Original Article

Sexual Dimorphism by Odontometric Evaluation of Permanent Canine Teeth: A Study from Three Cities

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Aims: The aim of this study was to investigate whether sexual dimorphism (SD) can be established by odontometric study of permanent maxillary canine teeth as well as intercanine width (ICW).

Materials and Methods: The study was conducted at the Department of Forensic Science, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad. The sample for the study comprised 600 canine teeth on 150 maxillary and 150 mandibular dental casts, obtained from 50 patients each from Bareilly, Lucknow, and Allahabad cities. The casts were poured in dental stone or die stone after taking impressions of the maxillary and mandibular arch using alginate material. The mesiodistal diameter (MD) of the crown of permanent maxillary and mandibular canine both on the right and left sides and ICW were measured on the cast with Digital Vernier Caliper. The percentage of SD was assessed for all the parameters.

Results: The parameter which showed maximum SD was maxillary MD on both right and left sides and observed in Lucknow and Allahabad. In Bareilly, the maximum dimorphic parameter was maxillary and mandibular ICW which has the highest values of SD among all.

Conclusion: The present study supports that there exists a significant SD in maxillary and mandibular canines. However, values are population specific and have shown varying output and degree of SD.

KEY WORDS: *Canine teeth, intercanine width, mesiodistal diameter, odontometric study, sexual dimorphism*

INTRODUCTION

During forensic and archeological excavations, it is often the case that not all the bones of an individual are collected. Therefore, the skull and the teeth often provide the only identification material.[1,2] Because skeletal remains that come from archeological series are very often poorly preserved and fragmentary, demanding careful handling to prevent further damage, sex determination can be particularly complex. Numerous methods have been developed to determine sex in poorly preserved human remains.[3,4]

Sex may be determined either from the cranium or the bones of the postcranial skeleton.[5] In addition, evaluation of the pelvis provides more reliable sex estimation than cranial. When an entire skeleton is available for inspection, sex determination is usually immediately possible with 95%–100% accuracy. Accuracy of prediction decreases to approximately 95% with the pelvis alone, 90% with the skull alone, and 80%–90% with bones of the postcranial skeleton.[6]

However, determination of sex using skeletal remains presents a challenge for forensic experts, especially when only fragments of the body are recovered. Forensic odontology plays an important role in establishing the sex of victims when bodies are mutilated beyond recognition following major mass disasters.[7] In such situations, forensic dentists assist other experts, using skull fragments and teeth to identify the sex of the remains and to solve this difficulty, tooth size standards based on odontometric data can be used.[8]

Teeth provide resistance to damage in terms of bacterial decomposition and high temperature during fire when the rest of the body is damaged beyond recognition. It makes them valuable tool in forensic investigation for identification of age, sex, and race based on odontometric parameters.[9,10] Mesiodistal and buccolingual diameters of the permanent tooth crown are the two most commonly used. Studies have shown that the mesiodistal diameter (MD) of maxillary and mandibular canines provides evidence of sex determination due to dimorphism.[11]

Sexual dimorphism (SD) refers to the differences in size, stature, and appearance between male and female in the same species. This can be applied to dental identification also because no two mouths are alike.[12]

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Although the DNA profile gives accurate results, yet measurement of linear dimensions such as odontometric parameters can be used for sex determination in a large population because they are simple, reliable, inexpensive, and easy to measure.[13]

Bossert and Marks and Krogh stated that the study of the canine teeth offers certain advantages. They are the least frequently extracted teeth and being less affected by periodontal disease.[14,15] In addition, canine teeth have also been reported to survive in air and hurricane disasters.[16]

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 population specific values to make identification and sex determination possible on the basis of dental measurements.[17]

Therefore, the study aimed to evaluate the SD of permanent maxillary and mandibular canines on the basis of average mesiodistal width (MD) on the right and left sides and average intercanine width (ICW) specific for males and females in Bareilly, Lucknow, and Allahabad cities of India.

MATERIALS AND METHODS

The present study was conducted at the Department of Forensic Science, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, after taking approval from the ethical committee of the institute. The sample for the study comprised 600 canine teeth on 150 maxillary and 150 mandibular dental casts, obtained from 50 patients each from Bareilly, Lucknow, and Allahabad cities.

For the collection of samples from different cities, private dental practitioners and consultants from dental institutions in the above cities were requested to provide maxillary and mandibular casts of the patients. The casts were poured in dental stone or die stone after taking impressions of the maxillary and mandibular arch using alginate material. Totally 50 such pairs of casts had been collected from each city. The dental surgeons were informed about the selection criteria (inclusion/exclusion) of the casts.

