ORIGINAL ARTICLE

Sex assessment by molar odontometrics in North Indian population

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Abstract

Introduction: Human identification is based on scientific principles, mainly involving dental records, fingerprints, estimation of age, postmortem reports, differentiation by blood groups, and DNA comparisons. Sex assessment is one of the prime factors employed to assist with the identification of an individual. **Aims and Objective:** To investigate univariate sex differences in the dimensions of permanent first molars and to assess sex, based on buccolingual (BL) and mesiodistal (MD) dimensions of permanent first molars in a population of north India. In addition, the study intended to evaluate the reliability of dimensional variation of these teeth in assessment of sex among the population. **Materials and Methods:** The study sample consists of 410 adult individuals (200 males and 210 females), from a north Indian population. The BL and MD diameters of the permanent first molars were measured using digital vernier callipers. **Results:** It was observed statistically significant difference between males and females with $P < 0.05$, in maxillary casts in both BL and MD dimensions; but only in the MD dimension in mandibular casts. A high level of sexual dimorphism of 7.7% was found in the BL dimension of the maxillary right first molar. The accuracy of sex assessment by each dimension was deliberated by univariate analyses with an overall accuracy ranging from 67.5 to 88% for various dimensions. **Conclusion:** Sexual dimorphism of teeth is population specific and among north Indian population, BL and MD dimensions in maxillary first molar and MD dimension in mandibular first molar can be used for sex assessment.

Key words: Forensic, molar, sexual dimorphism

Introduction

One of the challenges faced by man in earlier days was to establish the identity of an individual. The concept of "identity" is a set of physical characteristics, functional or psychic, and normal or pathological that defines an individual. Identification of an individual is a prerequisite for certification of death and for personal, social, and legal reasons.[1] Human identification is based on scientific principles; mainly involving dental records, fingerprints, estimation of age, measurement of height, postmortem reports, differentiation by blood groups, and DNA comparisons.[2]

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Sex assessment is one of the prime factors employed to assist with the identification of an individual. 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. Teeth are one of the strongest human tissues and are known to resist a variety of antemortem and postmortem insults.[3]

Teeth being the central component of the masticatory apparatus of skull, are good sources of material for civil and medicolegal 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 assessment and age estimation using dental traits and cheiloscopy.[4,5]

Information concerning tooth size aids in age and sex assessment of human remains.[6] With such tooth size standards, whenever it is possible to predict the sex, identification is simplified because then only missing persons of one sex need to be considered. In this sense identification of sex takes precedence over age.[7] Sex assessment using dental features is primarily based upon the comparison of tooth dimensions in males and females or upon the comparison of frequencies of non-metric dental traits like Carabelli's trait of upper molars, deflecting wrinkle of the lower first molars, distal accessory ridge of the upper and lower canines, or shoveling of the upper central incisors.[8] This is based on the fact that although the morphology of the tooth structure is similar in males and females, the size of the tooth does not necessarily remain the same, as the tooth size is determined by cultural, environmental, racial, and genetic factors.[9]

'Sexual dimorphism' refers to those differences in size, stature, and appearance between male and female that can be applied to dental identification because no two mouths are alike. Teeth are considered to be a very useful tissue for sex assessment and molars are among the most dimorphic teeth.[10] Molars are the first permanent teeth to erupt in the oral cavity; and hence, they are available for use in sex assessment at an early age as compared to other permanent teeth. It scores an advantage over canine, which have greater chances of being impacted and thus being unavailable for odontometric analysis. Similarly, the incisors are more prone to trauma, developmental anomaly (peg lateral), and frequently show crowding; resulting in difficulty in odontometric analysis. Hence for the above said reasons, molars scores over other teeth in the oral cavity; and thus, odontometric analysis was carried out to assess the reliability of molar in sex assessment.

The present study aims to determine sexual dimorphism in the dimensions of permanent first molars and to establish sex, based on buccolingual (BL) and mesiodistal (MD) dimensions of permanent first molars in the adult population of north India. In addition, the study intended to evaluate the reliability of dimensional variation of these teeth in determining sex among the population.

