

Dimorphic Mandibular canines in gender determination in Moradabad population of Western Uttar Pradesh

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Abstract

Background and Objectives: Among morphological characteristics that differentiate a male from a female, tooth size has also been evaluated in various populations for its applicability in anthropologic and forensic investigations to identify the gender from dental remains. The present study was undertaken to investigate the accuracy of mesio-distal width of the mandibular canines, inter-canine arch width, and Mandibular Canine Index (MCI) with which gender can be differentiated in Moradabad population and to correlate the results with other available data.

Materials and Methods: A cross-sectional study was conducted on the casts of 30 males and 30 females between the age group of 19-30 years. **Results:** The mean right and left canine dimension (RCW and LCW) for females was between 6.28 mm and 6.54 mm while that of males was 7.06 mm and 7.45 mm. The mean inter-canine arch width (ICW) in males was 27.64 mm, whereas in females was 23.42 mm. Area under curve (AUC) of ICW, RCW, and LCW had 100%, 98%, and 99.7%. The predicted sensitivity and specificity observed of three criteria was 100% for ICW, 93.3% and 93.3% for RCW, and 96.7% and 100% for LCW, which were found to be highly statistically significant. The mean values of right and left CMI were significantly higher in females as compared to males ($P < 0.001$). **Conclusion:** The MCI parameter in the present study was a quick and reliable method for sexual identification and showed sexual dimorphism by both the RMCI and LMCI with greater significance in identifying females by using RMCI.

Key words: Forensic identification, inter-canine width, mandibular canine index, sexual dimorphism

Introduction

Human identification is the mainstay of civilization, and the identification of unknown individuals

always has been of paramount importance to society.^[1] Identification of an individual living or dead is based on the theory that all individuals are unique. When an unidentified body is found, it is assumed that it could be anybody. By classifying the individual into characteristic groups (age, sex, race, height), the possibilities are narrowed.^[1]

Although DNA analysis is the most precise technique to determine the sex, sometimes, lack of facilities and the cost factor may be a hindrance.^[2] In such cases, teeth provide excellent models for the study of relationship between phylogeny and ontogeny. Identification of humans using

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the unique features of the teeth and jaws has been used since Roman times.^[1]

Teeth being the hardest and chemically the most stable tissue, which exhibit the least turnover of natural structure in the body, are selectively preserved and fossilized, thereby providing by far the best record for evolutionary change.^[3] Their durability in the face of fire and bacterial decomposition makes them invaluable, excellent material in living and non-living populations for anthropological, genetic, odontologic, forensic investigations, and identification.^[3,4] Also, since the human dentition has a complement of 32 teeth, at least a few teeth are usually recovered. Hence, they are routinely used in comparative identification of human remains.^[5] The benefits of determining sex from odontometric features are simple, inexpensive, reliable, and easy to perform.^[2]

Sex assessment constitutes an important step in constructing a postmortem profile, and correct sex identification limits the pool of missing persons to just one half of the population.^[5] The accuracy of sexing using diverse parameters of the body such as craniofacial morphology and measurements on the pubis ranges from 96% to 100%.^[5] Considering the fact that most teeth complete development before skeletal maturation makes them a useful adjunct as a sex indicator, particularly in young individual's dentition.^[5]

Sexual dimorphism represents a group of morphologic characteristics that differentiate a male from a female.^[3] Among these morphological differences, tooth size has been evaluated in various populations between males and females for its applicability in anthropologic and forensic investigations to identify the gender from dental remains.

Mandibular canines considered as "key teeth" for personal identification are found to exhibit the greatest sexual dimorphism amongst all the teeth with mean age of eruption of 10.87 years, less affected than other teeth by periodontal diseases, the last teeth to be extracted with respect to age and also better likely to survive severe trauma such as air disasters, hurricanes, or conflagration.^[6]

Hence, the study was undertaken to investigate the accuracy of mesio-distal width of the mandibular canines, inter-canine arch width, and mandibular canine index with which gender can be differentiated in Moradabad population and to correlate the results with other available data.

