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Morphometric Analysis of Mandibular Ramus for Sex Determination on Orthopantomogram

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ABSTRACT

Background: Mandible is the strongest and most dimorphic bone of skull which resists postmortem changes and plays an important role in sex determination. Skeletal characteristic differ in different population therefore need of population specific studies. The aim of present study was to determine sex by morphometric analysis of mandibular ramus.

Methods: A cross sectionalstudy was performed in orthopantomogram of patients collected from Dental Department of Patan Hospital, Lalitpur, Nepal. One hundred and fifty digital orthopantomogram of patient fulfilling inclusion criteria were included in the study. Five different mandibular parameters (maximum ramus breadth, minimum ramus breadth, condylar height/maximum ramus height, projective height of ramus, and coronoid height) were measured bilaterally resulting in total 300 rami being assessed. Orthopantomogram were made with Planmeca ProMax classic 2D machine and all the measurements on digital radiograph were performed with Planmeca Romexis viewer software version 5.1.0.R. Discriminant function analysis was performed to find the most significant predictors for determining sex.

Results: All the measured mandibular parameters were statistically significantly higher in male than females ($P<0.001$). Condylar height was the most significant predictors for determining sex. The discriminate function equation was derived to determine sex with an overall accuracy of 84.0%.

Conclusions: Morphometric analysis of mandibular ramus using digital orthopantomogram showed a high sexual dimorphism.

Keywords: Discriminant function analysis; mandibular ramus; orthopantomogram; sexual dimorphism.

INTRODUCTION

Identification of sex is an important part of medicolegal practice which can be determined 100% accurately when entire adult skeleton is available. But in cases of mass disasters where usually fragmented bones are available, 100% accuracy is not possible. In such situations, pelvis and skull bones are used.[1] Skull is easily sexed portion of skeleton providing accuracy of 92%.[2] Mandible is the strongest and most dimorphic bone of skull which resists postmortem changes and plays a crucial role in sex determination.[3,4] In general, male mandibles are large with prominent muscular markings and are slightly more robust than the female mandibles.[5]

Despite the morphometric and anthropometric methods used in identifying sex from excarnated skull, radiographs also offer accurate, simple and emulative method of sex determination by linear and angular measurements.[6] The accuracy of orthopantomogram(OPG), in providing anatomic measurements has been well established.[7] Worldwide, various studies were conducted to determine sex from morphometric analysis of mandibular ramus using orthopantomogram.[1,8,9] But no such studies have been recorded among Nepalese population and skeletal characteristic differ in different population therefore need of population specific studies. Thus, present study was conducted to determine sex by morphometric analysis of mandibular ramus on orthopantomogram.

METHODS

A cross sectional study was conducted in department of anatomy and dental department of Patan Hospital,

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Patan Academy of Health Sciences (PAHS), Lalitpur, Nepal from 1st October 2020 to 30th June 2021. Digital orthopantomograph (OPG) of the patients used for this study was collected from dental department of Patan hospital. OPG of the patients aged 18 years and above of both sex were included whereas OPG of those patients exhibiting artifacts, poorly visualized,deformities, fractures, pathologies involving the mandible were excluded from the study.Ethical approval was obtained from of Institutional Review Committee (IRC) of PAHS (Ref no: drs 2011101466) before conducting this study.

In present study sample size was calculated on basis of similar study conducted by Pangotra et al.[8]

Mean projected height of ramus in males (μ_1) =67.5

Std. Deviation of projected height of ramus in males (sd_1) = 4.8

Mean projected height of ramus in females (μ_2) =59.1

Std. Deviation of projected ramus height in females (sd_2) = 3.4

Calculation of pooled variance (σ) on the basis of sd_1 and sd_2 = 17.3

Assuming,

Power of the study (1 -β) = 80%

Level of significance (α) = 5%

Keeping values of μ_1, $\mu_2$and σ in the following sample size formula:

$$N = 2 [\{(Z_{\alpha/2} + Z_{1-\beta})/ (\mu_{1} - \mu_2)/\sigma\}^2]$$

The minimum sample size is 67 in each group. After amplification of sample size by 10% for measurement errors, the final sample size is 75 in each group.In present study150 Digital OPG's of patient fulfilling inclusion criteria were included i.e.75 OPG of male and 75 OPG of female patient.From every OPG digital measurements were performed bilaterally resulting in a total of 300 rami being assessed. All these OPG'S were made with Planmeca ProMax classic 2D machine,manufactured in Helsinki, Finland.

