

Odontometrics: A Key to Gender Determination

¹Divya Teja Dalli, ²Sudhakara Reddy, ³Sahithi Dathar, ⁴Rajesh Nallakunta, ⁵Preethi Madugula, ⁶Geetanjali Darna

ABSTRACT

Introduction: Identification of an individual is a prerequisite for certification of death and for personal, social, and legal reasons. Sex determination is one of the important parameters in forensic identification. Tooth being strongest component can resist bacterial decomposition and fire when rest of the body is damaged beyond recognition. Sexual dimorphism refers to the systemic difference in the form between individuals of different sexes within the same species. Teeth of various species are known to exhibit sexual dimorphism. The present study aims to evaluate the linear dimensions of permanent molars and canines for sex determination and to estimate their level of accuracy.

Materials and methods: Sixty subjects were included in the study. Study casts were prepared and the dimensions of permanent canines and first permanent molars were measured as the greatest distance between the buccal and lingual surface as well as mesial and distal aspects of the crown by using digital vernier callipers.

Results: Discriminant function analysis had shown that males have greater mean mesio-distal (MD) and bucco lingual (BL)/labio-lingual (LL) dimensions for each tooth in comparison to females. Right upper canine showed the maximum accuracy followed by right lower and left upper canines. Out of four molars, right lower molar showed maximum accuracy of 86.7%.

Conclusion: The present study showed the importance of linear dimensions of canines and molars in the assessment of sex and molars can be used as an alternative to canines when their evidence is missing in forensic investigations.

Keywords: Forensic dentistry, Mandible, Maxilla, Sexual dimorphism.

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INTRODUCTION

Identification of a person is of utmost importance in various pathetic situations, such as mass murders,

airplane crash, train and road accidents, fires, natural disasters like tsunamis, earthquakes and floods, etc.¹ In earlier days, it was the most challenging task to recognize a person and certify his/her death. Since then forensic medicine played a major role in the identification of dead bodies in sudden and unexpected death.² Sex, age, stature, and ancestry background are the four leading features of biological identity and forensic anthropologists authenticate these traits for personal identification.³ Thus, gender/sex determination is being the initial step in the identification of the skeletal remains.⁴ It has significant contribution in the construction of a physical profile of the decedent along with other parameters (race, stature, and age) and forms a part of archeological and medicolegal examinations.⁵

“Sexual dimorphism” refers to differences in size, stature, and appearance between a male and a female.⁶ Till now, various methods have been used for the identification of sex, such as lip prints, palatal rugae patterns, analysis based on dry mandibles, etc. The only method that can give a totally accurate result is the Deoxyribo Nucleic Acid (DNA) analysis, but in many cases, it cannot be used due to the expensive, time-consuming, laborious technique of DNA isolation. Also the need for qualified experts in DNA identification highlights the need for alternative simple, rapid, and reliable methods for gender determination.^{7,8}

Sex can be assessed with high precision using pelvic and cranial bones. But the main drawback of using these bones is that they easily get fragmented, which may be major hindrance for assessment of sex.³ Sex determination with the aid of skeletal remains poses a great dilemma to forensic experts, particularly, when only a part of the body is endured and in those conditions where the body gets disfigured to such an extent that identification by a family member is neither reliable nor desirable.⁹

Teeth are the hardest and chemically the most stable tissue in the body and the fact that most of the teeth complete their development before skeletal maturation makes a valuable indicator of gender.¹⁰ It is considered as the first rate material in living as well as dead population for forensic investigations which can show signs of changes in morphology and are easily accessible for examination.^{3,4}

Of all the teeth in the human dentition, canines are the least frequently extracted teeth because of the relatively decreased incidence of caries and periodontal disease. Bansal et al¹¹ considered mandibular canines as the key

1,3,5,6Postgraduate Student, ²Professor and Head, ⁴Assistant Professor

¹⁻⁶Department of Oral Medicine And Radiology, Vishnu Dental College, Kovvada, Andhra Pradesh, India

Corresponding Author: Divya Teja Dalli, Postgraduate Student Department of Oral Medicine and Radiology, Vishnu Dental College, Kovvada, Andhra Pradesh, India, Phone: +918500707047 e-mail: divyateja.dalli@gmail.com

teeth for personal identification. Whereas, molars are the first permanent teeth to erupt in the oral cavity; and hence, they are readily available for use in sex assessment at an early age when compared with other permanent teeth. It scores an advantage over canines, which have greater tendency of being impacted and thus being unavailable for odontometric analysis.¹²

The present study aims to evaluate the mesiodistal (MD) and labiolingual (LL)/buccolingual (BL) dimensions of first permanent molars and canines for the determination of sexual dimorphism and to estimate the level of accuracy with which they can be used for sex determination.

MATERIALS AND METHODS

A total of 60 subjects of age group between 15 and 30 years attending the outpatient Department of Oral Medicine and Radiology, Vishnu Dental College, South India, were recruited in the study. Individuals with all the four canines and molars with healthy periodontium were included in the study. Those with proximal restorations, rotations, crowding, excessive incisal attrition, dental erosion or abrasion, dental trauma, or any previous orthodontic treatment were excluded from the study.

