Metric study of fragmentary mandibles in a North Indian population

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Abstract

Sex discrimination is crucial in an anthropological examination. Researchers investigated the usefulness of different skeletal elements in sex determination in various populations using a range of variables and a variety of techniques. Each population needs its own specific and updated standards due to the differences in skeletal morphology.

The present study aims to examine the importance of the mandible in sex discrimination of a north Indian population. A total of 190 adult mandibles (M:F:145:45) from the Department of Forensic Medicine, Institute of Medical Sciences, Banaras Hindu University, Varanasi, India were collected. Five variables were measured and discriminant function analysis was performed using SPSS 16.00. The sex classification accuracies ranged from 48.9% to 67.4% for single variables. The highest sexing accuracy (71.6%) was achieved in stepwise analysis with the selection of 3 variables. In conclusion the variables selected for the present study were not suitable for forensic and archeological investigation. It is suggested that these variables must be examined on other populations to see their utility.

Keywords: Forensic Anthropology; Discriminant Function Analysis; Sexual Dimorphism; Mandible; North Indian Population

Introduction

Identification of sex is the most important aspect of anthropological examination as its knowledge immediately eliminates half of the population being considered. Moreover, the methods of age and stature estimation depend on correct sex determination. It has widely been acknowledged that discriminant function derived from one specific population cannot be applied to another as the magnitude of sex-related differences such as body size, robusticity etc., vary significantly among regional populations (1-3). Therefore each population requires the development of population-specific standards for accurate sex determination for a skeleton deriving from that population. The study of sex determination is not only important from a forensic point of view but also for regional variations and population history. Previous studies have been conducted on mandibles using traditional anthropological methods as well as modern imaging methods (1,4-8).

The mandible is considered the most durable and sexually dimorphic bone of skull (4). Presence of a dense layer of compact bone makes it very durable and hence mandibular remains preserve better than many other bones. Dimorphism in the mandible is reflected in its shape and size. As the mandible is the last skull bone to cease growth (9), it is sensitive to the adolescent growth spurt (10).The stages of mandibular development, growth rates and its duration are distinctly different in both sexes so this bone is particularly useful in differentiating between sexes. In addition, masticatory forces exerted are different for males and females, which influence the shape of the mandibular ramus (11-13).

Previously, efforts have been made to identify sex using the mandibular ramus on the same population (14,15) but it was on a smaller sample size. In present study a larger sample and a different set of variables is used to test their applicability in sex discrimination in a north Indian population.

Materials and methods

The sample was collected in the Department of Forensic Medicine, Institute of Medical Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India. It comprised of 190 adult mandibles (145 males and 45 females) between the age group of 18-65 years, from forensic cases. No pathological, fractured, deformed or edentulous mandible was included in the study.

All measurements were taken three times with a sliding caliper (0.05 mm precision) and mean value was used for analysis. The following measurements were taken:

- Mandibular Body Height [MBHt]: direct distance from the alveolar process to the inferior border of the mandible perpendicular to the base at the level of the mental foramen (16).
- Maximum Ramus Breadth [MaxRBr]: 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 the jaw (16).

- Minimum Ramus Breadth [MinRBr]: The minimum breadth of the mandibular ramus measured perpendicular to the height of the ramus or smallest anterior-posterior diameter of the ramus (16).
- Breadth of Condyle [ConBr]: The distance between the most anterior and most posterior point of the mandibular condyle (13).
- Length of Condyle [ConLt]: The distance between the most lateral and the most medial point of the mandibular condyle (13).

SPSS 16.00 was used to analyse the data and to provide discriminant functions. The discriminant function is constructed by assigning a discriminant score to each case. The discriminant score changes from case to case depending on the variable and combination of variables for a function. A sectioning point (SP) is created by using the mean male and female discriminant scores, which are also known as the group centroids. Therefore, each function has a different sectioning point, which is based on the variables entered in the function. Unstandardized (raw) coefficients are used to create the discriminant formula. The standardized (Fisher's) coefficients give an idea about the relative importance of the independent variables. For cross-validation "leave-one-out method" was used at the end of the analysis. In this form, each case is classified using a discriminant function based on the rest of the sample. This is thought to give a better estimate of what classification results would be in the population.

Results

General descriptive statistics for all five variables is provided in Table 1. The t test shows that all the measurements are significantly higher ($p<0.001$) in males except ConBr.

Table 2 shows the result of stepwise analysis. Out of 5 variables 3 variables were selected to provide maximum separation of sexes.

Table 3 shows the standardized and unstandardized discriminant function coefficients, structure matrix, group centroids, sectioning points and classification accuracy in stepwise and direct analysis. An overall accuracy of 71.6% was achieved using cross validated sample in stepwise analysis. In direct analysis 2 variables were used to make a discriminant function, and it provided slightly lower accuracy than stepwise.

Independently each variable provides a certain percentage of certainty about the sex of the mandible in an unknown sample. Table 4 provides sexing accuracy for the single variables in studied sample.

