SEXUAL DIMORPHISM IN THE PERMANENT MAXILLARY FIRST MOLAR: A STUDY OF THE HARYANA POPULATION (INDIA)

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ABSTRACT

Sexual identification of immature skeletal remains is still a difficult problem to solve in Forensic Anthropology. The aim was to evaluate the existence of sexual dimorphism in maxillary first molars. The base sample comprised 200 subjects (100 males and 100 females) aged 17–25 years. The buccolingual (BL) and mesiodistal (MD) diameters of maxillary first molars were measured using digital vernier calipers both intraorally and on study casts. Data was analyzed using Independent sample t-test and paired t-test. Results showed statistically significant sexual dimorphisms in male and female odontometric features. The mean values of the parameters were greater on the left side than on the right side. Amongst the intraoral group, the right maxillary first molar was found to exhibit the greatest sexual dimorphism (5.34%) in terms of buccolingual dimension. Amongst the study cast group, the left maxillary first molar was found to exhibit the greatest sexual dimorphism (5.54%) in terms of buccolingual dimension. The buccolingual dimensions exhibited greater sexual dimorphism than mesiodistal dimensions. Conclusion: sex determination from an incomplete skeleton or young children may be difficult and in such situations the odontometric features of the teeth can be of immense help in determining the sex.

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Keywords: Maxillary first molar, buccolingual (BL), mesiodistal (MD), sexual dimorphism

Running title: Sexual variation in permanent maxillary first molar

INTRODUCTION

Sex determination of skeletal remains forms part of archaeological and medicolegal examinations. The method may vary and depend upon the available bones and their condition.[1] The identification of sex is of significance in cases of mass fatality incidents where bodies are damaged beyond recognition.[2] Further, in situations where only fragments of jaw bones with teeth (or teeth alone) are found, then sex determination is possible only with the help of teeth.

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] Tooth size standards based on odontometric investigations can be used in age and sex determination.[4] 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.[5]

Sex determination 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 shovelling of the upper central incisors.[6] 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.[7] '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.[8] Many studies have established that amongst all the teeth, the permanent mandibular canines are found to exhibit the greatest sexual dimorphism.[9]

The purpose of this study was to evaluate the existence of sexual dimorphism using both buccolingual and mesiodistal dimensions of maxillary first molars, as they are the first permanent teeth to erupt into the oral cavity at the mean age of 6-7 years and are less commonly impacted as compared to canines. Further, sex can be determined accurately in mature individuals if the postcranial skeleton is intact. But in young children, determination of sex from the skeleton is difficult.[10] In such situations, the odontometric features of teeth that erupted at an early age can be of immense help in determining the sex.

MATERIAL AND METHODS

The base sample comprised 200 students (100 males and 100 females) of an age group ranging from 17-25 years, selected from M.M College of Dental Sciences and Research, Mullana, Ambala, Haryana, India. This particular age group was studied as ante-mortem insults such as 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 first molars

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

MD diameter of the crown: This measurement is the greatest mesiodistal dimension between the contact points of teeth on either side of jaw.

BL diameter of the crown: This measurement is the greatest distance between buccal and lingual surfaces of the crown, taken at right angles to the plane in which the mesiodistal diameter is taken.

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, intra-observer error was tested. The same measurements were obtained from 100 randomly selected teeth from the original sample at a different time by the same author to assess intra-observer error. Another observer measured the same randomly selected teeth in order to test the inter-observer 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 differences in the mean values of the parameters between the right and the left side measured intraorally and on study casts were tested using the paired 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 formula[11] to calculate sexual dimorphism

$$\text{Sexual dimorphism} = \frac{X_m - 1 \times 100}{X_f}$$

Where X_m = mean value for males and
X_f = mean value for females

OBSERVATIONS AND RESULTS

The following parameters were determined intraorally and on the study casts in males and females:

a) BL diameter of right and left maxillary first molars

b) MD diameter of right and left maxillary first molars

- ✓ It was observed that the comparison of mean values of parameters showed highly statistically significant differences between males and females, with $p<0.001$; measured both intraorally (Table 1) and on the study casts (Table 2).
- ✓ The mean values of the parameters were greater on the left side than on the right side whether measured intraorally or on the study casts.
- ✓ The paired t-test showed that the differences in the mean values of the parameters between the right and the left side were statistically significant with respect to pairs 1, 2 and 4 with

p value<0.05; while with respect to pair 3, the difference was highly statistically significant with p value<0.001 (Table 3).