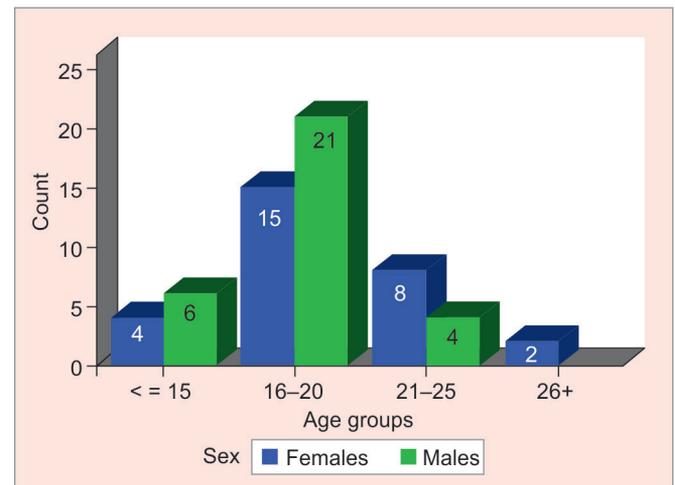
With the informed consent obtained from each subject, alginate impressions of upper and lower arches were taken and casts poured using dental stone. The maximum MD and BL/LL dimensions of all the canines and first permanent molars were measured on the study casts using digital vernier caliper.

The obtained data were entered in a spread sheet (Excel 2007, Microsoft Office) and were subjected to discriminant function analysis.

RESULTS

Among 60 subjects considered in the present study, 31 were males and 29 were females within the age range of 15 to 30 years. Graph 1 shows the distribution of males and females in the study. The mean values of MD and BL/LL dimensions of right and left maxillary and mandibular canines and first permanent molars were shown in Tables 1 and 2 respectively with statistically significant differences between males and females (p -value < 0.05).

Statistically significant difference was observed among males and females in all parameters and males showed greater mean MD and BL/LL dimensions for each tooth when compared to females. The differences between the sexes were analyzed by discriminant function statistics. The group centroids indicate the average discriminant scores for each sex (Tables 3 and 4). Raw coefficients are the discriminant function coefficients used to calculate the discriminant score. To assess the



Graph 1: The distribution of males and females in the study sample

Table 1: Comparison of mean values of MD and BL of right and left upper and lower canines

Canines	Sex	N	Mean	Std. deviation	Std. error mean	p-value
MD-RL	Females	29	6.690	0.6038	0.1121	0.001
	Males	31	8.032	0.4643	0.0834	0.001
MD-RU	Females	29	7.672	0.6447	0.1197	0.001
	Males	31	9.000	0.4082	0.0733	0.001
MD-LL	Females	29	6.845	0.7084	0.1315	0.001
	Males	31	8.048	0.4350	0.0781	0.001
MD-LU	Females	29	7.689	0.7956	0.1476703	0.001
	Males	31	8.974	0.4366	0.0784209	0.001
BL-RL	Females	29	6.672	0.6718	0.1248	0.001
	Males	31	7.613	0.7822	0.1405	0.001
BL-RU	Females	29	7.224	0.6490	0.1205	0.001
	Males	31	8.306	1.0139	0.1821	0.001
BL-LL	Females	29	6.690	0.7724	0.1434	0.001
	Males	31	7.500	0.8062	0.1448	0.001
BL-LU	Females	29	7.259	0.7149	0.1328	0.001
	Males	31	8.452	0.9430	0.1694	0.001

Table 2: Comparison of mean values of MD and BL dimensions of right and left, upper and lower molars

Molars	Sex	N	Mean	Std. deviation	Std. error mean	p-value
MD-RL	Females	29	11.276	0.4549	0.0845	0.001
	Males	31	12.274	0.5603	0.1006	0.001
MD-RU	Females	29	10.759	0.5609	0.1042	0.001
	Males	31	11.532	0.6700	0.1203	0.001
MD-LL	Females	29	11.328	0.4070	0.0756	0.001
	Males	31	12.161	0.5226	0.0939	0.001
MD-LU	Females	29	10.948	0.6174	0.1146	0.001
	Males	31	11.500	0.6583	0.1182	0.001
BL-RL	Females	29	10.793	0.5750	0.1068	0.002
	Males	31	11.387	0.7822	0.1405	0.002
BL-RU	Females	29	11.017	0.6612	0.1228	0.002
	Males	31	11.597	0.7120	0.1279	0.002
BL-LL	Females	29	10.810	0.5073	0.0942	0.001
	Males	31	11.339	0.6756	0.1213	0.001
BL-LU	Females	29	11.017	0.5425	0.1007	0.001
	Males	31	11.581	0.6204	0.1114	0.001

Table 3: The discriminant function coefficients and group centroids of four canine teeth

