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Research Article

Tooth Dimension Variations as a Gender Determinant in Permanent Maxillary Teeth

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- Dental anthropology
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- Sex determination
- Linear tooth measurements
- Stepwise discriminant analysis

Abstract

Background: Physical characteristics and the protection from the bone jaw preserve the dentition even when the bony structures of the body are destroyed. Due to this, the use of dental morphology to determine sexual dimorphism is a procedure established in anthropological and biological studies.

Aim and objectives: This study aims to determine gender of an individual based on buccolingual and mesiodistal dimensions of teeth and analyze if any sexual variation existed in both the dimensions of maxillary permanent teeth except second and third molars.

Materials and methods: The study examined 100 individuals (50 males and 50 females) in the age group of 18-30 years. Buccolingual and Mesiodistal dimensions were measure using Yamayo Vernier Caliper (0.01mm calibration). Using SPSS version 20, Independent sample't' test and step wise discriminant analysis were applied to the significant mean value and reliability of sexual variation.

Results: Independent sample't' test revealed that males have more mean value than females in buccolingual and mesiodistal dimensions. Then to find the reliability of sexual variation step wise discriminant analysis was applied and it was found that Mesiodistal measurements are better suited than Buccolingual dimensions for sex discrimination when used independently.

Conclusion: The mesiodistal dimension shows significant results marking reliable sexual dimorphism as compared to buccolingual dimension. Thus it can be concludes that both the dimensions must be taken into consideration for effective gender determination when applied in conjugation with skeletal and odontometric traits.

INTRODUCTION

Sexual variations in human skeleton and dentition have been of great concern for both odontologists and anthropologists. Several methods have been used for gender determination from skeletal remain [1]. It has been of great significance in mass disasters, natural calamities where bodies are damaged beyond recognition [2]. Teeth, being the hardest and chemically the most stable tissue in the body are an excellent material in living and non-living populations for anthropological, genetic, odontologic and forensic investigations [3].

Gender assessment from tooth measurements act as a useful adjunct to identifying forensic and anthropological skeletal specimens [4,5]. In the case of a complete jaw bone, it is possible to determine gender by measuring teeth sizes [6,7]. Teeth sizes show some difference in both gender and population [10].

Teeth are known to be unique organs made of the most enduring mineralized tissues in the human body [11]. As such, teeth are resistant to mechanical, chemical, physical and thermal types of destruction. Therefore, teeth are very important elements in the identification of skeletal remains, especially in cases when, due to the poor preservation of skeletal remains, the identification is not possible by standard methods [12]. Due to this, the use of dental morphology to determine sexual dimorphism is a procedure established in anthropological and biological studies [13].

The present study aims to determine gender of an individual based on buccolingual and mesiodistal dimensions of teeth and analyze if any sexual variation existed in both the dimensions of maxillary permanent teeth except second and third molars. In addition the study intended to evaluate the reliability of dimensional ariation of teeth in determining gender among individuals visiting the dental college.

MATERIALS AND METHODS

The Study analysed the maxillary dentition (50 males & 50 females) of individuals visiting Dental College. The study began in June 2012 and took 3 months to complete which included the procurement of casts, measurement of dimensions and statistical analysis. Convenience sampling method was adopted. Individuals were informed about the nature of the study and those who agreed to participate & were under 18-30 year age group were included in the study. Those having missing teeth, grossly decayed teeth and prosthesis were excluded from the study. All permanent maxillary teeth were included except 2nd and 3rd molars.

Buccolingual and mesiodistal dimensions were measured using a vernier calliper manufactured by Yamayo Measuring Tools Co. Ltd with 0.01 mm calibration according to the method of measurement recommended by Moorrees et al. [14].

The measurements were made by two operators and were blinded as to the sex of the individual information corresponding to the model, and through the method of remeasurement, a random sample was calculated to find interobserver correlation coefficient. (k=0.98).

Using the SPSS 20 software for Windows, descriptive statistics were obtained from the sample. The statistical significance of differences in mean in mesiodistal and bucolingual msamples with $p < 0.05$. Stepwise discrimination analysis was also done to evaluate the reliability of dimensional variation of teeth in determining gender.

Table 1 and Table 2 explains the descriptive statistics. In buccolingual dimension maxillary canine is found to be the most significant value followed by premolars and lateral incisors with higher mean value of males. Similarly in mesiodistal dimension maxillary first molar has the most significant value (p=.001) followed by central incisor and second premolar. Since the mean value of males is higher than females so it gives an edge to predict the subject as male.

But to find the reliability of gender determination discrimination analysis was also done.

Table 3 shows the Buccolingual and Mesiodistal tooth variables that contributed to the stepwise discriminant analysis. Wilks' lambda denotes how useful a given tooth variable is in the stepwise discriminant analysis and determines the order in which the variables entered the analysis, while the F statistic determines how much variation exists between the sexes and the significance level of the variance [15]. For Buccolingual variables, the maxillary right canine contributed most to sex differentiation followed by the right maxillar first molar. The maxillary left canine or the maxillary right lateral incisor entered each stepwise discriminant analysis undertake for the M/D variables. In (Table 3) mesiodistal dimension is having the highest Wilks Lambda statistic value and Extact F statistic value which determines that MD dimensions have better sex discriminatory ability as compared to buccolingual dimension.