The inclusion criteria incorporated only those casts, for which gender and age were confirmed, the age of patient between 18 and 30 years, both maxillary and mandibular casts for the same patient were present, casts with fully erupted all permanent canines and casts poured only in dental stone or die stone were included in this study. According to the exclusion criteria for the study, the casts with unerupted or partially erupted canines were excluded, casts of patients with excessive attrition of canines, out of arch canine, ectopically placed canine or with any malocclusion, canine carious or restored or prosthetically replaced, casts with defects such as bubbles, wear and tear and broken and casts poured in Plaster of Paris were excluded from the study.

However, the collected casts were again scrutinized and finally selected before odontometric analysis. MD [Figures 1 and 2] and ICW measurements [Figures 3 and 4] of permanent maxillary and mandibular canines were obtained from the casts using a

sliding Digital Vernier Caliper with calibration of 0.01 mm. All values were rounded to two decimal places. The measurements were defined and calculated as:

Mesiodistal measurement (MD) describes the greatest mesiodistal dimension between the approximate surfaces

Figure 1: Mesiodistal measurement of maxillary left canine on cast

Figure 2: Mesiodistal measurement of mandibular right canine on cast

Figure 3: Measurement of intercanine width in maxillary cast

of the crown was measured with the caliper beaks placed occlusally along the long axis of the canine tooth.

ICW consisted of distance between the tips of the two maxillary and mandibular canines in a straight line. To measure the distance, each of the caliper beaks was kept over the center of the tip of canine tooth of each side.

SD was calculated using formula given by Garn *et al.*[18] as follows:

SD = (Xm/Xf) – 1 × 100

Figure 4: Measurement of intercanine width in mandibular cast

Where: Xm = Mean value for males; Xf = Mean value for females.

All measurements were tabulated and subjected to statistical analysis. The statistical tests used were mean, standard deviation, Student's *t*-test, and level of significance (*P* value).

STATISTICS AND RESULTS

Statistical analysis shows that in Bareilly, the mean mesiodistal width (MD) of maxillary canine on the right side was 7.5272 ± 0.29977 mm in males while 6.8472 ± 0.62108 mm in females. On the left side, it was 7.5084 ± 0.29137 mm in males whereas 6.8828 ± 0.59266 mm in females. On comparing the average mesiodistal width of the mandibular canine on the right side, it was 6.6792 ± 0.51834 mm in males while 6.0828 ± 0.42446 mm in females. On the left side, it was 6.7100 ± 0.52772 mm in males whereas 6.1376 ± 0.42935 mm in females [Table 1].

In Lucknow, the mean mesiodistal width (MD) of maxillary canine on the right side was 7.6588 ± 0.23735 mm in males while 7.1372 ± 0.25388 mm in females. On the left side, it was 7.7236 ± 0.23581 mm in males whereas 7.2180 ± 0.24762 mm in females. On comparing the average mesiodistal width of mandibular canine on the right side, it was 6.8904 ± 0.37867 mm in males while 6.5864 ± 0.33796 mm in females. On the left side, it was 6.8600 ± 0.37982 mm in males whereas 6.5612 ± 0.33647 mm in females [Table 1].

City	Parameter	Gender	Number of samples (canine teeth)	Mean±SD (mm)	t	P
Bareilly	Maxillary MD-R	Male	25	7.5272±0.29977	4.930	0.000*
		Female	25	6.8472±0.62108		
	Maxillary MD-L	Male	25	7.5084±0.29137	4.736	0.000*
		Female	25	6.8828±0.59266		
	Mandibular MD-R	Male	25	6.6792±0.51834	4.451	0.000*
		Female	25	6.0828±0.42446		
	Mandibular MD-L	Male	25	6.7100±0.52772	4.207	0.000*
		Female	25	6.1376±0.42935		
Lucknow	Maxillary MD-R	Male	25	7.6588±0.23735	7.504	0.000*
		Female	25	7.1372±0.25388		
	Maxillary MD-L	Male	25	7.7236±0.23581	7.393	0.000*
		Female	25	7.2180±0.24762		
	Mandibular MD-R	Male	25	6.8904±0.37867	2.010	0.040*
		Female	25	6.5864±0.33796		
	Mandibular MD-L	Male	25	6.8600±0.37982	1.959	0.046*
		Female	25	6.5612±0.33647		
Allahabad	Maxillary MD-R	Male	24	7.5092±0.44060	0.388	0.700
		Female	26	7.4577±0.49354		
	Maxillary MD-L	Male	24	7.5787±0.39198	0.000	0.999
		Female	26	7.5688±0.52263		
	Mandibular MD-R	Male	24	6.8458±0.55874	0.736	0.465
		Female	26	6.7554±0.49298		
	Mandibular MD-L	Male	24	6.9425±0.49390	0.960	0.342
		Female	26	6.8769±0.49584		