For morphometric analysis of mandibular ramus five different mandibular parameters were measured as follows (Figure1).

Maximum ramus breadth (A): The distance between the most anterior point on the mandibular ramus and a line connecting the most posterior point on condyle and angle of jaw.

Minimum ramus breadth (B): Smallest anterior to posterior diameter of ramus.

Condylar/maximum ramus height (C): Height of the ramus from the most superior point on the mandibular condyle to the tubercle or most protruding portion of the inferior border of the ramus.

Projective ramus height (D): Projective height of ramus between the highest point of the mandibular condyle and lower margin of the bone on inferior border of ramus.

Coronoid Height (E): Projective distance between coronoid and most protruding portion of inferior border of ramus.

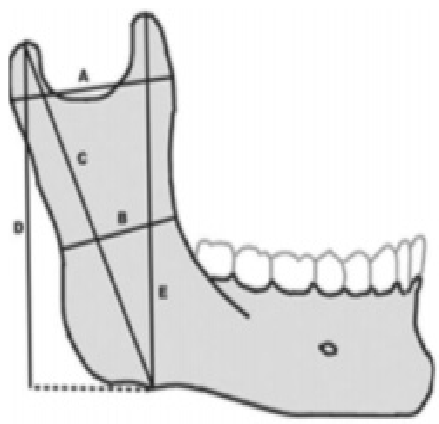

Figure1. Showing five parameters in mandibular ramusadapted from Saini et al. 9A: maximum ramus breath, B: Minimum ramus breath, C: Condylar/ maximum ramus height, D:Projective ramus height and E: Coronoid height.

All the measurements on digital radiograph were performed with PlanmecaRomexis viewer software version 5.1.0.R (figure 2). The measurements were recorded to the nearest millimeter.

All the parameters of mandible were measured by same investigator to prevent inter observer bias.

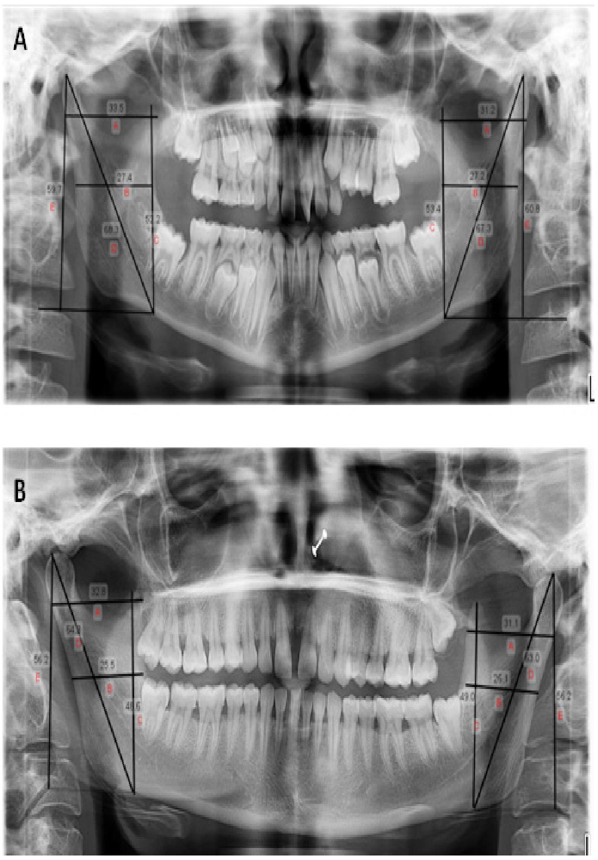

Figure 2. Measurement of mandibular parameters on orthopantomogram in a) male and b) female.

The data was collected and entered into Microsoft Excel sheet and was analyzed using statistical package social science (SPSS-16). Result obtained was presented as Mean ±SD for descriptive analysis. For inferential statistics t-test and discriminant function analysis was done. Discriminant function analysis was done to determine variables that discriminate between male and female. Independent t-test was used for sex-wise comparison of mean values of mandibular parameters. P-value <0.05 was considered statistically significant.

RESULTS

The present study was performed in 150 digital OPG of patients attending dental OPD. In each OPG, parameters were measured on both right and sides of the mandibular ramus thus, in this study n (sample size) becomes 300. The mean ± SD values of measured parameters in mandibular ramus as shown in table1. In present study mean of right and left side was used for statistical analysis.

Table1. Morphometry of mandibular ramus performed on OPG of all patients (n=300).

