Original Article

Bucco-lingual dimension of teeth - An aid in sex determination

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Abstract

Background: Bucco-lingual (B-L) dimensions of permanent teeth are known to exhibit sexual dimorphism. **Objectives:** Sexual dimorphism of B-L dimensions is known to be population specific. This study involves the measurement of B-L dimensions of all teeth except third molars of 99 native residents of Mysore district, Karnataka in the age group of 19-30 years. **Materials and Methods:** The B-L dimensional measurements of 28 teeth, except third molars, of 50 males and 49 females in the age group of 19 to 30 years were made on the study casts using vernier calipers with a resolution of 0.02 mm. The distance between the highest points on the buccal / labial and lingual / palatal surfaces were measured and analyzed using discriminant function analysis. **Results:** Males showed greater B-L dimensions of teeth in comparison to females with eight maxillary teeth exhibiting statistically significant dimorphism. However, discriminant function analysis showed an overall accuracy of classification of sex of 78%, among which 11 showed maximum dimorphism with a classification accuracy of 70.7% whereas both 23 and 26 showed an accuracy of 66.7%. **Conclusion:** Application of B-L dimensional variability among males and females in the population of Mysore can aid in sex determination in forensic scenario as the results of this study showed moderate magnitude of dimorphism in maxillary teeth with an accuracy rate of 78%. However, it is recommended to take this odontometric trait into consideration in combination with other skeletal and/or dental traits for sex determination.

Key words: Bucco-lingual dimension, dimorphism, sex determination, teeth

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Introduction

Sex determination is one of the important aspects of forensic sciences. Information concerning tooth size aids in sex determination of human remains. Many anthropologists have preferred osteometric techniques for the morphological assessment of differences in size and shape of the human remains.[1] Teeth being the central component of the masticatory apparatus of the skull, are good sources of material for civil and medico-legal identification. In addition, the degree to which they provide resistance to damage in terms of bacterial decomposition, fire and fracture, makes them valuable for forensic investigation and research. Various studies have been reported on sex determination and age estimation using dental traits and cheiloscopy.[2,3]

The persent study aims to determine sex of an individual based on B-L dimensions of teeth and analyze if any sexual variation existed in the B-L dimensions of permanent teeth, except third molars, in the adult population of Mysore. In addition, the study intended to evaluate the reliability of dimensional variation of teeth in determining sex among the population chosen.

Materials and Methods

The B-L dimensions of all permanent teeth (except third molars) of 50 males and 49 females, falling in the age group of 19 to 30 years, belonging to Mysore, were made on the study casts using vernier calipers with a resolution of 0.02mm. The greatest distance between buccal and lingual surfaces of crown parallel to the long axis of the tooth was measured and marked directly on study casts. A single observer read all the measurements. Data obtained from various measurements was recorded on a proforma. It was then analyzed using stepwise discriminant function statistics using SPSS version. Jackknife statistic was used to assess accuracy of the results on a presumable, unknown sample.

Results

Males showed greater B-L dimensions of teeth in comparison to females. However, eight maxillary teeth, i.e., maxillary right and left central incisors, left lateral incisors, right and left canines, right second premolar and right and left maxillary first molars showed statistically significant variability in their B-L dimensional measurements. None of the mandibular teeth showed statistically significant dimorphism. Based on this, three different functions were established.

The functions developed were as follows:

Function 1: BL measurement of all variables.

Function 2: BL measurement of all maxillary anterior teeth.

Function 3: BL measurement of all maxillary posterior teeth.

In the first function, all the teeth that showed statistically significant difference in B-L dimensions among males and females i.e., 11, 13, 15, 16, 21, 22, 23, and 26 have been included. The second function was established with an assumption that only maxillary anterior teeth are available for examination. Thus, function 2 includes 11, 13, 21, 22 and 23. The third function was established with an assumption that only maxillary posterior teeth are available for examination. Thus the third function included 15, 16 and 26.

Several stepwise discriminant function statistics have been used to develop formulae to determine sex. Table 1 provides coefficients and sectioning points for each function to determine sex. The group centroids indicate the average discriminant scores for each sex. Sectioning point is the average of male and female group centroids.

