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Comparison of buccolingual and mesiodistal dimensions of maxillary canine for gender determination using cone beam computed tomography

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Abstract

Introduction: Gender determination in forensic investigations is a tough task. Of many methods used for gender identification measurement of tooth size on dental casts is commonly used. Measuring the size of all the teeth to determine gender is a time consuming method. Also making alginate impressions and cast pouring to measure the tooth size makes the task more complicated. The present study measures the buccolingual and mesiodistal width of permanent maxillary canines on CBCT scan and evaluates its efficacy in gender identification.

Aim: To compare the buccolingual and mesiodistal dimensions of permanent maxillary canines in males and females using CBCT.

Objective: To evaluate whether buccolingual width is reliable or mesiodistal width is reliable for gender determination

Materials and Methods: Buccolingual and mesiodistal width of the right and left permanent maxillary canines were measured on sagittal cross-sections and axial sections of CBCT respectively. The data collected was subjected to statistical analysis. The mean, standard deviation, standard error, and *p*-value of all observations

were calculated using descriptive analysis. The *p*-value <0.005 was considered to be statistically significant.

Results: In the present study it has been observed that buccolingual dimensions of maxillary canine show a considerable size difference between males and females. It is higher in males as compared to females. Whereas this is not true in the case of mesiodistal dimensions. No statistical significant values were obtained when mesiodistal dimensions were measured.

Conclusion: The study concludes that buccolingual dimensions of permanent maxillary canines can be considered as reliable indicators for gender determination.

Keywords: Forensic Odontology, Gender Determination, Maxillary Canine, Buccolingual Width, CBCT

Introduction

Gender determination after accidental or natural disasters causing mass deaths is a tough assignment for a forensic Odontologist. Severe disintegration or severe burns often leads to complete soft tissue loss and identification of a dead body by facial features or fingerprints is next to impossible.[1] Human teeth being non-perishable and resistant to heat and chemical/mechanical damage are useful in determining the sex of an individual whose bodies have been severely mangled or commingled during disasters.[2] Human teeth not only survive demise but also generally remain unaltered for long periods.[3]

Many parameters in the maxillofacial region have been studied for gender determination. Maxillary sinuses, frontal sinuses, first molar dimensions, canine dimensions, or cumulative dimensions of all teeth are few to name.[4] So far sexual dimorphism using tooth dimensions has been studied on models. Since the advent of cone beam computed tomography (CBCT) many dental professionals have been utilising it for detailed analysis and more precise treatment plans for their cases. Once the scanning is done the data can be stored permanently which is helpful to both dental professionals and forensic odontologists in multiple ways. This study intends to determine the gender of an individual using maxillary canine dimensions made on CBCT. Since mandible is a movable bone and it is more prone to trauma and damage[5] maxillary canines have been considered for the study as maxilla is part of the skull and has the least chance of being lost. First and second molars being more prone to decay and loss, the great possibility of premolars undergoing orthodontic extraction and variable anatomy of lateral incisors, and third molars are reasons for their non-selection in this study.

Material and Methods

The study was conducted in YCMM & RDF's Dental College, Ahmednagar, Maharashtra. 435 CBCT scans of patients between 15 to 65 years of age were analyzed of which 124 CBCT scans (62 males and 62 females) were selected for the study. The inclusion criteria were non-carious and completely erupted right and left maxillary canines. Maxillary canine that were missing on the contralateral side or with wasting diseases, restoration/prosthesis, or morphologically altered and rotated /impacted were excluded from the study.

Required data was collected from available CBCT scans (Carestream CS 9300, KODAK Dental Systems, Carestream Health Rochester NY). Images were analyzed using CS 3D imaging software version 3.8.7. An oblique slicing window was utilised for the measurement of scans. Slice thickness was 90um. The greatest mesiodistal (MD) width of the right and left permanent maxillary canines were measured on sagittal cross-sections and the greatest buccolingual (BL)

dimension was measured on axial sections (Figure 1 and 2). The mesiodistal dimensions were measured as the greatest distance between the mesial and distal surfaces of the crown of permanent maxillary canines on sagittal sections. The buccolingual dimension was measured as the greatest distance between the buccal and lingual surface of permanent maxillary canines on axial sections. All the measurements were made by a single maxillofacial radiologist. To assess the intra-observer error all the measurements were repeated by the same radiologist after 10 days. No significant difference was found between the two readings. To determine the percentage of dimorphism between male and female teeth size the following formula[6] was used:

Sexual Dimorphism = (Mean male tooth dimension /Mean female tooth dimension) -1 × 100.