S.N	Mandibular parameters	Mean ± SD
1.	Maximum ramus breadth	33.81±3.18
2.	Minimum ramus breadth	26.42±2.62
3.	Coronoid Height	57.99±5.40
4.	Condylar/maximum ramus height	72.36±5.49
5.	Projective ramus height	65.25±5.30

The mean ± SD values of all the measured parameters: maximum ramus breadth, minimum ramus breadth, coronoid height, condylar height/maximum ramus height and projective height of ramus of both sides in males and females as shown in table 2.

All the five measured parameters on mandibular ramus were statistically significantly higher in male participants compared to female (p<0.001) (Table 3). The measured mandibular parameters with the greatest sexual dimorphism based upon Wilk's Lambda and f-statistics values were maximum condylar height followed by coronoid height, projective ramus height and maximum ramus width. A measurement showing least sexual dimorphism was with minimum ramus width (Table 3).

Table 2. Measured mandibular parameters mean of right and left side in male and female performed on OPG (n=300).

S.N	Mandibular Parameters	Male		Female	
		Right(n=75) (mean±SD)	Left(n=75) (mean±SD)	Right(n=75) (mean±SD)	Left(n=75) (mean±SD)
1.	Maximum ramus breadth	35.75±2.95	35.16±3.20	32.49±2.66	31.85±2.61
2.	Minimum ramus breadth	27.75±2.71	27.18±2.63	25.83±2.52	24.92±2.31
3.	Coronoid Height	61.87±4.80	60.92±5.21	55.17±3.63	54.02±3.42
4.	Condylar/maximum ramus height	76.70±4.70	75.27±4.94	69.56±3.53	67.92±4.13
5.	Projective ramus height	68.78±5.06	68.22±5.00	62.46±3.60	61.55±3.84

Table3. Sex wise difference in mandibular parameters performed on the OPG (n=300).

S.N	Mandibular parameters	Male (n=150) Mean ± SD	Female(n=150) Mean ± SD	Wilk's λ	F ratio value	p value
1.	Maximum ramus breadth	35.46±2.94	32.17±2.51	0.732	54.149	<0.001
2.	Minimum ramus breadth	27.46±2.51	25.37±2.29	0.840	28.240	<0.001
3.	Coronoid Height	61.39±488	54.59±3.40	0.602	97.847	<0.001
4.	Condylar/maximum ramus height	75.98±4.59	68.74±3.60	0.562	115.180	<0.001
5.	Projective ramus height	68.49±4.82	62.01±3.45	0.623	89.674	<0.001

Independent t-test value significant at p≤0.05

The Box's M statistics was applied to verify the applicability of mandibular ramus in determining sex which revealed that male and female can be differentiated and was found to be statistically significant (P< 0.05).

In present study, out of 75 males 63 (84%) were correctly predicted as males, likewise in female also, out of total 75 females 63 (84%) were correctly predicted as females. Thus, the overall accuracy for determining sex from mandibular ramus was 84%.

The estimated sex can be calculated using the linear discriminate (D) function equation which is as follows:

D_{Male} = -182.27+.439(max. ramus breath) +.567(min. ramus breath)+1.264(Coronoid Height) + 4.190(Condylar/maximum ramus height) -.934(Projective ramus height)

D_{Female} = -148.60+.370(max. ramus breath) +.682(min. ramus breath) + 1.040 (Coronoid Height)+ 3.731 (Condylar/maximum ramus height) - .753 (Projective ramus height)

In present study, sectioning point was -0.956. The discriminant value (D) greater than sectioning point indicates male and value less than the sectioning point indicates female (Table 4).

Table4. Canonical discriminate functions coefficient for male and female participants.

Measured parameters	Discriminant function coefficients values		Sectioning point	
	Male	Female	Male 0.956	Female -0.956
Maximum ramus breadth	.439	.370		
Minimum ramus breadth	.567	.682		
Coronoid Height	1.264	1.040		
Condylar/maximum ramus height	4.190	3.731		
Projective ramus height	-.934	-.753		
Value of constant	-182.279	-148.607		

DISCUSSION

Determination of sex is an important step in biological identification from skeletal remains, especially in forensic investigations as it can narrow down the possibility of identification of 50% of sexes.[10] Next to pelvis, the skull is most sexually dimorphic region of human skeleton and as a component of the skull, the mandible may be considered as second most sexually dimorphic bone and is an important source for sex determination.[11] Discriminant function analysis is increasingly used to determine the sex from skeleton. In this study, discriminant function analysis was done to study mandibular ramus measurements. Discriminant function equations are population specific and as such equation derived for one specific population cannot be applied to other populations 1241 female.Therefore, each population requires need of population specific standards for accurate sex determination.

