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Morphometric Analysis of Mandible for Sex Determination - A Retrospective Study

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ABSTRACT

BACKGROUND: The first step in Person identification process is sex determination. Mandible is dimorphic bone which is having a dense layer of compact bone which makes it very durable and well preserved than many other bones and can be used for sex determination. **AIMS AND OBJECTIVES:** To evaluate the accuracy of sex determination using various measurements on mandible using digital Orthopantomography (OPG). **MATERIALS AND METHODS:** A retrospective study was conducted using digital OPG of 154 males and 154 females between the age group of 20 and69 years. The Bi-condylar width, Bi-gonial width, Bi-mental width, Maximum ramus breadth, and Minimum ramus breadth measurements were recorded using measuring tools accompanied with Digora for windows 2.7.103.437 by two expert oral radiologists. The discriminate functional analysis was used to determine variables that discriminate between males and female. **RESULTS:** Statistical significant mean value noticed between measurements of males and females. The study revealed higher identification rates for males (71.8%) and females (70.4%) with a total accuracy rate of 71.1%. **CONCLUSION:** This study proved that mandible can be used as a reliable tool in sex determination. Out of five parameters used in the present study, Inter-condylar distance was found to be more reliable compared to other parameters.

INTRODUCTION:

Identification of human skeletal remains is required for both legal and humanitarian reasons. The first step in identification process is sex determination on which the subsequent methods for age and stature estimation are dependent.[1, 2]Sex can be determined up to 100% accuracy when the entire adult skeleton is available for analysis. But in cases of mass disasters where usually fragmented bones are found, 100% accuracy of sex determination is not possible. In such situations pelvis is used for sex determination. Skull is the most dimorphic and easily sexed portion of skeleton after pelvis, providing accuracy up to 92%.This is due to difference in growth pattern and maturation rate of skeletal bones which is seen early in females than males.[2]

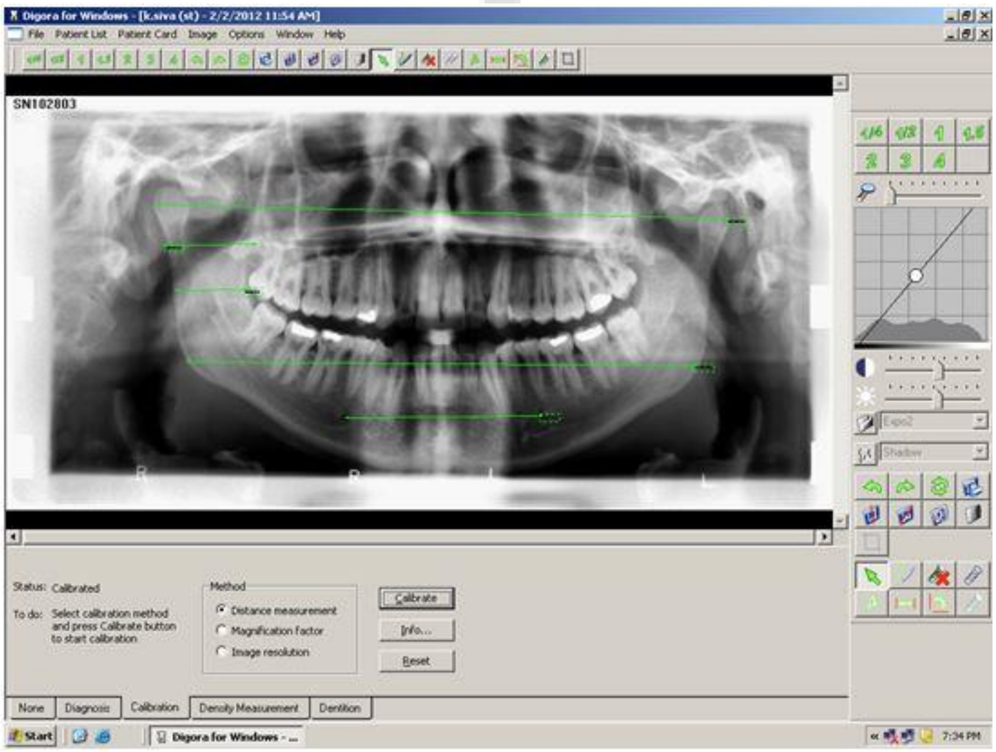
Mandible has a dense layer of compact bone which makes it very durable and well preserved than many other bones. Mandible may play a key role in sex determination as it is the most dimorphic, largest and strongest bone of the skull.[3-5]Generally, the shape of the mandible is developed by the sequential structural remodeling of bone at the time of its growth. Male bones are generally bigger and more robust than female bones.[1, 2]