Materials and Methods

A cross-sectional study was conducted among the population of Moradabad city, Western Uttar Pradesh. The study group consisted of 30 males and 30 females between the age group of 19-30 years consisting of caries-free teeth without attrition, spacing or crowding having healthy

periodontal status with class I molar relationship, normal overjet and overbite (2-3 mm).

Impressions of mandibular dentition were made with irreversible hydrocolloid material after obtaining the verbal consent and casts poured using dental stone. The following parameters such as inter-canine width (ICW), right and left mandibular canine width (RCW, LCW), and right and left mandibular canine index (RMCI, LMCI) were determined in male and female casts separately. Mesio-distal width i.e. RCW, LCW of the mandibular canine defined as the greatest distance between contact points on the approximate surfaces of tooth crown^[5] were measured on casts using digital vernier caliper with calibration of 0.02 mm [Figure 1]. The inter-canine arch width (ICW) was measured between the tips of both mandibular canines with caliper beaks placed along the long axis of the teeth^[5] [Figure 2].

The area under the ROC curve (AUC) is an effective and combined measure of sensitivity and specificity for assessing inherent validity of a diagnostic test. In a ROC curve, the true positive rate (Sensitivity) is plotted in function of the false positive rate (100-Specificity) for different cut-off points of a parameter. Each point on the ROC curve represents a sensitivity/specificity pair corresponding to a particular decision threshold.

Maximum AUC = 1 and it means, diagnostic test is perfect in differentiating diseased with non-diseased subjects. This implies both sensitivity and specificity are one and both errors- false positive and false negative-are zero. This can happen when the distribution of diseased and non-diseased test values do not overlap. This is extremely unlikely to happen in practice. The AUC closer to 1 indicates better performance of the test.

According to Rao *et al.*, mandibular canine width has a direct relationship with the inter-canine arch width enabling the Mandibular Canine Index (MCI).^[7]

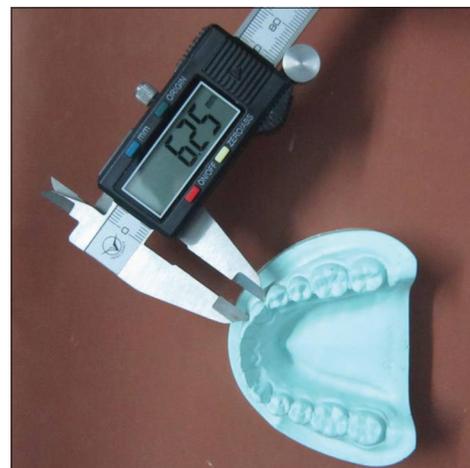


Figure 1: Measurement of mesio-distal width of mandibular canine

$$\text{MCI} = \frac{\text{Mesio-Distal crown width of mandibular canine}}{\text{Mandibular Canine arch width}}$$

The observed values were subjected to statistical analysis using “t” test.

Results

The descriptive statistics and the degree of sexual dimorphism for mesio-distal measurement of right and left mandibular canines, the mandibular inter-canine arch width, and the mandibular canine index are depicted in Table 1.

The mean right and left canine dimension for females was between 6.28 mm and 6.54 mm while that of males was 7.06 mm and 7.45 mm. The mean inter-canine arch width in males was 27.64 mm, whereas in females was 23.42 mm (4.22 mm > males). Area under curve (AUC) of ICW, RCW, and LCW had 100%, 98%, and 99.7% respectively.

The predicted sensitivity and specificity of three criteria observed were 100% and 100% (Cut-off > 25.49 for ICW), 93.3% and 93.3% (Cut-off value > 6.74 for RCW), and 96.7% and 100% (Cut-off > 7.06 for LCW), which were found to be highly statistically significant [Graph 1].

However, for canine indices of both sides, the AUC values were much lower as compared to width values. AUC of RCMi and LCMi was 84.3% and 75.8%, respectively. A cut-off value < 0.263 was predicted to be 80% sensitive and 60% specific for RCMi, whereas a cut-off value < 0.276 was predicted to be 70% sensitive and 60% specific for LCMi. The mean values of right and left CMI were significantly higher in females as compared to males ($P < 0.001$) [Graph 2].