*P > 0.05 Non Significant, P < 0.05 Statistically Significant, P < 0.001 Very highly significant. R: Right, L: Left, MD: Mesiodistal, SD: Standard deviation

In Allahabad, the mean mesiodistal width (MD) of maxillary canine on the right side was 7.5092 ± 0.44060 mm in males while 7.4577 ± 0.49354 mm in females. On the left side, it was 7.5787 ± 0.39198 mm in males whereas 7.5688 ± 0.52263 mm in females. On comparing the average mesiodistal width of mandibular canine on the right side, it was 6.8458 ± 0.55874 mm in males while 6.7554 ± 0.49298 mm in females. On the left side, it was 6.9425 ± 0.49390 mm in males whereas 6.8769 ± 0.49584 mm in females [Table 1].

The mean MD of maxillary and mandibular canine on both right and left sides was significantly high in Bareilly and Lucknow (*P* < 0.01), while in Allahabad, there was variation in the values, but the difference was not significant [Table 1].

In Bareilly, mean ICW of maxillary canine was 32.5328 ± 2.16190 mm in males and 25.9248 ± 3.47854 mm in females, whereas mean ICW of mandibular canine was 29.6144 ± 2.15445 mm in males and 22.4860 ± 2.64648 mm in females. In Lucknow, mean ICW of maxillary canine was 34.2476 ± 0.95245 mm in males and 32.8364 ± 1.20913 mm in females, whereas mean ICW of mandibular canine was 32.5392 ± 0.96945 mm in males and 30.1608 ± 1.24473 mm in females. In Allahabad, mean ICW of maxillary canine was 34.9562 ± 2.00073 mm in males and 34.4431 ± 1.97616 mm in females, whereas mean ICW of mandibular canine was 30.5187 ± 2.50568 mm in males and 30.4058 ± 2.55253 mm in females [Table 2].

On evaluation, mean ICW on both maxillary and mandibular canine, a highly significant value was obtained in Bareilly and Lucknow (*P* < 0.001), while in Allahabad the values showed no significant difference [Table 2].

The evaluation of SD shows that in Lucknow, Allahabad, the parameter which showed maximum SD was maxillary MD on both right and left sides. In Bareilly, the maximum dimorphic parameters were maxillary and mandibular ICW [Table 3].

DISCUSSION

Odontometry is an anthropological science that can distinguish different groups and populations based on their dental parameters.[19] Odontometric features that show SD are used in sex determination in cases where sex could not be determined using craniofacial features. As a means of determining sex, odontometric features have been the subject of research for a long time.[5]

Various features like tooth morphology and crown size are characteristic for males and females.[20] The research performed by Stroud *et al*. showed that males have larger MDs of single teeth, which is due to a thicker dentin layer.[21] Tooth morphology is also known to be influenced by cultural, environmental, and racial factors.[22]

Doris *et al*. indicated that the early permanent dentitions provide the best sample for tooth size measurements because early adulthood dentition has less mutilation and less attrition in most individuals.[23] The intercanine distance does not increase after 12 years of age.[24] Thus, only participants in the 18–30 years' age group were included in the present study sample.

The dimensions of canine teeth were studied by several methods which include measurement of linear dimensions, such as mesiodistal width, buccolingual width, and incisocervical height.[25] These linear dimensions of canine teeth can be employed in a large population because it is simple, reliable, inexpensive, and easy to perform.[11,26]

In the present study, the mean MD of maxillary and mandibular canine on both right and left sides was significantly high in Bareilly and Lucknow (*P* < 0.01), while in Allahabad, there was variation in the values, but the difference was not significant [Table 1]. This is in accordance with the study conducted by Parekh *et al*. in Gujarat population in which MD of maxillary canines was significantly greater in males than females.[27] The values were 6.923 + 0.611 mm (right) and 7.098 + 0.535 mm (left) in males and 6.359 + 0.526 mm (right) and 6.617 + 0.51 (left) mm in females with a statistically significant difference in males and females.

