

Estimating Sexual Dimorphism using Anthropometric measurements of Permanent Dentition

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ABSTRACT

CONTEXT: The ability to determine the sex of an unknown person is extremely useful because it narrows the search to nearly half of the population. Teeth are excellent choice for identification since they are resistant to putrefaction and are well protected anatomically.

AIMS: The study is aimed at presence of sexual dimorphism in different tooth measurements in the lower jaw.

SETTINGS AND DESIGN: Cross sectional study

METHODS AND MATERIAL: The study was conducted on 51 male and 54 female participants. Exclusion criteria for the subjects were: Dental caries, Crowded or excessive spacing in the anterior teeth, Orthodontic treatment, Occlusal abnormalities, Any trauma to lower jaw. Measurements were taken clinically using geometric divider and digital callipers. Odontometric dimensions included in the study taken from the lower jaw only are: Mesiodistal width (MD) and Buccolingual width (BL) for canine, central incisor and first molar (both left and right) and inter canine width (ICW).

STATISTICAL ANALYSIS USED: Jamovi Software version 2.3.24 was used for statistical analysis. Independent sample t and Binomial logistic regression was applied to see the accuracy of predictive measures for different dimensions in identifying sex of an individual.

RESULTS: Mesiodistal and buccolingual dimensions of canines, central incisor and first molar in the lower jaw differ significantly in males and females. Mesiodistal dimensions are more accurate in identifying

the sexes. Mandibular canines are more sexually dimorphic compared to mandibular central incisors and first molars.

CONCLUSIONS: The study findings indicate that the Mandibular dental measurements and canine indices can be used as supportive adjunct rather than the sole criteria for sex determination in forensic investigations.

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Keywords: Sexual dimorphism; Canine; Mandibular canine Index; Inter canine width.

Key Messages: Mandibular dental measurements and canine indices can be used as supportive adjunct for sex determination in forensic investigations. Further studies are needed with larger sample size from the population for a higher accuracy in the use of these parameters for sex determination.

INTRODUCTION

Determining the sex where only body parts or remains are available, is always a challenging task. Teeth being well preserved anatomically, make excellent identification tools.^{1,2,3} Canines are most dimorphic teeth and also resist extreme conditions.^{4,5,6} Sexual dimorphism is found highest in mandibular teeth.^{7,8,9} In this study we focussed on mandibular canines together with central incisors and first molars. Few past studies have employed clinical measurements; the majority are based on dental casts. This study aims at presence of sexual dimorphism in lower jaw teeth.

OBJECTIVES

- i. To estimate sexual dimorphism for different tooth in lower jaw.
- ii. To evaluate the accuracy of sex determination from various dental measurements.

SUBJECTS AND METHODS

A cross sectional study was conducted on young adult Indian population aged between 18-25 years of age, as this group shows less attrition of teeth. The study was initiated after the approval from Institutional Ethics Committee and registering in Clinical Trial Registry of India (CTRI).

Inclusion Criteria: Subjects with normal dentition and good oral hygiene.

Exclusion Criteria: Subjects under the following criteria were excluded from the study:

1. Dental caries
2. Crowded or excessive spacing in the anterior teeth
3. Orthodontic treatment
4. Occlusal abnormalities
5. Any trauma to canine, central incisor, or 1st molar teeth in the lower jaw.

A total of 105 subjects participated in the study consisting of 51 male and 54 female students pursuing MBBS. Each participant was informed about the study in detail and prior consent were obtained.

Measurements were taken clinically using geometric divider and digital callipers with the provision to fix it in the desired position to avoid any errors.

Odontometric dimensions included in the study are taken from the lower jaw only:

1. Mesiodistal width (MD) - for canine, central incisor and first molar (both left and right)
2. Buccolingual width (BL) - for canine, central incisor and first molar (both left and right)
3. Inter canine width (ICW)

Mesiodistal width (MD) was measured as the greatest width of the crown between the contact points of the teeth on either side of the jaw. Buccolingual width (BL) was measured as the maximum width between the buccal and lingual surfaces of tooth perpendicular to the mesiodistal width. ICW was measured as the distance between the cusps tips of two canines in the same jaw.

Mandibular Canine Index was Calculated for each side using the Formula:

Mandibular canine index (MCI) = Mesiodistal crown width of mandibular canine / ICW

Standard canine index for male and female were calculated using the formula:

Standard canine index = [(Mean Male MCI-SD) + (Mean female MCI+SD)] / 2

According to Rao *et al*, canine index more than the standard canine index suggests the unknown individual to be male and vice versa. Canine index less than the standard canine index suggests female.¹⁰ The percentage accuracy of reporting sex identity by this technique was then calculated by matching against the true sex of each participant.