Formula to determine gender of subject can be derived from the discriminant analysis which on calculation tells the Z value which gives the reliability of gender determination.

Z= Constant + a(p) + b(q) + consequent variables

Table 1: Descriptive Statistics- Buccolingual Dimension.

B/L	Gender of subject N=50 Each	Mean	Std.Deviation	Std. Error Mean	P Value
11	Male	.8080	.10755	.01521	.253
	Female	.7880	.05938	.00840	
12	Male	.7180	.06833	.00966	.011
	Female	.6820	.07126	.01008	
13	Male	.8600	.06547	.00926	.001
	Female	.8160	.06503	.00920	
14	Male	.9840	.06503	.00920	.001
	Female	.9420	.06007	.00849	
15	Male	.9780	.06240	.00882	.009
	Female	.9480	.04840	.00685	
16	Male	1.1760	.08221	.01163	.360
	Female	1.1520	.16505	.02334	
21	Male	.8090	.10723	.01517	.229
	Female	.7880	.05938	.00840	
22	Male	.7180	.06833	.00966	.014
	Female	.6830	.07115	.01006	
23	Male	.8600	.06547	.00926	.001
	Female	.8160	.06503	.00920	
24	Male	.9840	.06503	.00920	.002
	Female	.9440	.06115	.00865	
25	Male	.9790	.06316	.00893	.007
	Female	.9480	.04840	.00685	
26	Male	1.1760	.08221	.01163	.085
	Female	1.1390	.12588	.01780	

Table 2: Descriptive Statistics- Mesiodistal Dimension.

M/D	Gender of subject N=50 each	Mean	Std. Deviation	Std. Error Mean	P value
11	Male	.9160	.07656	.01083	.032
	Female	.8820	.07939	.01123	
12	Male	.7040	.08562	.01211	.611
	Female	.7120	.07039	.00996	
13	Male	.8100	.06851	.00969	.571
	Female	.8020	.07211	.01020	
14	Male	.7260	.05175	.00732	.511
	Female	.7180	.06833	.00966	
15	Male	.7040	.04721	.00668	.041
	Female	.6800	.06701	.00948	
16	Male	1.0700	.04949	.00700	.001
	Female	1.0260	.07969	.01127	
21	Male	.9160	.07656	.01083	.032
	Female	.8820	.07939	.01123	
22	Male	.7050	.08406	.01189	.604
	Female	.7130	.06911	.00977	
23	Male	.8100	.06851	.00969	.617
	Female	.8030	.07101	.01004	
24	Male	.7260	.05175	.00732	.511
	Female	.7180	.06833	.00966	
25	Male	.7040	.04721	.00668	.041
	Female	.6800	.06701	.00948	
26	Male	1.0710	.04854	.00686	.001
	Female	1.0260	.07905	.01118	

Z = -18.587+10.668(B/L 13)-9.665(M/D 22)+3.681(B/L 26)+11.673(M/D 26)

Table 4 and Table 5 shows the canonical discriminant co-efficients and function at group centroids. The above mentioned formula is derived from the discimination function co-efficients (unstandardized co-efficients). A group centroid is the mean discriminant score for each gender. After calculating the Z value from the formula, it will be compared with the section point which is calculated as 0. If the Z value is more than 0 then it is male and vice versa for females. This clearly classifies the subjects as male and female.

Table 6 shows the classification results. 71% of the subjects are correctly classified. Hence the results show that mesiodistal dimensions are better suited than buccolingual dimensions for gender determination when used independently but still the results will be better if both the dimensions are considered together.

DISCUSSION

Gender determination is one of the important factors used to assist with the identification of an individual. In damaged and mutilated dead bodies or from skeletal remains it constitutes the foremost step in identification in medicolegal examination and bioarcheology. There are many methods used for gender determination for eg. DNA analysis, bone ossification test but odontometry still remains the important method as it acts as an adjunct in gender determination and have an advantage of identification in large population as it is simple, reliable, easy to measure and inexpensive [16].

Table 3: Step Wise Discriminant Analysis.

Step	Variables	Wilks' Lambda Statistic	Exact F		
			Statistic	df2	Sig.
1	M/D 26	.893	11.766	98.000	.001
2	B/L 13	.837	9.451	97.000	.000
3	M/D 22	.760	10.128	96.000	.000
4	B/L 26	.729	8.844	95.000	.000

At each step, the variable that minimizes the overall Wilks' Lambda is entered. Minimum partial F to enter is 0.05; maximum partial F to remove is 0.10.
F-values are all significant at p < 0.01 level.
All 28 buccolingual and mesiodistal variables, respectively, were included in the analysis.

Table 4: Canonical Discriminant, Function Coefficients. Unstandardized coefficients.