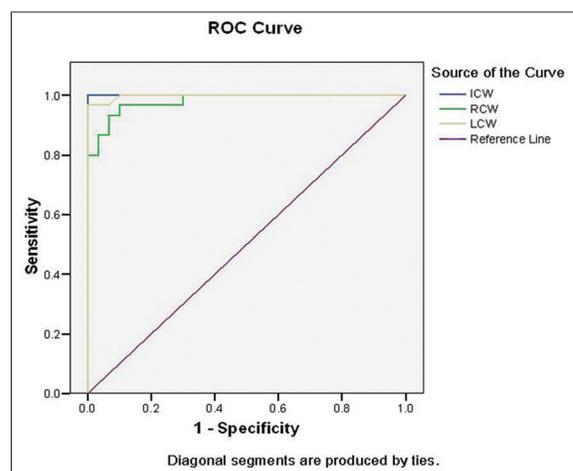
Discussion

Gender determination in damaged and mutilated dead bodies or from skeletal remains constitutes the foremost

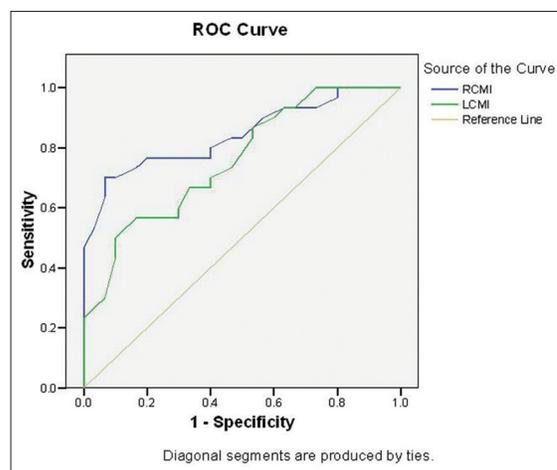
step for identification in medico-legal examination. By classifying the individual into characteristic groups, the possibilities are narrowed.^[8]



Figure 2: Measurement of mandibular intercanine arch width



Graph 1: Area under curve depicting the specificity and sensitivity for ICW, RCW, LCW



Graph 2: Area under curve depicting the specificity and sensitivity for RCMi and LCMi

Table 1: Descriptive statistics of various parameters according to gender

Variable	Male		Female		Significance	
	Mean	SD	Mean	SD	“t”	“P”
ICW	27.64	0.42	23.42	0.28	46.08	<0.001*
RCW	7.06	0.26	6.28	0.28	11.12	<0.001*
LCW	7.45	0.26	6.54	0.29	12.77	<0.001*
RCMI	0.25	0.01	0.27	0.01	-5.07	<0.001*
LCMI	0.27	0.01	0.28	0.01	-3.87	<0.001*

Test applied, Student t-test, * $P < 0.05$ was considered statistically significant

It is necessary to determine specific population values in order to make identification possible on the basis of dental measurements considering the fact that there are differences in odontometric features in specific population and also within the same population in the historical and evolutionary context.^[9] Hence, the present study was undertaken to evaluate the sex in the Moradabad population of western Uttar Pradesh by using mandibular canine.

According to Doris *et al.*, early adulthood dentition has less mutilation and attrition in most individuals. Hence, the early permanent dentitions provide the best sample for tooth size measurements, and consequently, the effect of these factors on the actual MD width would be minimum.^[10] Thus, the population with the age group of 19-30 years was included in the present study.

The mesio-distal width of right and left canine, inter-canine width, and mandibular canine index has been used in numerous studies as useful parameters in sex determination.^[2,3,11,12] The present study also establishes the existence of a definite statistically significant sexual dimorphism in the morphometry of the mandibular canines using the above parameters as far as the widths are concerned. The mean values of mesio-distal width of right canine in males and females were of 7.06 ± 0.26 mm and $6.28 \text{ mm} \pm 0.28$ mm and that of left canine were 7.45 ± 0.26 mm and 6.54 ± 0.29 mm in males and females respectively. These values were found to be significantly higher in males compared to females correlating with the findings of other studies.^[11-16]