Sexual dimorphism in different tooth dimensions was calculated using the formula given by Garn *et al*

(1967)¹¹:

$$\text{Sexual dimorphism} = [(X_m/X_f)-1] \times 100,$$

X_m = Mean value of males,

X_f = Mean value for females.

Different dimensions observed in the study were subjected to analysis by statistical methods. Statistical analysis was done using Jamovi Software version 2.3.24. Mean and standard deviation of the observed measurements were calculated. Independent sample t-tests were used to compare the means in male and female participants. Binomial logistic regression was applied to see the accuracy of predictive measures for different dimensions in identifying sex of an individual.

RESULTS

A total of 105 subjects participated in the study. Out of which 54 were female (51.4%) and 51 were male (48.6%). The mean age of participants was 20.8 for both male and female.

Mean mesiodistal and buccolingual dimensions of male participants for each tooth in the study is found to be more than that of the female. Inter canine width (ICW) in male (27.68±2.665) was also found to be higher than that in female (26.96±2.120).

The comparison of mean of the different measurements in male and female using independent sample t-test based on normality check of different parameters is depicted in Table no. 1. Student t-test was applied for most of the samples while for CMDR (right canine mesiodistal) and MMDL (left first molar mesiodistal) Mann Whitney test were applied after normality check. (Table No. 1.1) As shown the differences in mean measurements in the two groups (male and female) are statistically significant p < 0.05, except for the Inter canine width (p > 0.05).

Table 1: Comparison of mean of the different measurements in male and female.

Independent Samples T-Test

		Statistic	df	p
CBLR	Student's t	-3.15	103	0.002
CMDL	Student's t	-6.78	103	<.001
CBLL	Student's t	-3.32	103	0.001
MMDR	Student's t	-3.51	103	<.001
MBLR	Student's t	-4.38	103	<.001

MBLL	Student's t	-3.81	103	<.001
IMDR	Student's t	-2.60	103	0.011
IBLR	Student's t	-2.73	103	0.007
IMDL	Student's t	-3.73	1.03	<.004
ICW	Student's t	-1.54	103	0.127

Note: H F_μ # μ_m

Levene's test is significant (p < .05), suggesting a violation of the assumption of equal variances.

Table 1.1

Independent Samples T-Test

		Statistic	p
CMDR	Mann-whitney U	361	<.001
MMDL	Mann-Whitney U	940	0.005

Note: H F_μ # μ_m

Levene's test is significant (p < .05), suggesting a violation of the assumption of equal variances.

Mandibular canine index was calculated for each participant for both left and right side. Mean mandibular canine index for right mandibular canine is 0.247 ± 0.0315 for female and 0.0274 ± 0.0329 for male. Mean mandibular canine index for left mandibular canine is 0.259 ± 0.0224 for female and 0.276 ± 0.0311 for male.

Table No. 2 depicts the statistically significant difference between the mean mandibular canine indices, both left and right when compared in male and female. Similar findings were reported in other studies where had higher statistically significant value for MCI compared to female.^{4,12,13,14}

Table 2: Comparison of means of right and left mandibular canine indices for two sexes

Independent Samples T-Test

		Statistic	df	p
MCIR	Student's t	-4.32	103	<.001
MCIL	Student's t	-3.32	103	0.001

Note: H F_μ # μ_m

Levene's test is significant (p < .05), suggesting a violation of the assumption of equal variances.

Standard Mandibular canine index for right and left mandibular canines for the sample was calculated as Standard MCIR= 0.2598 and Standard MCIL = 0.2632 using the formula given by Rao *et al.* Percentage accuracy of reporting correct sex identity by this technique was calculated. Table

no. 3 shows an accuracy of 66.7% and 57.1%, respectively for right and left standard mandibular canine index. This method was found to be more accurate in females in conformity with the findings of Rao *et al*, Muller *et al* and Kushal *et al*.^{4,10,15}

Table 3: Predictability using the standard canine index.

Standard MCIR	Cases	% Age accuracy
Female	37/54	68.5
Male	33/51	64.7
	70/105	66.7

Standard MCIL	Cases	% Age accuracy
Female	31/54	75.4
Male	29/51	56.9
	60/105	57.1

Sexual dimorphism was calculated for each tooth using the formula by Garn *et al* (1967) (Table No. 4). Mesiodistal dimensions in the right mandibular canine (CMDR) is found to be having the highest dimorphism (13.4%) followed by mesiodistal dimension in the left mandibular canine (CMDL) (9.22%) and Buccolingual dimension in the left mandibular canine (CBLL)(7.16%).