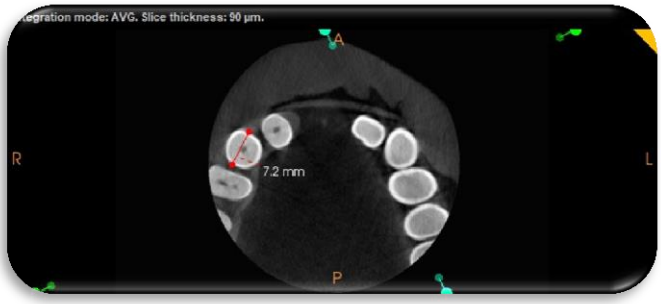
Figure 1: showing measurement of the buccolingual dimension of permanent maxillary canine on cross-sections:

Male

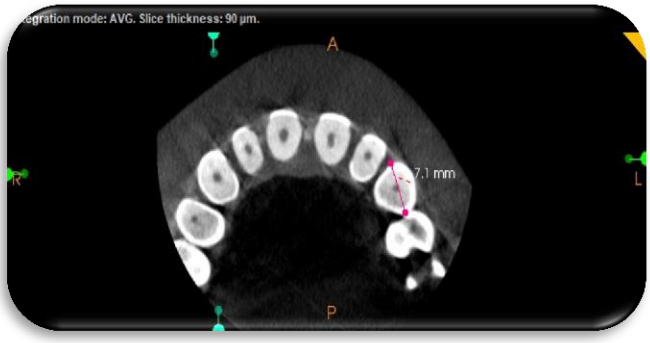
Female

Figure 2: Showing measurement of the mesiodistal dimension of permanent maxillary canine on axial sections:

Male



Female



Statistical Analysis

The data collected were subjected to statistical analysis using SPSS software version 20. The mean, standard deviation, standard error, and the *p*-value of all observations were calculated using descriptive analysis. *P*-value <0.005 was considered to be statistically significant.

Table 1: Mean, standard deviation, standard error, and p-value of all observations were calculated using descriptive analysis

	Gender	*n*	Mean	SD	SEM	*P- value*
MD width right	male	62	7.424194	.6929825	.0880089	.209
	female	62	7.267742	.6856310	.0870752	
MD width left	male	62	7.412903	.6783499	.0861505	.305
	female	62	7.290323	.6474945	.0822319	
BL width right	male	62	8.041935	.6139227	.0779683	.000
	female	62	7.054839	.6639863	.0843263	
BL width left	male	62	8.059677	.6173608	.0784049	.000
	female	62	7.082258	.6577468	.0835339	

n- number , SD-standard deviation, SEM- standard error of mean.