Materials and Methods

The study sample consists of 410 individuals (200 males and 210 females) of an age group ranging from 20-40 years, in a north Indian population. Mean age group for males was 29.3 years, while that for females was 30.6 years. This particular age group was studied as antemortem insults such as regressive alterations (attrition and abrasion) affecting occlusal and approximal tooth surfaces are minimal. The inclusion criteria taken into consideration were as follows:

- Healthy state of periodontium
- Caries free teeth
- Presence of bilateral maxillary and mandibular first molars.

Following informed consent, impressions of the maxillary and mandibular arch were made with irreversible hydrocolloid (alginate) material and casts poured immediately in type II dental stone to minimize dimensional change. The BL and MD diameters of the permanent first molars were measured using digital vernier calipers (resolution 0.01 mm) on study casts.

Tooth crowns are routinely measured by MD and BL crown diameter, which were first defined at least a century ago. Their definition was reassessed several times over the years.[11] In this definition; the MD crown diameter is the largest mesial-to-distal dimension, taken parallel to the occlusal surface. The BL crown diameter is then the greatest distance between the buccal (or labial) and lingual (or palatal) surfaces perpendicular to the MD diameter.[12]

The measurements were performed by one person and all values were rounded to two decimal places. In order to assess the reliability of the measurements, intraobserver error was tested. The same measurements were obtained from 50 randomly selected teeth from the original sample at a different time by the same observer to assess intraobserver error. Another observer measured the same randomly selected teeth in order to test the interobserver error. Their measurements were analyzed using Student's *t*-test. There was no statistically significant difference between the findings of the two observers. Statistically significant sexual dimorphisms in male and female odontometric features were tested by the unpaired *t*-test.

The level of statistical significance was set at $P < 0.05$. The mean values of BL and MD dimensions of males and females were subjected to the following formula[13] to calculate sexual dimorphism:

Percentage of sexual dimorphism = $[(Xm/Xf) - 1] \times 100$

Where, Xm = mean male tooth dimension and Xf = mean female tooth dimension.

Data obtained from various measurements was further analyzed using stepwise discriminant function statistics using SPSS version.

Result

BL and MD diameter of right and left maxillary and mandibular first molars were measured on the study casts. It was seen that the mean values of parameters showed statistically significant differences between males and females with $P < 0.05$, in the maxillary casts in both BL and MD dimensions; but only in the MD dimension in the mandibular cast [Table 1]. A high level of sexual dimorphism of 7.7% was found in the BL dimension of the maxillary right first molar, followed by MD dimension of the maxillary right first molar (6.9%), and BL dimension of the maxillary left first molar (6.6%) [Table 2]. Least sexual dimorphism was seen in the BL dimension of the mandibular molars.

Table 1: Comparison of mean values of different parameters in males and females measured on study casts using unpaired *t*-test

Study cast	Parameters	Sex	Mean (mm)± SD	*P values*
Maxillary	BL-R	M	11.09±0.52	0.000*
		F	10.30±0.45	
	BL-L	M	11.00±0.45	0.000*
		F	10.32±0.42	
	MD-R	M	10.42±0.50	0.000*
		F	9.75±0.42	
	MD-L	M	10.19±0.85	0.000*
		F	9.73±0.58	
Mandibular	BL-R	M	10.10±0.34	0.995**
		F	10.10±0.54	
	BL-L	M	10.06±0.33	0.765**
		F	10.08±0.61	
	MD-R	M	11.27±0.81	0.000*
		F	10.64±0.51	
	MD-L	M	11.12±0.56	0.000*
		F	10.65±0.62	

*$P<0.05$: significant, **$P>0.05$ not significant. SD: Standard deviation; BL: Buccolingual, MD: Mesiodistal; R: Right; L: Left; F: Female; M: Male

Table 2: Percentage sexual dimorphism in permanent first molars

Study cast	BL right (%)	BL left (%)	MD right (%)	MD left (%)
Maxillary	7.7	6.6	6.9	4.7
Mandibular	0	0.2	5.9	4.4

BL: Buccolingual; MD: Mesiodistal

For each dimension assessed, several stepwise discriminant function statistics were used to develop a formula to determine sex [Table 3]. Coefficients and sectioning points were calculated for each dimension. The group centroids indicated the average discriminant scores for each sex. Sectioning point is the average of male and female group centroids.

