ISSN (O): 2582-693X

Original Article

SEX DETERMINATION BY MANDIBULAR CANINE INDEX IN KOTA POPULATION-A COMPARATIVE STUDY

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ABSTRACT

Background: the four main attributes of biological identity that most forensic osteologists hope to determine are the sex, age, stature, and ethnic background of the individual. The estimation of sex is more reliable if the complete skeleton is available but in forensic cases human skeletal remains are often incomplete or damaged. In such cases teeth are good material in living and non-living population for anthropological, genetic, odontologic, and forensic investigations.

Methods: the study population constituted of 200 subjects inclusive 100 males and 100 females with age range of 18-25. Measurements made in mm at the contact point were mesiodistal width of right and left canine, intercanine distance both intraorally and on casts and mandibular canine index were calculated. The obtained data was subjected to t test/ mann whitney test and discriminant function analysis.

Results: All parameters of mandibular canines namely inter canine distance, canine width and canine index were greater in males compared to females suggesting significant sexual dimorphism of mandibular canines. Left canine width was greater compared to right canine width in both males and females. Right canine index casts were strongly significant among all the parameters. On subjecting the data to discriminant function analysis it classified sex correctly in 73% of samples.

Conclusion: Results of the study establishes existence of significant sexual dimorphism in mandibular canines. We can therefore recommend the use of mandibular canine dimensions as an applicable method for gender determination in human identification.

Keywords: Forensic anthrology, gender determination, mandibular canine.

INTRODUCTION

Human beings have come a long way from the early caveman age to the present day. His intelligence has also led to a surge in crime rate, terrorism, wars, mass disasters, road traffic accidents and dreadful diseases. In all such incidents the identity of the deceased, assailant or the cause of death becomes important, as the core of various investigations are based on these processes.[1]

The four main features of biological identity are sex, age, stature, and ethnic background.[2] Sex assessment of skeletal remains is an important step in building the biological profile of unidentified skeletons recovered in forensic contexts. It enables a more focused search of missing person files, with the potential of recovering antemortem records for comparison and establishing identity.[3]

It is widely agreed that the skull and pelvis are the most useful skeletal regions for sex determination. Krogman and Iscan ranked skeletal regions in order of their accuracy for determining sex: the pelvis 95%, the skull 92%, the mandible 90% and long bones (humerus and femur) 80%.[4]

Sexual dimorphism represents a group of morphologic characteristics that differentiate a male from a female. Among these dimorphic traits, tooth size has been evaluated in various populations for its applicability in anthropologic and forensic investigations. The morphological differences of the teeth between males and females have been reported and can be applied to identify the gender from dental remains.[5]

Although the morphology of the tooth structure is similar in males and females, the size of tooth does not necessarily remain the same, as the tooth size is determined by cultural, environmental, racial and genetic factors.[6] Earlier studies showed that sexual dimorphism have been observed in permanent maxillary anterior teeth,[7] maxillary molars,[8] mandibular canines and mandibular molars.[9] The least dimorphic teeth were the lower lateral incisor and the lower central incisor.[10] But canines have consistently shown the greatest sexual dimorphism; moreover, they are robust in terms of resistance to disease and trauma and more likely to remain intact in postmortem scenarios.[11] The mandibular canines are not only exposed to less plaque, calculus, abrasion from brushing,

DOI: 10.46376/IJMR/2.3.2021.

or heavy occlusal loading than other teeth, they are also less severely affected by periodontal disease and so, usually are the last teeth to be extracted with respect to age.[12]

MATERIALS AND METHOD

200 subjects (100 males and 100 females) between the age group of 18-25 years were selected from patients reporting to the O.P.D in Daswani dental college and research center, Kota, Rajasthan after taking written consent from the patient. The study was approved by the ethical review board of the college.

The subjects with the following criteria were included in the study: healthy gingiva and periodontal status, mandibular canines free from dental caries, normal overjet and overbite of teeth (2-3 mm), absence of spacing in the anterior teeth and Angle's Class 1 molar and canine relationship. Subjects with partially erupted or ectopically erupted teeth, missing teeth, occlusal abnormalities, teeth showing physiologic or pathologic wear and tear and with history of trauma and orthodontic treatment were excluded from the study.