Graph 1: Mean buccolingual and mesiodistal dimensions in males and females

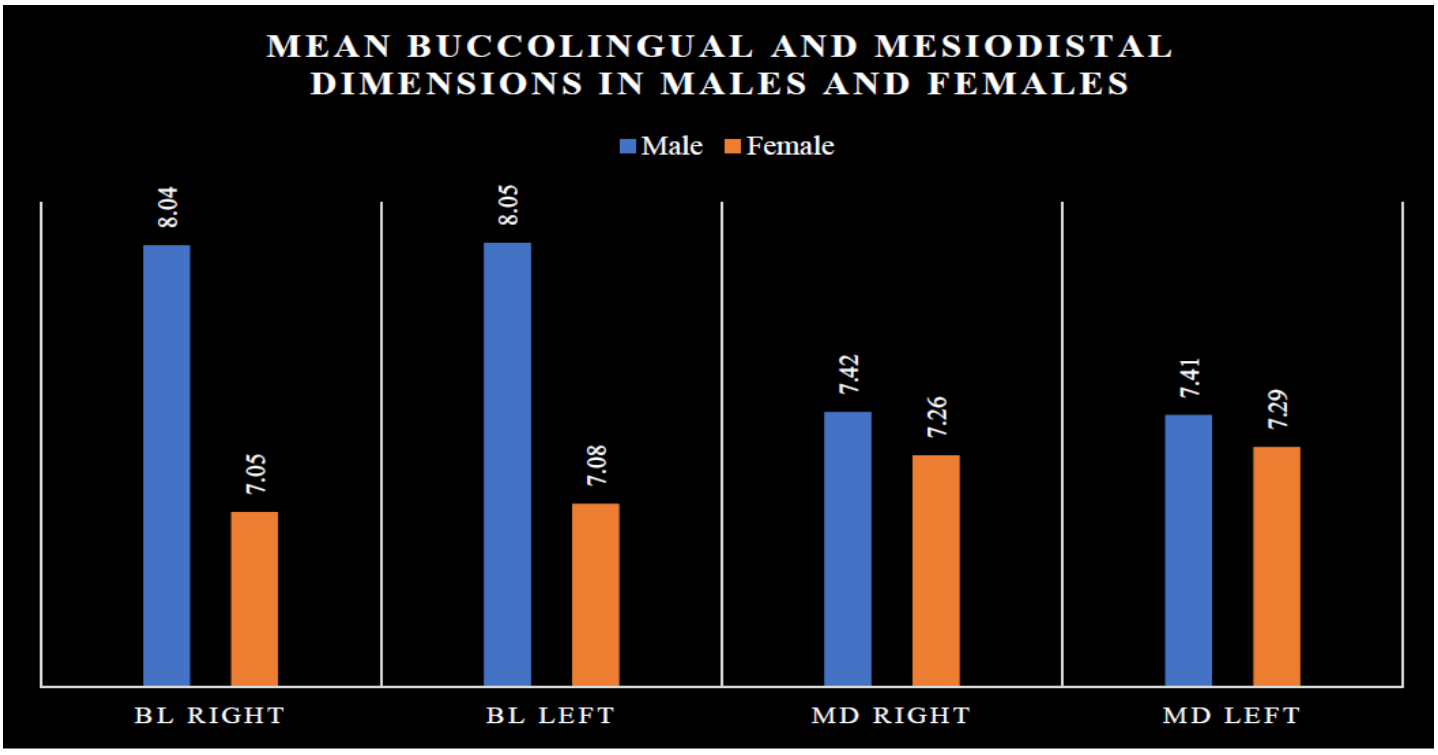


Table 2: Independent t-test obtained by calculating the average of the MD width

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
MD	Equal variances assumed	.257	.613	**1.155**	122	.250	.13952	.12076	-.09953	.37856
	Equal variances not assumed			**1.155**	121.938	.250	.13952	.12076	-.09953	.37857

Table 3: Independent t-test obtained by calculating the average of the BL width

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
BL	Equal variances assumed	.098	.755	**8.608**	122	.000	.98226	.11411	.75637	1.20815
	Equal variances not assumed			**8.608**	121.337	.000	.98226	.11411	.75636	1.20816

Table 4: The formula for sexual dimorphism showed the following results:

Parameter	Dimorphism (%)
BL	13.896
MD	-98.9808

Table 1 shows the mean MD width and BL width of the right and left permanent maxillary canines. It was observed that the mean MD width of maxillary canines in both males and females did not show any significant differences. However, when BL dimensions were analyzed it was observed that BL width was larger in males compared to females. The p- value of the MD dimension of right and left maxillary canines was more than 0.05 which was statistically non-significant. However, the p-value for the right and left BL dimensions was less than 0.05 which was statistically significant.

Graph 1 shows the mean BL and MD dimensions of permanent maxillary canines. It was observed that the mean value of BL dimensions obtained is 8.045 for males and 7.065 for females. It was observed that in both males and females the range of MD dimensions was between 7.0 to 7.5mm.

Tables 2 and 3 show the result of the independent t-test. It is an inferential statistical test that determines whether there is a statistically significant difference between the means in two unrelated groups. The independent t-test assumes that the variances of the two groups under study are homogenous (equal population). Homogeneity of variance can be tested by Levene's test of equality of variances. The test provides an F-statistic and significant value (p-value). If the p-value is > 0.05 group variances are considered to be equal. From the result of Levene's Test for Equality of Variances, we can reject the null hypothesis that there is no difference in the variances between the groups and accept the alternative hypothesis that there is a statistically significant difference in the variances between groups. T value is the calculated difference in units of standard error. As the t value increases evidence against the null hypothesis increases. If t values of tale 2 and table 3 are compared, it is observed that for BL dimensions the t value is greater which indicates that there is a significant difference. However, in MD dimensions, the t value is nearer to 0 which indicates that there is no significant difference.

Table 4 shows the percentage of differences in tooth size between males and females. It was observed that the BL dimension showed a significant difference between males and females (13.896) whereas the MD dimensions were yielding negative values (-98.9808).

Results

In the present study, it has been observed that BL dimensions of maxillary canine show a considerable size difference between males and females. It is higher in males as compared to females. Whereas this is not true in the case of MD dimensions. No statistical significant values were obtained when MD dimensions were measured. Hence BL dimensions of maxillary canines can be used for gender determination for forensic purposes.