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 (b) and added to the constant (a). If the values (y) thus obtained were greater than the sectioning point, the individual was considered as male and if less than the sectioning point the individual was considered female;

that is, $y = a + b(x)$;

where, x is dimension of the tooth in centimeters.

Since the BL dimensions of mandibular first molar did not show any statistically significant dimorphism, they were not subjected to further analysis. The accuracy of sex assessment by each dimension was deliberated with an overall accuracy ranging from 67.5 to 88% for various dimensions [Table 4].

Discussion

Although the DNA profile gives accurate results yet measurement of linear dimensions such as anthropometric or odontometric parameters can be used for sex assessment in a large population because they are simple, reliable, inexpensive, and easy to measure. The fact that most teeth complete development before skeletal maturation makes the dentition a valuable sex indicator, particularly in young individuals.[14]

Considering the fact that there are differences in odontometric features in specific populations, even within the same population in the historical and evolutional context, it is necessary to determine specific population values in order to make identification possible on the basis of dental measurements.[15] The present study tends to

Table 3: Summary of canonical discriminant function coefficient for BL and and MD dimensions

Study cast	Standard coefficient	Structure matrix	Unstandardized coefficient	Raw coefficient (constant)	Group centroids		
					Male	Female	Sectioning point
Maxillary BL-R	1.000	1.000	20.539	−21.960	0.827	−0.788	0.019
Maxillary BL-L	1.000	1.000	22.733	−24.227	0.789	−0.751	0.019
Maxillary MD-R	1.000	1.000	21.589	−21.763	0.739	−0.704	0.017
Maxillary MD-L	1.000	1.000	13.752	−13.690	0.328	−0.312	0.008
Mandibular MD-R	1.000	1.000	14.794	−16.197	0.474	−0.452	0.011
Mandibular MD-L	1.000	1.000	16.801	−18.285	0.401	−0.382	0.009

BL: Buccolingual; MD: Mesiodistal; L: Left; R: Right

Table 4: Accuracy of sex assessment

Variable	Sex	Number (%)			Overall accuracy (%)
		Total	Males	Females	
Maxillary BL-R	Males	200 (100)	160 (80)	40 (20)	88
	Females	210 (100)	9 (4)	201 (96)	
Maxillary BL-L	Males	200 (100)	155 (77.5)	45 (22.5)	85.6
	Females	210 (100)	14 (7)	196 (93)	
Maxillary MD-R	Males	200 (100)	168 (84)	32 (16)	78
	Females	210 (100)	58 (28)	152 (72)	
Maxillary MD-L	Males	200 (100)	166 (83)	34 (17)	75
	Females	210 (100)	70 (33)	140 (67)	
Mandibular MD-R	Males	200 (100)	158 (79)	42 (21)	67.5
	Females	210 (100)	92 (44)	118 (56)	
Mandibular MD-L	Males	200 (100)	168 (84)	32 (16)	70.5
	Females	210 (100)	90 (43)	120 (57)	

BL: Buccolingual; MD: Mesiodistal; Ll: Left; R: Right

establish the impact of morphometry of permanent first molars in a north Indian population in assessment of sex.

The comparison of mean values of parameters measured between males and females showed statistically significant differences with $P < 0.05$ in the BL and MD dimensions of maxillary first molar and MD dimensions of mandibular first molars; and these results were in agreement with the studies done by various researchers[16-20] in which they have observed that the males had larger teeth than females in all the dimensions. In the present study, maxillary right first molar showed significant sexual dimorphism. This is consistent with two different studies conducted on the Nepalese by Acharya.[4,20] In a study conducted by Zorba *et al*., in a Greek population, they found that males have bigger teeth than females and canine showed greatest sexual dimorphism.[21] In their study, first molars also showed significant dimorphism especially for the BL dimension, which is in contrast to the present study taking into account the mandibular first molar.