The sectioning point for function 1 was calculated to be minus 0.006 and minus 0.004 for function 3. The sectioning point for function 2 was similar to that of the first since the same variables contributed for the same.

Raw coefficients are the discriminant function coefficients used to calculate the discriminant score. To assess the sex, tooth dimensions are multiplied with the respective raw or unstandardized coefficients and added to the constant. If the values thus obtained were greater than the sectioning point the individual was considered a male and if less than the sectioning point the individual was considered female.

i.e.,

$$y = a + b\,(p1) + b(M2)$$

Where a = constant of each particular function. b = unstandardized coefficient of that particular tooth; for function 1, a = –13.696; for function 2, a = –13.696; for function 3, a = –18.620 and y = constant of unstandardized coefficient of a particular function plus (unstandardized co efficient of that particular tooth) multiplied by tooth measurement in centimeters plus unstandardized co efficient of that particular tooth, multiplied by tooth measurement in centimeters [Table 1].

Percentage of dimorphism

The percentage of dimorphism is defined as the percent by which the tooth size of males exceed that of females. The percentage of dimorphism for each tooth was calculated using the following formula

Percentage of dimorphism $\{(Xm/Xf)-1\}\times 100$

Where Xm = mean male tooth dimension; Xf = mean female tooth dimension.

Mean percentage of dimorphism

Mean percentage of dimorphism is the percentage by which the male dentition size as a whole exceeds that of females. It is obtained by adding the percentage of dimorphism of each tooth and then dividing it by the number of teeth. Mean percentage of dimorphism

Table 1: Summary of canonical discriminant function coefficient for the B-L dimensions of teeth

Functions	Standardized coefficient	Structure matrix	Unstandardized coefficient	Raw coefficient (constant)	Group centroids		
					Male	Females	Sectioning point
Function 1							
11	0.620	0.567	6.440	-13.696	0.589	-0.601	-0.006
23	0.826	0.785	12.526				
Function 2							
11	0.620	0.567	6.440	-13.696	0.589	-0.601	-0.006
23	0.826	0.785	12.526				
Function 3							
26	1.000	1.000	17.176	-18.620	0.375	-0.383	-0.004

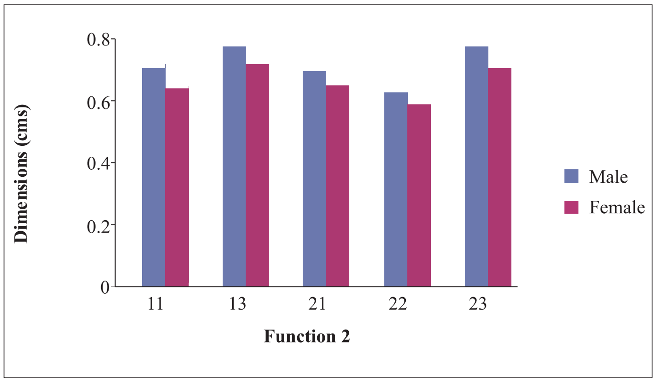

Figure 1: Dimensional variation among males and females for function 2

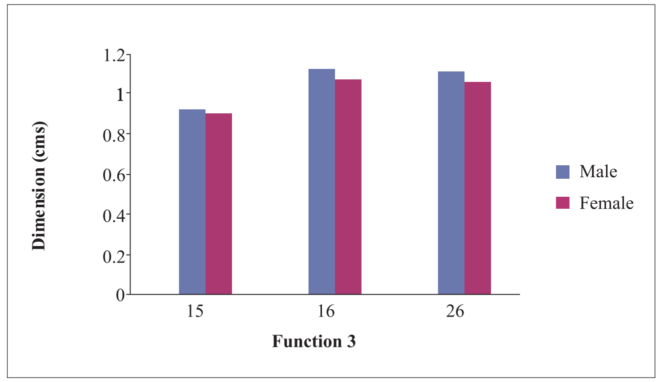

Figure 2: Dimensional variation among males and females for function 3

Table 2: Accuracy of determination of sex using 11

Variables	Total		Males		Females	
	Number	%	Number	%	Number	%
Original	50	100.0	42	42.9	8	57.1
	49	100.0	21	84.0	28	16.0
Cross-validated	50	100.0	42	84.0	8	16.0
	49	100.0	21	42.9	28	57.1