The Mandibular ramus, Mandibular angle measurements from a dry adult mandible can be used for sex determination.[2,6-12]The mandible as a whole has been studied in great detail for its use in determination of sex using non-metric discrete traits by Giles in1964.[13] A large number of studies on mandible using metric methods like discriminant function analysis are also available in the literature. So far among the metric methods conducted in India, the minimum accuracy in sex determination using mandible was 60.3%, 70.9%, 76%.[1, 9]

Orthopantomogram (OPG) is commonly used for obtaining a comprehensive overview of the maxillofacial complex. In forensic anthropology, comparison of antemortem and postmortem radiographs is one of the key features of identification of human remains. Antemortem OPG may be of great value in the identification of human remains.[2] Hence the present study was conducted to evaluate the accuracy of sex determination using various measurements on mandible using digital OPG.

MATERIALS AND METHODS:

A retrospective study was conducted using digital OPG of 154 males and 154 females between the age group between 20 and69 years. Properly taken digital OPGs of complete dentate patients with properly identify landmarks were selected for the study. Developmental anomalies, disease affecting the growth of mandible or surgery to the mandible, and edentulous mandibles were excluded from the study.Radiographs were taken by SatellacDigital Panoramic and Cephalometric System (70kVp, 12 mA, 12 s) using PSP film of size 6x12cms. The anatomical landmarks on digital OPG were identified and measurements were recorded using measuring tools accompanied with Digora for windows 2.7.103.437. The parameters that were measured on digital OPG are (Figure 1):



1. Bi-condylar width*:* The distance between the most lateral points on the two condyles.
2. Bi-gonial width: It is the distance between both gonia.
3. Bi-mental with: The distance between both mental foramen.
4. 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. Minimum ramus breadth: Smallest anterior–posterior diameter of the ramus.

Mandibular ramus measurements were carried out by the two expert oral radiologists and the results were recorded. The same procedure was repeated with one of the oral radiologists after one month to check for intra-observer variability. The data subjected to statistical analysis using SPSS (SPSS **statistical package, version 13.0).** Discriminate functional analysis was used to determine variables that discriminate between males and female and is increasingly utilized for sex diagnosis from skeletal measurements.

RESULTS:

Inter and intra observer's measurements were subjected to statistical analysis. There is no statistically significant difference between inter and intra-observers at 5% level of significance (Table 1).

A statistically significant difference was observed in the mean values of Bi-condylar width, Bi-gonial width, mental foramen width, maximum breadth of ramus, and minimum breadth of ramus. The results show a definite dimorphic feature in these measurements, which help in sex differentiation using these parameters.

Of all the parameters the Bi-condylar width showed highest sex differentiation in its measurements (wilks' lambda = 0.78), followed by Bi-gonial width (Table 2). Discriminant analysis was done using gender as a grouping variable and Bi-condylar width, Bi-gonial Width, Bi-mental Width, Maximum Ramus Breadth, Minimum Ramus Breadth as independent variables and the discriminant equation was obtained for sex determination.

D= (0.794x BICONDYLARWIDTH) + (0.028 x BIGONIAL WIDTH) + (0.056 x BIMENTAL WIDTH) + (0.894x MAXIMUM RAMUS BREADTH)-(0.230 x MINIMUM RAMUS BREADTH)-20.235. (Where "D" is the discriminant score).

A greater calculated D (>0) indicates male gender, while the D value less than the reference value (<0) indicates female gender. The more extreme the calculated D value from the cutoff value (zero), the higher the probability that the predicted gender is correct.

The study revealed higher identification rates for males (71.8%) and females (70.4%) with a total accuracy rate of 71.1% (Table 3). These results justify that the above said parameters can produce reliable results in sex determination from OPG.

DISCUSSION:

Sex determination based on morphological marks is subjective and probably to be inaccurate, but methods based on measurements and morphometry are accurate and can be used in determination of sex.[1] Laster WS *et al* proposed that panoramic radiographs are accurate in providing anatomic measurements.[10] The limitations of OPG are magnification and geometric distortion, and this technique is somewhat sensitive to positioning errors because of relatively narrow image layer.[11] In our study, this limitation did not affect our results since all images were taken under same machine and were uniformly magnified. The inter and intra-observer variability was insignificant indicating that these measurements can be reproducible.