Studies conducted by different researchers on various population shows a varied percentage of dimorphism in maxillary teeth. Native South American population has shown the least dimorphism of 1.90%. A relatively larger percentage of dimorphism was seen in American Caucasoid (6.11), South African Caucasoid (4.83), and Australian Aborigine (4.02) populations. 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).[13]

In a study conducted by Astete[22] in Spanish and Chilean population showed that most of the teeth examined were larger in men as compared to women, with the exception of upper incisors and first mandibular molars in respect to MD dimension.

In the present study, the BL and MD width of maxillary first molars showed significant sexual dimorphism, while only the MD dimension of mandibular first molar was statistically significant. The result of the present study regarding MD dimension of mandibular first molar is not in agreement with the study conducted by Astete.[22] A high level of sexual dimorphism of 7.7% was found in the BL dimension of the maxillary right first molar, followed by MD dimension of the maxillary right first molar (6.9%), and BL dimension of the maxillary left first molar (6.6%). No sexual dimorphism was observed in the BL dimension of mandibular first molar, which is not in agreement with any of the previous studies. Hence, it can be inferred that a comparison of sexual dimorphism in teeth between different populations differs among different groups The magnitude and pattern of sexual dimorphism in size of teeth differs from one population to another and also between the generations.[22,23]

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.[4,20] According to Garn *et al*.,[23] 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.[4,20] 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.

It was further postulated by Garn *et al*.,[23] that tooth size dimorphism in various populations can also be due to various factors, the first being identity in patterning but differences in level or variability and the second being variability in patterning as well as variability in magnitude or level.

There is a greater BL tooth size noted among the male population as compared to females and this could be attributed to the differences 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.[24]

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.[4]

According to Townsend and Alvesalo,[25] 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

6th or 7th week of embryogenesis rather than any direct effect of sex chromosome themselves.[13]

It has been shown that 'Y' chromosome has a direct effect on tooth size, which may be related to a more nonspecific effect of heterochromatism or cellular activity.[13]

Univariate analysis of the study showed that statistically significant dimorphism was obtained in BL and MD dimensions of maxillary first molars and only MD dimension of mandibular first molar. The mean value of these dimensions in male dentition was greater than those of the females.

In the present study, the BL dimension of right and left maxillary 1st molar showed 88% and 85.6% accuracy, respectively in assessment of sex correctly. However, the study conducted by Rani *et al*.,[13] reported a 66.7% accuracy of determining sex in BL dimension of left maxillary 1st molar. The overall accuracy of sex assessment by each dimension in the 1st molar ranged from 67.5 to 88% in the current study which is greater than the study conducted by Iscan and Kedici,[15] where the canines could correctly classify the sex by 77%. Higher accuracy level of molar as compared to that of canine warrants its use as a superior odontometric tool in sex assessment.

It is important to emphasize that, although the accuracy of sex assessment increases when a multivariate analysis is done using combination of values for all first molars;[13] but in the present study, a univariate analysis on molars was found to be equally informative in assessment of sex. The preference of univariate analysis over multivariate analyses for sex assessment in the present study highlights the importance of situations when only a single molar is available for examination.

On the whole, the study concludes that sexual dimorphism of teeth is population specific and amongst the north Indian population, BL and MD dimensions in maxillary first molar and MD dimension in mandibular first molar can aid sex assessment. Further on, it is inferred that optimal results in dental sex assessment can be obtained when univariate analysis of first molars are used along with other odontometric and skeletal traits. It is recommended to conduct studies based on alternative measurements like MD and BL cervical diameters as well as crown and cervical diagonal diameters on various populations as an additional parameter for evaluating the accuracy of different teeth in sex assessment.

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