Table 3: Overall accuracy of classification

Variables	Total		Males		Females	
	Number	%	Number	%	Number	%
Original	50	100.0	42	84.0	8	16.0
	49	100.0	13	26.5	36	73.5
Cross-validated	50	100.0	42	84.0	8	16.0
	49	100.0	13	26.5	36	73.5

Table 4: Accuracy of determining sex using 23

Variables	Total		Males		Females	
	Number	%	Number	%	Number	%
Original	50	100.0	37	74.0	13	26.0
	49	100.0	20	40.8	29	59.2
Cross-validated	50	100.0	37	74.0	13	26.0
	49	100.0	20	40.8	29	59.2

Table 5: Accuracy of determining sex using 26

Variables	Total		Males		Females	
	Number	%	Number	%	Number	%
Original	50	100.0	35	70.0	15	30.0
	49	100.0	18	36.7	31	63.3

66.7% of original grouped cases correctly classified.

for maxillary teeth was calculated to be 7.278 and for mandibular teeth it was 4.552. A mean percentage of dimorphism greater than zero indicates larger male dentition. If the value is closer to zero the magnitude of sexual dimorphism is lower.

Discussion

Univariate analysis of the study showed that B-L dimensions of male dentition are greater than those of females' which is in accordance with the previous studies [Figures 1 and 2]. Rather, statistically significant dimorphism was exhibited by only a few teeth i.e., maxillary right central incisor, canine, second pre molar, first molar, left central incisor, canine, and first molar. In multivariate analysis, the variables that contributed most for the analysis are 11, 23 and 26 whereas other univariate variables did not enter the functions.

Maxillary left canine belonging to function one in the study exhibited a sexual dimorphism. This is in accordance with the studies conducted on Turks (here, the measurements were made only on teeth of left side of the jaws) by Iscan.[1] The study by Iscan differs from this study in the fact that it shows significant dimorphism in mandibular canine, first and second molars and first premolars while the present study has not. A study conducted by Otuyemi and Noar[4] shows dimorphism in maxillary canines bilaterally and another by Lund and Monstad shows dimorphism of maxillary right canine.[5] However, the study by Vodanovic and co-workers reports a consistent sexual dimorphism in the maxillary canine.[6] It also reports that the right and left side teeth are not significantly different from each other in measurement. Maxillary right first molar with a p-value of 0.001, belonging to third function, showed significant sexual dimorphism. This is consistent with two different studies conducted on Nepalese by Acharya AB[2,7] These studies differ from the present study in that they have the left mandibular canine showing dimorphism apart from maxillary left second molar and maxillary right first premolar showing sexual dimorphism.

In contrast to the above mentioned studies, the present study shows a significant consistent sexual dimorphism in right central incisor of function one. The results show that it has a higher classification accuracy (70.7%) [Table 2] than teeth belonging to other functions, proving that sexual dimorphism is a population specific phenomenon.

In the present study, right maxillary central incisor showed maximum dimorphism. The accuracy of correct classification of sex on the whole is about 66.7- 78.8% [Tables 2-5] which is greater than the study conducted by Iscan and Kedici where the canines could correctly classify the sex by 77%. The current study differs from the study conducted by Iscan and Kedici on Turks in that only the left maxillary canine is statistically dimorphic, whereas in Turks all the canines (maxillary and mandibular) showed significant dimorphism.[1]

This study shows no sexual dimorphism in mandibular teeth. Among maxillary teeth, posterior dentition / teeth did not discriminate the sexes as much as the anterior ones. However, 26 separated the sexes by 66% [Table 5]. Acharya BA and Malini S have quoted that Kieser *et al.* on South African Whites tested posterior teeth and obtained an accuracy of 87% in the classification of sex[2]. A number of tooth variables such as 11, 23, and 26 showed statistically significant univariate dimorphism. They also contributed to the discriminant analysis while others did not enter the discriminant functions. A similar result was encountered by Potter in one of her studies, in which almost half of the tooth measurements that contributed for the discriminant analysis showed no significant univariate differences. According to Potter, tooth measurements within an individual are inter related and treating them as independent of each other will not give an accurate picture of the sex difference.[2]

Classification of sex

Variables of function 1 could classify the original and cross-validated grouped cases correctly by 78.8 % [Table 3]. Individually the accuracy of classification of sex by 11 is 70.7% [Table 2] and 23 is 66.7% [Table 4]. Function 3 included maxillary posterior teeth. Here the classification accuracy of 26 was 66.7% [Table 5] among the original and cross validated group cases. Function 2 is similar to that of one.