The results of the study are also consistent with the study conducted by Minzuno in a Japanese population,[26] Khangura *et al*. in north Indian population,[13] Yuwanati *et al*. in central Indian population,[28] Sassi *et al*. in Uruguayans,[29] and Filipovic *et al*. in a sample of Serbian population, which

City	Parameter	Gender	Number of samples (canine teeth)	Mean±SD (mm)	t	P
Bareilly	Maxillary ICW	Male	25	32.5328±2.16190	8.067	0.000*
		Female	25	25.9248±3.47854		
	Mandibular ICW	Male	25	29.6144±2.15445	10.444	0.000*
		Female	25	22.4860±2.64648		
Lucknow	Maxillary ICW	Male	25	34.2476±0.95245	4.584	0.000*
		Female	25	32.8364±1.20913		
	Mandibular ICW	Male	25	32.5392±0.96945	3.418	0.001*
		Female	25	30.1608±1.24473		
Allahabad	Maxillary ICW	Male	24	34.9562±2.00073	0.912	0.366
		Female	26	34.4431±1.97616		
	Mandibular ICW	Male	24	30.5187±2.50568	0.121	0.904
		Female	26	30.4058±2.55253		

Table 2: Mean intercanine width of maxillary and mandibular canines

*P > 0.05 Non Significant, P < 0.05 Statistically Significant, P < 0.001 Very highly significant. ICW: Intercanine width, SD: Standard deviation

Table 3: Sexual dimorphism of various parameters

Parameter	Bareilly	Lucknow	Allahabad
Maxillary MD-R	9.93	7.31*	0.89*
Maxillary MD-L	9.09	7.00*	0.83*
Mandibular MD-R	9.80	3.10	0.62
Mandibular MD-L	9.33	2.98	0.75
Maxillary ICW	25.49*	4.30	0.49
Mandibular ICW	31.70*	3.54	0.29

*Denoting the highest two values of sexual dimorphism in each city. ICW: Intercanine width, MD: Mesiodistal, R: Right, L: Left

conclude that MD of both maxillary and mandibular canines show SD; however, maxillary canine shows a higher degree of SD as compared to the mandibular canine.[30]

However, Mohammed *et al.* in their study on Saudi Arabian population observed the mean MD of maxillary canines having values 7.54 ± 0.68 mm (right) and 7.54 ± 0.67 mm (left) in males, while in females, it was 6.8 ± 0.925 mm (right) and 6.83 ± 0.934 mm (left), but the differences in males and females were not statistically significant.[11]

Rao *et al.* have demonstrated that ICW and canine index are useful parameters as measured in differentiating the sexes.[10] On evaluation, in the present study, the mean ICW on both maxillary and mandibular canine, a highly significant value was obtained in Bareilly and Lucknow ($P < 0.001$), while in Allahabad, the values showed no significant difference.

Consistent with the results of the present study, Srivastava in their study also observed that mean value of ICW was higher in males than females and the difference was statistically highly significant ($P < 0.01$). However, the right and left mandibular canine index (MCI) among genders showed no significant difference.[31]

The evaluation of SD in the present study showed that in Lucknow, Allahabad, the parameter which showed maximum SD was maxillary MD on both right and left sides. In Bareilly, the maximum dimorphic parameters were maxillary and mandibular ICW which also has highest values of SD among all.

Similar results have been observed by Omar and Azab in a sample of adult Egyptian population showed that there was SD in both mesiodistal and labiolingual diameters of canine teeth (maxillary and mandibular). The stepwise multi-regression analysis elicited formulae for determination of gender from maxillary and mandibular canines with an accuracy of 82.73% and 81.82%, respectively.[32]

Parekh *et al.* in Gujarat population also observed that there was SD in mesiodistal width, ICW, and canine index of permanent maxillary canine teeth.[27] Rastogi *et al.* in Mangalore population found that mandibular canine width and MCI showed significant difference ($P < 0.001$) between males and females. Maximum SD existed in mandibular canine width (12.678), although ICW had no applicability in sex determination.[33]

The variation and differences in SD may be due to the racial, cultural, and geographical diversity of the population,

the inclusion and exclusion criteria in case selection and methodology employed.

Conclusion

It can be inferred from the study that there exists a significant SD in maxillary and mandibular canines. For this reason, teeth assessment is necessary by odontometric investigation, which is population specific and has shown varying output and degree of SD. Thus, the usefulness of dentition as an aid in gender determination by odontometric analysis is well supported.

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Conflicts of interest

There are no conflicts of interest.

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