The sexing accuracies were not very promising for individual variables and highest overall classification of 67.4% was achieved by mandibular body height (MBHt). The cross-validation method demonstrated reduced classification percentages.

Discussion

In forensic and bioarchaeological investigations sex identification is an important demographic assessment. Osteometric assessment by means of discriminant function analysis is one of the most commonly used methods of estimating sex in unidentified skeletal remains. It has widely been recognized, however, that levels of sexual dimorphism are population-specific, due to a combination of genetic and environmental factors (17).

Weidenreich (1936) found that modern human female mandible size is an average 92.4% of male size (cited in Humphrey et al, 1999) but most of the differentiating points cannot be seen until adulthood when all sex-differentiating features become clearly visible. Humphrey et al, (18) pointed out that during growth, the mandibular ramus and condyle are the sites which are associated with the greatest morphological changes in size and remodeling, hence most dimorphic. Sexual dimorphism in the modern human mandible has been interpreted in the literature as being related to differences between male and female growth trajectories and musculoskeletal development.

Vodanovic et al, (13) found maximum ramus breadth, minimum ramus breadth, and maximum ramus height highly significant for differentiating sex in a Croatian archeological sample. In their study MinRBr provided an accuracy of 74% which is higher than the present study. Franklin and co-workers (4) reported a very high accuracy of 95% with ten variables employing geometric morphometric techniques on South African blacks. They reported that the regions of mandible expressing the greatest sexual dimorphism are the condyle and ramus. Their results were in agreement with the findings of Humphery (18) on great apes and different human populations. In a recent study Pokhrel and Bhatnagar (19) used four variables of the ramus and achieved an accuracy of 82.9% using minimum and maximum ramus breadth. Also a comparatively high accuracy (70.9%) was achieved using breadth and length of condyle. They used demarcation points instead of sectioning points for sex identification. In the present study the condylar measurements couldn't provide very high classification accuracy, as previous researchhas claimed. Even ConBr was found to be non significant in sex discrimination (table 1). The most accurate variable (MBHt) could provide only 67.4% sexing rate (table 4), though this percentage of certainty significantly changes when considered in combination with other variables (Table 3). This variation in classification accuracies clearly shows that the same variables may provide different classification accuracies depending on the degree of dimorphism in population under consideration.

Conclusion

In conclusion, the variables used in the study were not able discriminate sex with high efficiency, which is the foremost need in forensic or archeological context. However, the functions can be used to a limited extent, when only a fragmentary mandible is available. A possible limitation of the study is unequal male female ratio (3.2:1), which is previously acknowledged (20). Further, it is suggested that the applicability of these variables should be verified on other population groups, which may result in comparatively better discrimination than the north Indians.

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Variables	Males (n=145)			Females (n=45)			t-value	Sig.
	Mean	SD	Min.-Max.	Mean	SD	Min.-Max.		
MBHt	28.13	3.16	18.05-36.00	25.40	2.94	17.342-32.35	5.132	.000***
MaxRBr	42.55	3.48	34.20-52.00	39.49	3.65	31.00-46.15	5.102	.000***
MinRBr	31.12	2.92	23.30-38.15	29.38	2.38	25.35-34.833	3.639	.000***
ConBr	8.39	1.20	6.15-12.25	8.18	1.16	6.10-11.00	1.055	.293
ConLt	19.45	1.81	14.817-23.208	18.26	1.52	15.35-21.35	4.025	.000***

**p<.05 Significant, **p<.01Moderate Significant, ***P<.001Highly Significant*

Table 1. Descriptive statistics for mandibular measurements (mm), t-test and significance of differences between males and females.

Functions and Variables	Wilks lambda	Eq. F ratio	Degree of Freedom
MBHt	.877	26.335	1,188
MaxRBr	.810	21.981	2,187
ConLt	.785	17.017	3,186

Table 2. Stepwise discriminant function analysis

Functions and Variables	Raw Coefficients	Standardized Coefficients	Structure Coefficients	Centroids	Males identified n=145	Females identified n=45	Accuracy N=190	
							O	C
Stepwise analysis								
MBHt MaxRBr ConLt (Constant)	.171 .161 .222 -15.703	.533 .566 .388	714 710 560	M=0.290 F=0-.935 SP=-0.323	69.7	77.8	72.6	71.6
Direct analysis								
MBHt ConLt (Constant)	.243 .300 -12.425	.754 .524	.858 .673	M=0.242 F=-0.779 SP=-0.269	68.3	68.9	69.5	68.4

Table 3. Discriminant function analysis and classification accuracies for mandibular measurements

Variables	Males (n=145)	Females (n=45)	Classification accuracy N=190	
			O	C
MBHt	69.7	60.0	67.4	67.4
MaxRBr	66.2	62.2	65.3	65.3
MinRBr	62.1	66.7	63.2	63.2
ConBr	43.4	66.7	48.9	48.9
ConLt	64.8	64.4	64.7	64.7

Table 4: Correct sex classification accuracies (%) for single variables