	Function 1
B/L 13	10.668
M/D 22	-9.665
B/L 26	3.681
M/D 26	11.673
(Constant)	-18.587

Table 5: Functions at Group Centroids. Unstandardized canonical discriminant functions evaluated at group means

Gender of subject	Function 1
Male	.604
Female	-.604

Table 6: Classification Resultsa,c.

		Gender of subject	Predicted Group Membership		Total
			Male	Female	
Original	Count	Male	36	14	50
		Female	15	35	50
	%	Male	72.0	28.0	100.0
		Female	30.0	70.0	100.0
Cross-validatedb	Count	Male	36	14	50
		Female	15	35	50
	%	Male	72.0	28.0	100.0
		Female	30.0	70.0	100.0

a. 71.0% of original grouped cases correctly classified.
b. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.
c. 71.0% of cross-validated grouped cases correctly classified.

In the present study the Buccolingual and Mesiodistal dimensions of the tooth are measured using a vernier caliper. After applying descriptive statistics with the help of independent sample't' test it was found that mean of males is higher than females in most of the dimensions which means that males have larger teeth. It is in concordance with many previous studies [17-19]. To find a reliable result of gender determination, step wise discrimination analysis was done. It was found that Mesiodistal dimension was the most accurate method for gender determination and better results were found when both the dimensions were taken together. An accuracy of 72 % was found while gender determination with both the variables.

Doris et al. concluded that the early permanent dentitions proved to be the best sample for tooth size measurements because of less mutilation and less attrition in early adulthood dentition. Thus the effect of these factors on the actual mesiodistal tooth width would be the least. Thus only subjects in the 18-30 years' age group were included in the study sample [20]. These results are in concordance with various studies previously carried out using odontometric measurements. These studies report clear dimorphic differences between male and female teeth [21-23].

Refering to Garn et al. (1966) finding, their view point showed that BL dimension performed sexually difference between males and females' dentitions which males' were statistically significant larger than females'. This implied that males' tending toward more nearly square dimensions and females' showing greater size reduction buccolingually than mesiodistally [17]. Practically, Garn and colleagues also stated that BL dimension was recommended wider use similar to Iscan and Kedici (2003) who implied that this dimension was more reliable measurement than other variables [17,24].

Positive aspect of the present study is that it gives us a foundation to judge that MD dimension has more potential for gender determination as compared to BL dimension.

A previous study indicated that MD dimension was better suited for discriminating sexes than BL in case that only MD or BL measurements could be selected. They discussed that greater sex discriminatory ability of MD could be related to the upper and lower arch dimensions that antero-posterior jaw measurements were statistically larger in males and that arch size influenced tooth size, implying that larger jaws in males affected comparably to larger MD dimension [23]. On the other way, this study concluded that combining both MD and BL dimensions exhibited more discriminatory power than utilizing BL dimension solely.

MD dimension is more difficult to measure than BL, considering the proximal contact that exists between teeth and crowding in anterior segment of the jaws. Also, excessive attrition and interproximal wear facets can undermine this dimension. On the other hand, there were a lot of information discussing about the usefulness of MD and BL dimensions. Although BL dimensions are more easily measured (and may be conveniently obtained on occlusally worn teeth in forensic scenarios), their ability to correctly sex an individual is moderate when used independently. If one has the option of choosing between the two types of linear measurements, MD dimensions should be preferred.

Some authors have also explained that environmental factors like variation of food resources exploitation by different populations, interference of cultural factors with biological forces, complex interaction of genetic and environmental factors are responsible for variation in magnitude of dimorphism which may be a negative aspect of determining gender by tooth dimensions. 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 [17].

Relating all the facts and the results of the previous studies we have an inference that some studies show that BL dimension has more gender determination potential [16,17] and some prove MD to be a better gender predictor [25,22,23]. So it is preferred to go for both the dimensions rather than choosing a single dimension for gender prediction.

To find the accuracy of sex determination other diverse parameters of the body such as craniofacial morphology and measurements on the pubis also give accurate results with accuracy of 96% to 100% [26,27]. Correct sex identification limits the pool of missing persons to just one half of the population. In forensic contexts, however, it is not uncommon to recover partial remains, with fragmentary skull and pelvic bones. The teeth are one of the strongest human tissues and are known to resist a variety of ante-mortem and post-mortem insults [28].

CONCLUSION

The study evaluated the use of tooth dimensions for sexual dimorphism because of simplicity and reliability. It was finally concluded that males have larger teeth than females and MD dimension is a good gender predictor than BL dimension. Due to the difficulty in measuring the MD dimensions due to close proximal contacts, there may be discrepancy in its measurement. So including both the dimensions for gender determination would be better and more reliable [23].

71.0% of cross-validated grouped cases are correctly classified so we can infer that MD dimension is a better predictor but this is not sufficient to differentiate males from females solely on these bases. Thus it can be concluded that BL and MD dimension must be taken into consideration for effective gender determination when applied in conjugation with skeletal and odontometric traits.

Further study can be planned with a more diverse sample which can represent north Indian population and a regression formula can be derived which can be used by forensics experts and represent the whole north Indian population as there may be tooth morphologic differences due to difference in environmental and genetic factors.

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