Tooth	Canonical discriminant function coefficients			Function group centroids		Wilk's lambda
	Mean MD	Mean BL	Constant	Females	Males	
	Right lower canine	1.896	0.043	-13.690	1.294	
Left lower canine	1.718	0.004	-12.793	-1.066	0.997	0.476
Right upper canine	1.676	0.322	-16.509	-1.329	1.243	0.369
Left upper canine	1.270	0.433	-14.019	-1.110	1.038	0.456

Table 4: The discriminant function coefficients and group centroids of four molar teeth

Tooth	Canonical discriminant function coefficients			Function group centroids		Wilk's lambda
	Mean MD	Mean BL	Constant	Females	Males	
	Right lower molar	1.794	0.383	-25.410	-1.043	
Left lower molar	1.931	0.402	-27.163	-0.942	0.881	0.538
Right upper molar	1.312	0.582	-21.226	0.699	0.654	0.679
Left upper molar	0.802	1.149	-22.005	-0.563	0.527	0.765

sex, tooth dimensions were multiplied with the respective raw or unstandardized coefficients and added to the constant. If the values 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 as female.

When the level of accuracy for sex determination was measured, right upper canine showed the maximum accuracy of 96.7% followed by right lower and left upper canines 88.3% accuracy. Out of four molars, right lower molar showed maximum accuracy of 86.7%.

DISCUSSION

Forensic dentistry is a specialized branch of forensic medicine that helps in human identification based on the dental evidence from which a proper evaluation and presentation of dental findings can be made. Human identification by dental and other allied orofacial structures beholds importance for various purposes like legal,

criminal, mass disasters, human trafficking, child abuse, and other antisocial crimes.¹³ Sex or gender determination of unidentified human remains constitutes the foremost step for identification in medico-legal examination. Correctly determined gender limits the number of missing persons to just one half of the population. Although, the accuracy of sex determination was as high as 100% for pelvis followed by skull, yet it is not always possible to obtain intact skeleton for evaluation.¹⁴

Tooth, being the strongest and most stable tissue in the body, can be used in forensic investigations. The fact that most teeth complete development before skeletal maturation makes the dentition a valuable sex indicator, particularly in young individuals.¹⁵ In our study, we have selected individuals of age group between 15 and 30 years. The early permanent dentitions provide the best sample for tooth size measurements and early adulthood dentition has less mutilation and less attrition in most individuals.¹³ Ditch and Rose¹⁶ were the first to



prove that teeth diameters can be successfully used in determining sex in poorly preserved and fragmentary skeletal remains in archeology.

When different parameters of the tooth are compared, males have shown significantly greater dimensions than that of females (Table 1) which goes in accordance with the study conducted by Narang et al.¹² This can be explained by the reason that Y chromosome increases the mitotic potential of the tooth germ and induces dentinogenesis, whereas X chromosome induces amelogenesis owing to the greater dentin and enamel thickness in males as compared to females. In earlier days, sex discrimination was done using combinations of root lengths and crown diameters and obtained an accuracy of 80%.¹⁷

In the current study, we have selected canines because, among all the teeth of human dentition, canines are less severely affected by the periodontal disease and usually, they are the last teeth to be extracted with respect to age.¹³ Rao et al¹⁸ proposed the mandibular canine index (MCI) which is the ratio between the right canine MD dimension and the mandibular canine arch width. It was widely used in previous days. But in later days, several studies have been conducted using this MCI and found to be less accurate in sex determination.^{5,19} When compared with the canines, molars have the advantage of early eruption and are less likely to be impacted. Hence, in the present study, we have selected first permanent molars along with the canines and compared their accuracy in sex determination.

Mesiodistal and BL/LL dimensions of the four canines and four permanent molars (first molars) were measured using the digital vernier caliper on the study casts. When the mean values of different parameters were compared, a statistically significant variation was observed among males and females (Table 1).

Stepwise discriminant function analysis was performed to develop formulas for sex determination. Raw coefficients are the discriminant function coefficients used to calculate the discriminant score. Group centroids indicate the average discriminant score for each sex.

When the percentage accuracy of four canines were assessed using the formulas, right upper canine had showed maximum accuracy of 96.7% followed by left upper canine (88.3%) which is in accordance with the results of Khangura et al,²⁰ who reported that canines were found to be statistically significant for sexual dimorphism and maxillary canines exhibiting significant sexual dimorphism.³ But, it is contradictory to the study conducted by Garn et al, where the mandibular canine showed a greater degree of sexual dimorphism than the maxillary canine.²¹

Similarly, when the percentage accuracy of four molars were assessed using the formulas obtained by

discriminant function analysis, right lower molar had shown the maximum accuracy of 86.7% which is in contradictory to the results given by Narang et al, where the right maxillary first molar had shown maximum accuracy for gender determination.¹²

Thus, the present study had emphasized the importance of molars in sex determination and can be used as an alternative to canines when their evidence is found to be missing.

CONCLUSION

The present study highlighted the importance of linear dimensions (MD and BL) of canines and molars in the assessment of sex. The study showed that molars can be used as an alternative to canines when their evidence is lost for forensic investigations. In our ethnic group, we got maximum accuracy for right upper canine followed by right lower molar. Further studies on different ethnic groups have to be carried out to rule out the amount of accuracy of canines over molars.

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