The reasons for the high level of dimorphic differences between male and female canines are uncertain, and consequently it has been postulated that, in the evolution of primates, the canines are functionally not masticatory but are related to threat of aggression and actual aggression. A transfer of this aggressive function occurred from the teeth to fingers in man and until this transfer was complete, survival was dependent on canines, especially in males. The notable difference between canine in determining the sex was noted to be due to the influence of Y chromosome, which was not uniform in all teeth. The X-linked genetic influence on tooth was rather uniform for all the teeth.^[16]

Moss *et al.*,^[17] explained that the tooth crowns being larger in males may be because of the greater thickness of enamel due to the longer period of amelogenesis for both the primary and secondary dentitions in males, and according to Acharya *et al.*, it is because of Y chromosome producing slower male maturation.^[18]

Mesio-distal width of left canine showed statistically highly significant value as compared to right in both the male and female ($P < 0.001$). Findings are in accordance with Kaushal *et al.*,^[19] but in contrast to findings of Vishwakarma and Guha^[3] who studied Gwalior population in Madhya

Pradesh in the age group of 17-23 years and noted that right mandibular canine is dimorphic (12.51%) than left mandibular canine (10.15%). It is the Y chromosome, which intervenes most in the size of teeth by controlling the thickness of dentine, whereas the X chromosome for a long time is considered being responsible concerning the thickness of enamel.^[16]

In the present study, we observed that whenever the canine width is greater than 7.5 mm, the probability of sex being male is 100%. In the other studies, probability of being male occurred when the canine width was greater than 7.3 mm, 7.0 mm, and 7.2 mm respectively.^[4,7,11] This finding could be of immense medico-legal importance in identification of sex in Moradabad population as it makes identification easier.

The variation in the magnitude of dimorphism can be a result of various factors, and one such factor is 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, secular changes, and bilateral asymmetry. There can be a complex interaction between a variety of genetic and environmental factors that are responsible for the variation in the magnitude of dimorphism.^[20]

The inter-canine distance in both males and females is found highly significant ($P < 0.001$) with mean inter-canine distance in males being greater (27.64 ± 0.42 mm) as compared to (23.42 ± 0.23 mm) females. These findings are in accordance with findings of studies on different populations across the globe.^[4,11,12,15,16,19,21] This could be due to the fact that the larger jaw dimensions and a greater predilection for bi-lobate and square-shaped chin in males in contrast to pointed ones in females. The inter-canine width which is related to the mandibular arch dimension may, therefore, be expected to show recognizable sexual dimorphism.^[22] According to Cassidy *et al.*,^[23] the arch dimensions were significantly larger in boys than in girls, mesio-laterally as well as antero-posteriorly - a sex difference largely established prior to the onset of the adolescent growth spurt.^[23]

The ratio between the mesio-distal width of lower canine and inter canine arch width resulting in mandibular canine index (MCI) measured in the present study showed significantly higher RMCI and LMCI in females as compared to males ($P < 0.001$) with mean RMCI 0.27 ± 0.01 and LMCI 0.28 ± 0.001 in females as compared to males with RMCI 0.25 ± 0.01 and LMCI 0.27 ± 0.001 . Same kind of results has been obtained in other studies with females having higher MCI values.^[4,7,11,24] The percentage of accuracy in determining the sex by using RMCI was 84.3% accuracy, with <0.263 cut-off value whereas LMCI with 75.8% of accuracy and <0.276 cut of value. The values were lower

than the findings of Rao *et al.*,^[7] and greater than Reddy *et al.*^[16] RMCI in females in the present study showed slightly greater difference with accuracy in identifying the female and was in accordance with the data available in the literature.^[4,11,24]

Finally, we recognize in the present study that the canines revealed greatest and most sexual dimorphism with significant mesio-distal widths in males and females, showing left canine to be more dimorphic than right canine and the significant mandibular inter-canine width, which is greater in males.

Conclusion

The MCI parameter in the present study was a quick and reliable method for sexual identification and showed sexual dimorphism by both the RMCI and LMCI with greater significance in identifying females by using RMCI. As the accuracy of MCI in identification of sex has never exceeded 87.5%, it can only be used as a supplemental tool along with other parameters.

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