In present study, mean values of all five measured parameters in mandibular ramus: maximum ramus breadth, minimum ramus breadth, coronoid height, condylar height/maximum ramus height and projective height of ramus were statistically significantly higher in male than female participants (P<0.001), indicating that the mandibular ramus expresses good sexual dimorphism. The finding of present study is in accordance with the study conducted by Indira et al., in Banglore where each of the five variables measured on mandibular ramus using OPG(50 males and 50 females) were significantly higher for males compared to females.[7] Similarly, Taleb et al., in their study on 191 panoramic images of Egyptian patients found that the mean values of all measured mandibular parameters were statistically significantly higher in male than females.[13] Likewise study from Saudi by Sandeepa NC et al., performed in 200 panoramic images (100 males and 100 females) revealed that all measured mandibular parameters were significantly higher in male than female.[14] Additionally Pangotra et al., Mehta et al.,and More et al., also reported similar findings.[8,15,16] Mandibular ramus are sexually dimorphic i.e. can be differentiated between sexes, as the stages of mandibular development, growth rates and duration are distinctly different in both sexes. In addition, masticatory forces exerted are different for males and females, which influence the shape of mandibular ramus.[17] Sexual dimorphism observed can also arise due the difference in the levels of testosterone between males and females, because testosterone brings about a direct increase in the size and mass of muscles and bones.[18]

In present study, mandibular ramus with greatest dimorphism was condylar ramus height and least with minimum ramus breadth. The finding was in agreement with Pangotra et al., and Kaur et al.[8,19] Likewise, Elsayed et al., reported condylar height to be the best discriminating variables between sexes with an overall accuracy of 97% in males and 100% in females. In comparison, the least predictor for sexual dimorphism was the minimum ramus breath.[9] In another similar study conducted by Taleb et al., among Egyptian population documented condylar and coronoid height being the best predictors for sex determination with overall accuracy of 79.6%.[13] SandeepaNC et al., reported highest sexual dimorphism waswith maximum ramus width, coronoid height followed by condylar height and least dimorphism was with minimum ramus width in their study conducted upon Saudi population.[14] However, Indira et al., and Nimi et al., reported greatest univariate sexual dimorphism in terms of minimum ramus breadth among Indian population.[7,20] In study by Chalkoo et al., highest sexual dimorphism was seen with projective height of ramus and least with minimum ramus breadth.[21] This difference in highest sexual dimorphism with different parameters of mandibular ramus might be due to difference in genetic makeup, environmental factors, food style and physical activities in different study population.

In present study, 63 out of 75 males (84%) were correctly predicted as males, likewise 63 out of total 75 females (84%) were correctly predicted as females. Thus, the overall accuracy for determining sex from mandibular ramus was 84%. Chalkoo et al., reported the accuracy of sexual dimorphism was 80% in male and 95% in female with overall prediction rate of 87.5% which is comparable to the present study. [21] Study from Egypt reported 81% of the males and 77.9% of the females were correctly classified with overall correct classification of 79.6%.[13] Okkesim et al., measured morphometric parameters of the mandible using 3D CBCT in Turkish population, reported prediction accuracy rate of 77.4% and 73.5% in male and female respectively.[22] Likewise More et al. reported overall accuracy for determining sex was 69%, whereas for diagnosing male and female, the accuracy was 68% and 70% respectively.[16] In similar study by Saloni et al., 78.4% of males and 76.8% females were successfully identified by morphological analysis of mandibular ramus on OPG with overall accuracy of 77.6%.[1] In addition, Indira et al. achieved an accuracy of 76% in determining sex.[7]Several studies reported accuracy rate was lower than that of present study.[1,6,13,16,22] This difference in accuracy for sex determination might be due to small sample size of our study and also due to different nutritional, geographic, and racial features of populations in different studies.

The limitations of the study is that we had only included patient attending dental outpatient department of Patan hospital so, finding of this study cannot be generalized to whole Nepalese population.

CONCLUSIONS

The findings of the present study showed that the mandibular ramus could play an important role in sex determination due to its high sexual dimorphism. Hence, we conclude that mandibular ramus could be considered as one of the tool in sex determination However, further studies are recommended with larger sample size from diverse geographic regions of Nepal are needed to set our population standard for determination of sex. The derived discriminant function equations can be used as a reference for the determination of sex. These data may be useful in anthropological assessments as well as in reconstructive surgeries of mandible.

CONFLICT OF INTEREST

None.

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