- ✓ The mean values of the parameters in both males and females were greater on the left side than on the right side. The paired t-test showed that the differences in the mean values of the parameters with respect to pairs 2 and 3 (in males); pairs 3 and 4 (in females) were highly statistically significant with p value<0.001. The difference was statistically non-significant with respect to pairs 1 and 4 (in males), and pair 2 (in females) with p value>0.05. While the difference was statistically significant with respect to pair 1 (in females) with p value<0.05 (Table 4).
- ✓ Sexual dimorphism amounted to 5.34% and 5.16% for right and left buccolingual dimensions of maxillary first molars respectively as compared to 4.51% and 4.55% for right and left mesiodistal dimensions of the same teeth measured intraorally (Table 5).
- ✓ Sexual dimorphism amounted to 5.44% and 5.54% for right and left buccolingual dimensions of maxillary first molars respectively as compared to 4.74% and 4.84% for right and left mesiodistal dimensions of the same teeth measured on study casts (Table 5).
- ✓ Amongst the intraoral group, the right maxillary first molar was found to exhibit the greatest sexual dimorphism (5.34%) in terms of buccolingual dimension while it is the least dimorphic (4.51%) in terms of mesiodistal dimensions.
- ✓ Amongst the study cast group, the left maxillary first molar was found to exhibit the greatest sexual dimorphism (5.54%) in terms of buccolingual dimension while the least dimorphic value was that for right maxillary first molar (4.74%) in terms of mesiodistal dimensions.
- ✓ Comparing both the groups, all the measurements of maxillary first molars on the left side exhibited greater sexual dimorphism than their respective counterparts, except for the right buccolingual measurement taken intraorally.
- ✓ Comparing the linear measurements, the buccolingual dimensions of maxillary first molars were found to exhibit greater sexual dimorphism than mesiodistal dimensions of the same teeth.

Table 1: *Comparison of mean values of different parameters in males and females measured intraorally using unpaired t-test (right and left maxillary molars).*

Parameters	Sex	Mean (mm) ± S.D	p value
BL-R	M	11.09 ± 0.35	<.0001
	F	10.53 ± 0.42	
BL-L	M	11.10 ± 0.36	<.0001
	F	10.56 ± 0.43	
MD-R	M	10.51 ± 0.44	<.0001
	F	10.06 ± 0.31	
MD-L	M	10.52 ± 0.44	<.0001
	F	10.06 ± 0.31	

Table 2: *Comparison of mean values of different parameters in males and females measured on study casts using unpaired t-test (right and left maxillary molars).*

Parameters	Sex	Mean (mm) ± S.D	p value
BL-R	M	10.93 ± 0.36	<.0001
	F	10.37 ± 0.42	
BL-L	M	10.96 ± 0.36	<.0001
	F	10.38 ± 0.42	
MD-R	M	10.37 ± 0.44	<.0001
	F	9.90 ± 0.31	
MD-L	M	10.39 ± 0.45	<.0001
	F	9.91 ± 0.31	

Table 3: *Comparison of differences in the mean values of parameters between the right and the left side measured intraorally and on the study casts using paired t-test.*

Pairs	Parameters	Mean (mm) ± S.D	95% Confidence interval of the difference		p value
			Lower	Upper	
Pair 1	Intaoral BL-R - BL-L	-0.02 ± 0.12	-0.039	-0.005	.009
Pair 2	Intraoral MD-R - MD-L	-0.006 ± 0.03	-0.011	-0.001	.008
Pair 3	Study cast BL-R - BL-L	-0.017 ± 0.02	-0.020	-0.013	.000
Pair 4	Study cast MD-R - MD-L	-0.013 ± 0.07	-0.023	-0.003	.009

Table 4: *Comparison of differences in the mean values of the parameters in males and females measured both intraorally and on study casts using paired t-test.*

Sex	Pairs	Parameters/ Group	Mean (mm) ± S.D	95% Confidence interval of the difference		p value
				Lower	Upper	
M	Pair 1	Intraoral BL(R) - BL(L)	-0.013 ± 0.10	-0.03	0.006	0.187
	Pair 2	Intra oral MD(R) – MD(L)	-0.008 ± 0.02	-0.01	-0.003	.0001
	Pair 3	Study cast BL(R) – BL(L)	-0.022 ± 0.02	-0.02	-0.017	.0001
	Pair 4	Study cast MD(R)–MD(L)	-0.018 ± 0.09	-0.03	0.001	0.069
F	Pair 1	Intra oral BL(R)- BL(L)	-0.031 ± 0.13	-0.05	-0.004	0.024
	Pair 2	Intra oral MD(R) – MD(L)	-0.004 ± 0.04	-0.01	0.003	0.278
	Pair 3	Study cast BL(R) - BL(L)	-0.011 ± 0.01	-0.01	-0.007	.0001
	Pair 4	Study cast MD(R) – MD(L)	-0.086 ± 0.02	-0.01	-0.004	.0001