It was established that discriminant function derived from one specific population cannot be applied to another as magnitude of sex-related differences varies significantly among regional populations.[2] So, there is always a need to develop population-specific standards for accurate sex determination based upon the ethnic origin. Hence, standards have been developed for many studies in different populations worldwide. But no study was conducted in the south Indian population using Mandibular measurements.

In the present study, discriminant analysis was employed, testing the combination of the five variables which showed statistically significant differences between sexes, indicating that mandible expresses strong sexual dimorphism in South Indian population. Of these, the best parameter in this study is Bi-condylar width showed highest sex differentiation followed by Bi-gonial width, Maximum breadth of ramus, Minimum breadth of ramus, Mental foramen width. In this study the mean value of Bi-condylar width in males is 21.57cms and females are 20.49cms. It shows significance difference between the sex as the sharp tubercles on the medial and lateral aspect of anterior surfaces of Mandibular condyles are stress indicators and were smaller in females compared to males.[12]

The prediction rate using all five variables was 71.1%, with males, 71.8%withfemales, with an overall accuracy rate of 70.4%.Earlier studies on mandible by Morant *et al*. (1936), Martin (1936), and Hrdlicka (1940), have established the usefulness of mandible for determination of sex.[2]Indira AP *et al*, reports 76% accuracy in sex identification using the Mandibular ramus in Indian population.[1]Giles reported mandibular ramus height, maximum ramus breadth, and minimum ramus breadth as highly significant factors with classification accuracy of *85%* in American white and Negros.[13] Steyn and Iscan observed an accuracy of 81.5% with five mandibular parameters (Bi-gonial breadth, total mandibular length, Bi-condylar breadth, minimum ramus breadth, and gonion-gnathion) in South African whites which is comparable with the current study.[14] Dayal *et al*. found mandibular ramus height as the best parameter in their study with 75.8% accuracy.[15] Previously, Franklin *et al*. reported a very high accuracy of *95%* with 10 variables employing geometric and morphometric technique on South African population. They reported that in South African blacks, the condyle and ramus of mandible express the greatest sexual dimorphism with an accuracy of 87.5%, which is higher than the present study.[16]

The variation in prediction accuracy in width measurements on mandible may be because of ethnic differences in size and expression of dimorphic characteristics, which is of low degree in Indian population. It can also be attributed to the difference in musculoskeletal development between males and females of various population groups. Hence these differences emphasize the need for population-specific osteometric standards for each population group in the world.

The limitations of the study are the inability to reliably assign sex in the age range below the age of complete development of mandible and inability to assess the gender in case of edentulous patients.

CONCLUSION:

This study proved that mandible can be used as a reliable tool in sex determination as it is resistance to damage and disintegration processes. Out of five parameters all showed significant sex difference with mean values and Intercondylar distance is more reliable compared to remaining in the present study. Further studies should be done on a large scale in various population group to assess the significance of this parameter in sex determination.

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Table-1: Table Showing Inter and Intra observer Variability

Observers Vsbicondylar width	Mean	S.D	F-value(P-value)	Decision	Multiple Comparisons	P-value
Observer-I (A)	20.87	1.354	0.34 (0.711)	Not Significant	AB	0.856
Observer-II(B)	20.804	1.454			BC	0.480
Observer-I 2nd Time(C)	21.153	2.262			AC	0.559

Table-2: Table Showing Mean and Standard Deviation of Co-efficient in Original Sample.

	SEX	N	Mean	Std. Deviation	Wilks' Lambda	p-value
BICONDYLAR WIDTH (BW)	MALE	154	21.57	1.07	0.78	0.01
	FEMALE	154	20.49	1.00		
BIGONIAL WIDTH (BIW)	MALE	154	19.19	0.95	0.88	0.01
	FEMALE	154	18.45	1.04		
BIMENTAL WIDTH (BMW)	MALE	154	6.51	3.94	0.99	0.04
	FEMALE	154	5.85	0.65		
MAXIMUM BREADTH OF RAMUS (MABR)	MALE	154	3.82	0.38	0.89	0.01
	FEMALE	154	3.58	0.33		
MINIMUM BREADTH OF RAMUS (MIBR)	MALE	154	2.92	0.32	0.95	0.01
	FEMALE	154	2.77	0.31		

Table-3: Table Showing Prediction Accuracy

	PREDICTED MALE	PREDICTED FEMALE	Total
MALE	107	47	219/308
	71.8%	29.6%	
FEMALE	42	112	71.1%
	28.2%	70.4%	