Table 4: Sexual dimorphism in various tooth measurements used in this study.

Sex	CMDR	CBLR	CMDL	CBLL	MMDR	MBLR	MMDL	MBLL	IMDR	IBLR	IMDL	IBLL
Female	6.64	6.93	6.94	6.98	10.9	11.1	10.9	11	5.86	5.81	5.85	5.57
Male	7.53	7.4	7.58	7.48	11.5	11.7	11.2	11.6	6.16	6.11	6.23	6.09
% sexual dimorphism	13.404	6.782	9.222	7.163	5.505	5.405	2.752	5.455	5.119	5.164	6.49	5.91

Binomial logistic regression model for different measurements suggested highest predictive measure accuracy for Mesiodistal dimension for

right canine (CMDR)(79%) followed by mesiodistal dimension for left canine (CMDL)(73.3%) and right central incisor (IMDR)(73.3%). (Table No. 5)

Table 5: Predictive measure accuracy by logistic regression for different tooth measurements

-	sex	CMDR	CBLR	CMDL	CBLL	MMDR	MBLR	MMDL	MBLL	IMDR	IBLR	IMDL	IBLL
Mean	F	6.64	6.93	6.94	6.98	10.9	11.1	10.9	11	5.86	5.81	5.85	5.75
	M	7.53	7.4	7.58	7.48	11.5	11.7	11.2	11.6	6.16	6.11	6.23	6.09
Predictive measure accuracy		79	63.8	73.3	62.9	71.4	63.8	65.7	62.9	73.3	60	67.6	65.7

DISCUSSION

Identification is the fixation of individuality of a person. Sex determination undertakes half of the task in that process and narrow down the search to half of population. Many anthropometric parameters are available which are immensely helpful for the purpose. In cases where only body remains are available odontometric dimensions are also used. Dentition being the part of the body which resists degradation for a long time and thus is a valuable tool.

The mean mesiodistal and buccolingual measurements of tooth were found to be more in male than in female, which was statistically significant. Similar statistically significant difference in width of canines were obtained in the previous studies done by Kushal *et al*. and Rao *et al*.

This is explained as the Y chromosome controls the thickness of dentin, whereas the X chromosome is responsible for the thickness of enamel.¹²

This study also finds Intercanine width more in males compared to females, but the difference was not significant. Agnihotri *et al* in their study which focused on three Indian cities, also found similar in significant differences in ICW in one of the groups.¹⁶ However previous studies by Singh SK *et al* and Kushal *et al* have shown significant differences in ICW in male and female.^{4,12}

The present study establishes a statistically significant sexual dimorphism in 3 set of mandibular teeth (canines, central incisor and first molars).

In this study mesiodistal dimension in the mandibular canines demonstrated the highest sexual dimorphism. Similar findings were reported on mandibular canines in previous studies.^{5,7,9,12}

The right and left canines had a score of 13.4% and 9.22% respectively. These values are higher in comparison to the corresponding values of 6.2% and 7.7% reported for south Indian population and 7.954% and 8.891% for North Indian population.⁴

Buccolingual dimension showed highest sexual dimorphism in the left mandibular canine 7.16%, followed by right mandibular canine and mandibular left first molar. There are very few studies in Indian population using the buccolingual dimensions for reporting sexual dimorphism. Prabhu S *et al* and Zorba E *et al* reported BL dimension to be the highest sexually dimorphic in their respective studies on Indian and Greek population.^{5,14}

Present study also shows the percentage accuracy of identifying sex correctly by comparing the calculated MCI with the standard MCI. For right and left sides, it was found out to be 66.7% and 57.1% respectively, with overall accuracy of 61.9%. Nearly similar percentage accuracy has been reported by studies conducted by Muller *et al*. (2001) on the French population (59.57%) and also by Mohsenpour K *et al*.^{15,17} Higher overall accuracy of 75-85.9% has been reported by other Indian studies in different population groups.^{4,10,12}

The logistic regression method demonstrated higher chances to predict the sex correctly in

Canines. The higher accuracy was found in Mesiodistal dimension in Mandibular canine. Similarly high predictive accuracy was reported by Martins *et al*.¹⁸

CONCLUSION

The study findings indicate that the mesiodistal and buccolingual dimensions of canines, central incisor and first molar in the lower jaw differ significantly in males and females. Mesiodistal dimensions are more accurate in identifying the sexes. Mandibular canines are more sexually dimorphic compared to mandibular central incisors and first molars. Mandibular dental measurements and canine indices can be used as supportive adjunct rather than the sole criteria for sex determination in forensic investigations. Further studies are needed with larger sample size from the population for a higher accuracy in the use of these parameters for sex determination.

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