Table 5: *Percentage Sexual Dimorphism in Maxillary first molars.*

GROUP	BL-R	BL-L	MD-R	MD-L
Intraoral	5.34%	5.16%	4.51%	4.55%
Study Cast	5.44%	5.54%	4.74%	4.84%

DISCUSSION

Sex determination is one of the prime factors employed to assist with the identification of an individual. The accuracy of sex determination using diverse parameters of the body such as craniofacial morphology and measurements on the pubis ranges from 96% to 100%.[12,13] 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.[14]

The human dentition has a complement of 32 teeth; at least a few teeth may be recovered. Hence, they are routinely used in comparative identification of human remains. The fact that most teeth complete development before skeletal maturation makes the dentition a valuable sex indicator, particularly in young individuals.[15]

The present study established the impact of sex factor on the morphometry of maxillary first molars. Buccolingual and mesiodistal diameters of right and left maxillary first molars in males and females were measured both intraorally and on study casts. The comparison of mean values of parameters measured between males and females showed highly statistically significant differences with $p<0.001$and these results were in agreement with the studies done by Perzigian AJ[16], Ghose LJ et al.[17], Stroud JL et al.[18], Hattab FN et al.[19], Rai B et al.[20] and Ghodosi A et al.[21], in which they have observed that the males had larger teeth than females in all the dimensions. Such differences in dimensions of the teeth can be due to greater dentine thickness in males as compared to females, as the Y chromosome increases the mitotic potential of the tooth germ and induces dentinogenesis; whilst the X chromosome induces amelogenesis.[6]

The present study showed that the mean values of all parameters were greater on the left side as compared to the right side whether measured intraorally or on study casts. The results were in agreement to the study done by Rai B et al.[20], who found the left buccolingual dimensions of maxillary first molars to be greater than its counterparts. Similar results were obtained by a study done by Zarringhalam M,[22] who found that dimensions of all permanent teeth were greater on the left side than the right side in upper jaw while it was reverse in the lower jaw. Right-Left differences may be attributed to dental asymmetry; as perfectly bilateral body symmetry is a theoretical concept that seldom exists in the living organisms.

Amongst the intraoral group, the right maxillary first molar was found to exhibit the greatest sexual dimorphism (5.34%) in terms of buccolingual dimension. The results of the present study were in agreement with the study done by Rai B et al,[20] who found a similar result with the right maxillary first molar exhibiting the greatest sexual dimorphism (8.9%). Amongst the study cast group, the left maxillary first molar was found to exhibit the greatest sexual dimorphism (5.54%) in terms of buccolingual dimension while the least dimorphic value was that for the right maxillary first molar (4.74%) in terms of mesiodistal dimensions.

Comparing the linear measurements, the buccolingual dimensions of maxillary first molars in the present study were found to exhibit greater sexual dimorphism than mesiodistal dimensions of the same teeth. The results of this study are in agreement with the study done by Garn SM et al,[23] who found that among 117 adolescents, sexual dimorphism amounted to 5.6% for the buccolingual diameter as compared to 4.2% for the mesiodistal diameter of the same teeth.

The method in the present study employed is simple and inexpensive to conduct and therefore can be applied in forensic odontology for establishing sex identity of an individual.

SUMMARY AND CONCLUSION

The emerging field of forensic odontology in India relies a lot on inexpensive and easy means of identification of persons from fragmented jaws and dental remains. It is in such situations that the dentist can be called upon to render expertise in forensic science. A database may be established of dental morphometric measurements of non-attrited teeth with a view to determining the variations amongst large populations that may be beneficial for anthropological, genetic, legal and forensic applications.

The present study established the existence of statistically significant sexual dimorphism in maxillary first molars. But in order to raise the level of confidence and percentage in success of determining sex, it is best to combine several different methods, when possible, especially when the ante-mortem data on sex are not available (most commonly in archaeological series).

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