Magnitude of sexual dimorphism

Percentage of dimorphism

In the present study, the mean percentage of dimorphism for maxillary teeth was 7.278. This value is lower, compared to the values obtained in the study conducted on Turks. Turks reported a mean percentage of dimorphism of 7.31 for maxillary teeth. However, studies conducted by different researchers on various populations shows relatively medium and lower percentage of dimorphism. Native South American population has shown the least dimorphism of 1.90 percent. A relatively medium percentage of dimorphism is seen in American Caucasoid (6.11), South African Caucasoid(4.83), Australian aborigine (4.02) populations.

The study showed the mean percentage of dimorphism to be 4.552 for mandibular teeth which is a relatively moderate level of dimorphism. Similarly, a moderate level of dimorphism has been demonstrated in the mandibular teeth in Nepalese (2.69), Swedish (2.80), Australian aborigines 3.88, and American Caucasoids (5.20), in contrast to the Turks as quoted by Ashith A B.[2] Turks have reported a greater magnitude of dimorphism i.e., 7.26.[1,2]

This variation in the magnitude of dimorphism can be a result of various factors. Some authors have explained that such variation could be due to environmental influences on tooth size. Variation in food resources exploited by different populations has been explained as one such environmental cause. Others have suggested the interference of cultural factors with biological forces.[2,7] There can be a complex interaction between a variety of genetic and environmental factors that is responsible for the variation in the magnitude of dimorphism. According to Garn *et al*, teeth have behaved in many ways through the course of evolution, ranging from reduction of the entire dentition to reduction of one group of teeth in relation to another.[2,7] Such behavior influenced by genetic and environmental factors could have caused the reduction in the degree of dimorphism in Mysoreans.

There is a greater B-L tooth size noted among the male population of Mysore. According to Moss, greater diameter of the crown of canines in males is a result of difference in enamel thickness due to the long period of amelogenesis in males. However, in females the completion of calcification of the crown occurs earlier in both deciduous and permanent dentition as quoted by de Vito.[8]

Sex chromosomes are also known to cause different effects on tooth size. The 'Y' chromosome influences the timing and rate of body development, thus producing slower male maturation, and acts additively and to a greater extent than the 'X' chromosome.[2]

Kalia. S quotes that according to Townscend the difference in size has been attributed to differently balanced hormonal production between the sexes consequent to the differentiation of either male or female gonads during the sixth or seventh week of embryogenesis rather than any direct effect of sex chromosome themselves.[9]

It has been shown that 'Y' chromosome has a direct effect on tooth size, which may be related to a more non- specific effect of hetero chromatism or cellular activity.

Vito CD quotes that according to Lewis *et al.* there is a low significant correction between sexual dimorphism of teeth and body size and it has been supported by Frayer and Wolpoff.[8]

On the whole, the study concludes that the sexual dimorphism of teeth is population specific and among Mysoreans, B-L dimensions can aid sex determination. It is recommended to conduct similar studies on the population taking greater sample size for further confirmation.

It is also recommended to consider the entity for sex determination along with other odontometric and skeletal traits as it has shown moderate magnitude of dimorphism.

Conclusion

The present study has described sexual dimorphism in the Mysoreans using univariate statistics and discriminant analysis. The maxillary right central incisor showed the most consistent univariate dimorphism and reinforces a plethora of previous reports along with a greater magnitude of univariate dimorphism. However, this is not sufficient to differentiate males from females solely.

It could be concluded that consideration of B-L dimension of teeth of Mysoreans can effectively aid in sex determination when applied in conjugation with other skeletal or odontometric traits.

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