Measurements were made intraorally and later on the casts obtained from the same subjects using digital Vernier caliper (Mitutoyo, Japan; Resolution-0.01mm; Accuracy- +/- 0.02mm). Alginate impression of mandibular arch was made using perforated metallic impression tray and the cast was poured using type III dental stone.

Greatest mesiodistal dimension was considered as the tooth width. Right and left mandibular canine width was measured intraorally and on the casts. Intercanine width was measured from the cusp tip of right mandibular canine to the cusp tip of left mandibular canine. Mandibular canine index (MCI) was calculated using the following formula

$$\text{Mandibular canine index} = \frac{\text{Mesio-distal width of mandibular canine}}{\text{Intercanine distance}}$$

Sexual dimorphism in right and left mandibular canines was calculated using formula given by Garn & Lewis (1967) as follows:

$$\text{Sexual dimorphism} = \frac{Xm}{Xf} - 1 \times 100$$

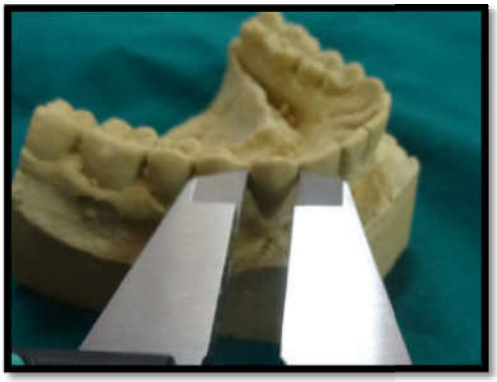
Where Xm = Mean canine width of males

Xf = Mean canine width of females

The measurements obtained were subjected to t test/ mann whitney test and discriminant functional analysis

DOI: 10.46376/IJMR/2.3.2021.

Photograph - Mesiodistal width of mandibular canine.



Photograph - Mandibular Intercanine distance.

RESULTS

The data was collected, tabulated and subjected to statistical analysis. The results are as follows:

Table 1: Comparison of different parameters between males & females:

Parameter	Group	Gender	Mean	Std Dev	SE of Mean	Mean Difference	t/z	P-Value
Intercanine Distance‡	Intraoral	Male	26.36	1.56	0.16	0.894	-3.929	<0.001*
		Female	25.46	1.69	0.17			
	Casts	Male	26.18	2.52	0.25	0.711	-3.823	<0.001*
		Female	25.47	1.69	0.17			
Right Canine Width	Intraoral	Male	6.81	0.41	0.04	0.435	7.456	<0.001*
		Female	6.37	0.41	0.04			
	Casts	Male	6.81	0.41	0.04	0.433	7.427	<0.001*
		Female	6.37	0.41	0.04			
Left Canine Width	Intraoral	Male	6.91	0.40	0.04	0.447	7.940	<0.001*
		Female	6.46	0.39	0.04			
	Casts	Male	6.91	0.40	0.04	0.517	6.201	<0.001*
		Female	6.39	0.73	0.07			
Right Canine Index‡	Intraoral	Male	0.26	0.01	0.00	0.007	-3.618	<0.001*
		Female	0.25	0.02	0.00			
	Casts	Male	0.26	0.01	0.00	0.008	-3.665	<0.001*
		Female	0.25	0.01	0.00			
Left Canine Index‡	Intraoral	Male	0.26	0.02	0.00	0.008	-3.661	<0.001*
		Female	0.25	0.01	0.00			
	Casts	Male	0.26	0.02	0.00	0.008	-3.673	<0.001*
		Female	0.25	0.01	0.00			

‡ Mann-Whitney test
*denotes significant difference

t-test/ Mann- Whitney test was applied to compare different parameters between males and females.

