Graph 1]. This is in accordance with other studies by Indira AP et al[2], Rinki C et al[11] and Bhagwatkar et al[12]. Humphrey LT et al emphasized that any site of mandibular bone deposition or resorption, or remodeling seems to have a potential for becoming sexually dimorphic. Hence, 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.[2,13]

On Lateral Cephalogram, mean values of all three variables were higher in males as compared to females and the difference was very highly significant statistically [Table 2 & Graph 2], which is consistent with studies by Barthelemy I et al [14] and Gupta K et al [7]. This significant dimorphism can be attributed to differential growth patterns and functional adaptations.[15]

Bizygomatic width and Bigonial distance measured on Postero-anterior Cephalogram demonstrated highly significant sexual dimorphism. The mean values of both the variables were significantly greater in males than the females [Table 3 & Graph 3]. This is in accordance with similar studies by Steyn M & Iscan MY [16], Naikmasur VG et al [6] and Gupta K et al [7]. Extended growth in male causes the malar bones to be large and the zygomatic arch to be displaced more laterally than the corresponding structures in the female. Therefore males have a larger width, providing robustness in the facial skeleton.[15]

Further logistic regression analysis was applied to determine accuracy in gender determination. condylar height, coronoid height and mandibular length were most significant predictors of sex with an accuracy of 85%, 82% and 83% respectively [Table 4]. The overall accuracy obtained was higher with variables on OPG (78%) followed by Lateral Cephalogram (75%) and Postero-anterior cephalogram (66%) [Graph 4]. Naikmasur et al [6] claimed accuracy of 81.5 and 88.2% respectively by comparing the reliability of craniomandibular parameters in South Indian and Indian immigrant of Tibetan populations using 11 variables on lateral and posteroanterior cephalograms. Robinson and Bidmos[17] evaluated 5 discriminant function equations in the crania and mandible of South African whites and the accuracy was in the range of 72–95.5%.

There may be disparity in the findings of different studies that may be explained by the use of varying number of parameters in the determination of sex.[1,8]In general, the differences in the overall accuracy reported by different researchers could be attributed to the fact that the discriminant function or regression equations are population specific and probably sensitive to ethnic and racial variations.[16]

## Conclusion

The consequences that can be drawn from our study are

- Skull and mandible demonstrates high sexual dimorphism
- Ramus height and mandibular length exhibited greater dimorphism and were found to be most accurate in the determination of sex
- Digital radiographic methods are highly accurate in illustrating gender dimorphism
- Application of Logistic regression analysis proved to be more objective and accurate method in the identification of gender

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**Legends Figures**


**Figure 1**

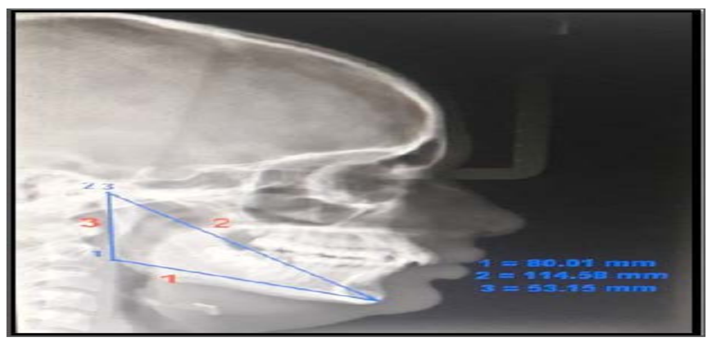



**Figure 2**

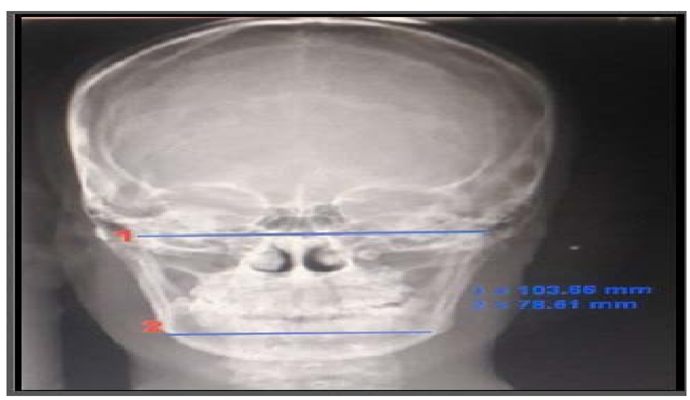
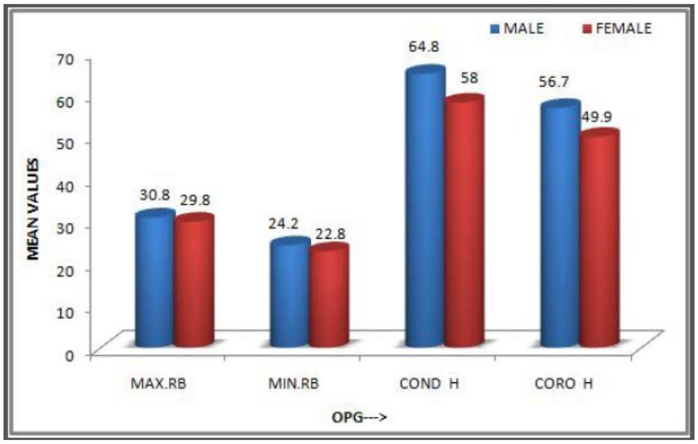
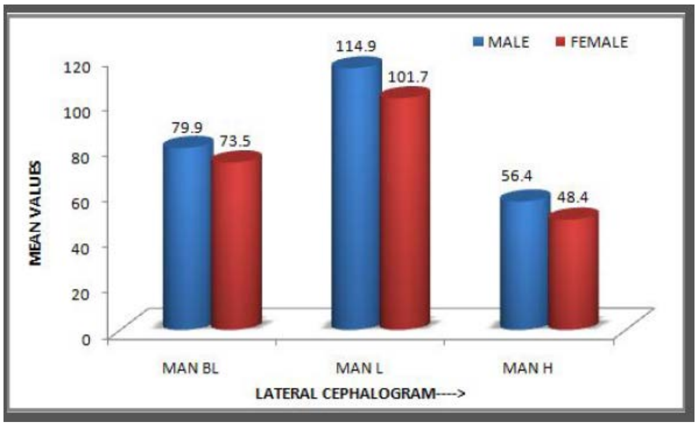


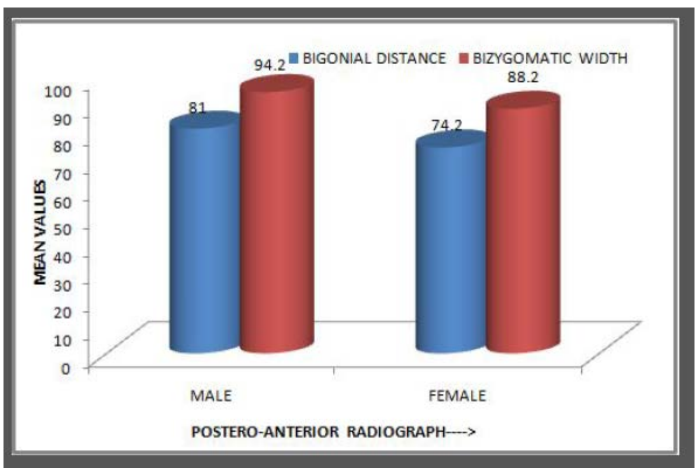

**Figure 3**




**Graph 1**




**Graph 2**




**Graph 3**