Discussion

After severe soft tissue mutilation in mass deaths, many times identification of the victim is based only on dental remains.[1] Identification of gender is the first step in such cases. Of the two approaches for gender determination (visual method and metric method), the metric approach has higher reliability[7]. The shape and size of teeth are established in the first stage of individual life and remain the same throughout life making gender determination possible from tooth size and shape[8]. The range of sexual dimorphism in human teeth is between 1%-7%.[6,8] Male teeth are larger than female teeth. Of all the teeth greatest sexual dimorphism has been shown by permanent maxillary canines.[6,9] and hence only permanent maxillary canines were made the part of the present study as they provide the most reliable information for gender determination in humans.

The present study shows that the BL width of maxillary canines is significantly higher in males compared to females. The mean value obtained is 8.045 for males and 7.065 for females. The accuracy rate for BL dimensions was found to be 92.2%. Whereas in the case of MD dimensions, no statistical difference was seen between male and female canine sizes. The results of our study correlate with Wankhede PK et al which measured buccolingual dimensions of all the teeth and concluded that buccolingual dimensions of all the teeth can be taken into account for sex determination; however, the overall accuracy in the study was 68%[10]. In another

study by Pratibha Rani et al, it was found that tooth 11 showed maximum sexual dimorphism; the accuracy rate was 70.7%, while for tooth 23 the accuracy rate was found to be 66.6%[11]. However maxillary central incisors are more prone to trauma and fractures and hence chances of loss of maxillary incisors are more because of which it is possible that they may not be available in gender determination after accidents. The results of our study also correlated with that of Litha et al which has proved that BL dimensions differentiate gender with an accuracy rate of 99.8% whereas in the case of the MD dimensions it is only 69.9%[7]. Also, Metgud et al survey of the Udaipur population proved that the BL dimension is a better predictor of sexual dimorphism and that males have larger teeth than females. The study has also shown that the mandibular teeth did not exhibit sexual dimorphism[2]. However, Acharya and Manali in their study have shown that MD variables were better indicators of gender than BL dimensions. BL dimensions show univariate differences. This was attributed to the fact that BL variables didn't enter the stepwise discriminant analysis[9]. They also stated that the accuracy level of the MD dimension alone is lower than the combined accuracy level of the MD and BL dimensions. This was further strengthened by Litha et al's study which concluded that the accuracy of BL dimensions alone in the prediction of gender is the same as the accuracy obtained when both MD and BL dimensions are combined together[7]. Phularietal has also concluded that only 50.5% of cases gave accurate results when the MD width of canine was used as a parameter for gender identification[5]. Canine is the tooth that shows the greatest sexual dimorphism and permanent maxillary canines prove this to more extent than their mandibular counterparts[12]. Reverse dimorphism is also observed in case the of maxillary canines.[10,13,14] environmental, cultural, and genetic factors have been claimed for this difference[15]. In a study by Kaushal et al, it has been stated that if the width of a canine is more than 7 mm, the probability of that person being male is 100%. In our study, all the males have shown BL dimensions of more than 8mm. Whereas MD dimensions of maxillary canines in both males and females range between 7.0 to 7.5mm and therefore MD width of canine is an unreliable variable for gender identification. The canine field of sexual dimorphism states that the greater the canine dimorphism; the greater the sexual dimorphism of adjacent teeth[12]. This field effect centres over the maxillary canine and spills over adjacent teeth i.e the lateral incisors and premolars[12]. So from the above concept of canine field dimorphism, permanent maxillary canines are reliable indicators of sexual dimorphism.

CBCT scans were used for data collection in this study as it provides multiplanar reformatted images and gives a clear picture of the dentition. Apart from measuring BL and MD dimensions of the crown, the number of roots, root canals, exact location of an impacted tooth if present, and several findings if required for the identification of an individual can also be derived. Also, data analysis becomes easier when 3D imaging techniques are used for study purposes. The complicated and time-consuming method of making impressions and cast pouring of all the samples and preserving the models without damage can be avoided.

Conclusion

We conclude that permanent maxillary canines alone can be considered a reliable indicator for gender determination. Measurement of the BL diameter is sufficient for evaluating gender. If the BL width of the permanent maxillary canine is ≥ 8mm, the individual can be considered a male. The MD diameter measurements

are inappropriate and not to be considered. Traditional methods of measurements over dental casts should be avoided. New emerging technologies like CBCT can be used for determining gender and additional information if required.

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