Intercanine distance

Parameter	Group	Gender	Mean	Std Dev	SE of Mean	Mean Difference	t/z	P-Value
Intercanine Distance‡	Intraoral	Male	26.36	1.56	0.16	0.894	-3.929	<0.001*
		Female	25.46	1.69	0.17			
	Casts	Male	26.18	2.52	0.25	0.711	-3.823	<0.001*
		Female	25.47	1.69	0.17			

of 200 subjects (100%), 100 males (50%) had mean intercanine distance of 26.36: SD of 1.56 intraorally; mean value of 26.18: SD 2.52 in casts. 100 females (50%) had mean

DOI: 10.46376/IJMR/2.3.2021.

intercanine distance of 25.46: SD of 1.69 intraorally; mean value of 25.47: SD of 1.69 in

casts. The values were significantly higher in males compared to females with p value <0.001.

Right canine width

Parameter	Group	Gender	Mean	Std Dev	SE of Mean	Mean Difference	t/z	P-Value
Right canine width	Intraoral	Male	6.81	0.41	0.04	0.435	7.456	<0.001*
		Female	6.37	0.41	0.04			
	Casts	Male	6.81	0.41	0.04	0.433	7.427	<0.001*
		Female	6.37	0.41	0.04			

Of 200 subjects (100%), 100 males (50%) had mean right canine width of 6.81: SD 0.41 intra orally; mean value of 6.81: SD 0.41in casts. 100 females (50%) had mean right canine width of 6.37: SD 0.41 intraorally; mean value of 6.37: SD 0.41 in casts. The values were significantly higher in males compared to females with p value < 0.001.

Left canine width

Parameter	Group	Gender	Mean	Std Dev	SE of Mean	Mean Difference	t/z
Left canine width	Intraoral	Male	6.91	0.40	0.04	0.447	7.940
		Female	6.46	0.39	0.04		
	Casts	Male	6.91	0.40	0.04	0.517	6.201
		Female	6.39	0.73	0.07		

Of 200 subjects (100%) , 100 males (50%) had mean left canine width of 6.91: SD 0.40

intraorally; mean value of 6.91: SD 0.40 in casts. 100 females (50%) had mean left canine width of 6.46: SD 0.39 intraorally; mean value of 6.39: SD 0.73 in casts. The values were significantly higher in males compared to females with p value < 0.001.

Right canine index

Parameter	Group	Gender	Mean	Std Dev	SE of Mean	Mean Difference	t/z	P-Value
Right canine index*	Intraoral	Male	0.26	0.01	0.00	0.007	-3.618	<0.001*
		Female	0.25	0.02	0.00			
	Casts	Male	0.26	0.01	0.00	0.008	-3.665	<0.001*
		Female	0.25	0.01	0.00			

Of 200 subjects (100%), 100 males (50%) had mean right canine index of 0.26: SD 0.01

intraorally; mean value of 0.26: SD 0.01in casts. 100 females (50%) had mean right canine index 0.25: SD 0.02 intraorally; mean value of 0.25: SD 0.01 in casts. The values

were significantly higher in males compared to females with p value < 0.001.

Left canine index

DOI: 10.46376/IJMR/2.3.2021.

Parameter	Group	Gender	Mean	Std Dev	SE of Mean	Mean Difference	t/z	P-Value
Left canine index*	Intraoral	Male	0.26	0.02	0.00	0.008	-3.66.	<0.001*
		Female	0.25	0.01	0.00			
	Casts	Male	0.26	0.02	0.00	0.008	-3.673	<0.001*
		Female	0.25	0.01	0.00			

Of 200 subjects (100%), 100 males (50%) had mean left canine index of 0.26: SD 0.02

intraorally; mean value of 0.26: SD 0.02 in casts. 100 females (50%) had mean left canine index of 0.25: SD 0.01; mean value of 0.25: SD 0.01 in casts. The values were significantly higher in males compared to females with p value < 0.001.

Table 2: Comparison of different parameters within males between intraoral and casts:

Parameter	Group	Mean	Std Dev	SE of Mean	Mean Difference	t/z	P-Value
Intercanine Distance[‡]	Intra Oral	26.36	1.56	0.16	0.182	-0.058	0.970
	Casts	26.18	2.52	0.25			
Right Canine Width	Intra Oral	6.81	0.41	0.04	0.001	0.021	0.984
	Casts	6.81	0.41	0.04			
Left Canine Width	Intra Oral	6.91	0.40	0.04	-0.006	-0.109	0.904
	Casts	6.91	0.40	0.04			
Right Canine Index[‡]	Intra Oral	0.26	0.01	0.00	0.000	-0.028	0.978
	Casts	0.26	0.01	0.00			
Left Canine Index[‡]	Intra Oral	0.26	0.02	0.00	0.000	-0.004	0.997
	Casts	0.26	0.02	0.00			

1. In male sample size of 100 (50%), the mean intercanine distance was 26.36 intraorally and 26.18 in the casts. No significant difference was observed between intraoral and casts with p value >0.05.

2. In male sample size of 100 (50%), the mean right canine width was 6.81 intraorally

and 6.81 in the casts. The mean left canine width was 6.91 intraorally and 6.91 in the casts. No significant difference was observed between intraoral and casts with p value

>0.05.

3. In male sample size of 100 (50%),the mean right canine index was 0.26 intraorally

and 0.26 in the casts. The mean left canine index was 0.26 intraorally and 0.26 in the casts. No significant difference was observed between intraoral and casts with p value

>0.05.

Table : Comparison of different parameters within females between intraoral and casts:

Parameter	Group	Mean	Std Dev	SE of Mean	Mean Difference	t/z	P-Value
Intercanine Distance[‡]	Intra Oral	25.46	1.69	0.17	0.002	0.016	0.987
	Casts	25.47	1.69	0.17			
Right Canine Width	Intra Oral	6.37	0.41	0.04	-0.001	-0.021	0.984
	Casts	6.37	0.41	0.04			
Left Canine Width	Intra Oral	6.46	0.39	0.04	0.064	0.776	0.439
	Casts	6.39	0.73	0.07			
Right Canine Index[‡]	Intra Oral	0.25	0.02	0.00	0.001	-0.038	0.970
	Casts	0.25	0.01	0.00			
Left Canine Index[‡]	Intra Oral	0.25	0.01	0.00	0.000	-0.029	0.977
	Casts	0.25	0.01	0.00			

1. In female sample size of 100 (50%), the mean intercanine distance was 25.46 intraorally and 25.47 in the casts. No

DOI: 10.46376/IJMR/2.3.2021.

significant difference was observed between intraoral and casts with p value >0.05.

2. In female sample size of 100 (50%), the mean right canine width was 6.37 intraorally and 6.37 in the casts. The mean left canine width was 6.46 intraorally and 6.39 in the casts. No significant difference was observed between intraoral and casts with p value >0.05.

3. In female sample size of 100 (50%), the mean right canine index was 0.25 intraorally and 0.25 in the casts. The mean left canine index was 0.25 intraorally and 0.25 in the casts. No significant difference was observed between intraoral and casts with p value >0.05.

The data acquired from sample size of 200 (100%) including males 100 (50%) and females 100 (50%) was subjected to discriminant function analysis. All the parameters was found to be statistically significant in determining the gender.

Two parameters namely, right canine width and left canine index in casts of both males and females failed the tolerance test due to high fluctuancy. So they are not included in the final discriminant model.

Using Fisher's linear discriminant function, co-efficient of each parameter was determined. **In males** (50%) intercanine distance-intraoral (X1) is 1876.94, intercanine distance-casts (X2) is 6.08, right canine width-intraoral (X3) is −4585.10, left canine width-intraoral (X4) is −2843.31, left canine width-casts (X5) is 40.23, right canine index-intraoral (X6) is −385.38, right canine index-casts (X7) is 120666.72, left canine index-intraoral (X8) is 71058.19.

In females (50%) intercanine distance-intraoral (X1) is 1877.68, intercanine distancecasts (X2) is 6.23, right canine width-intraoral (X3) is −4588.68, left canine widthintraoral (X4) is −2845.50, left canine width-casts (X5) is 39.77, right canine indexintraoral (X6) is −372.97, right canine index-casts (X7) is 120743.66, left canine indexintraoral (X8) is 71047.75

The equations thus formed are:

M = C + (1876.94)*X1 + (6.08)*X2 – (4585.10)*X3 – (2843.31)*X4 + (40.23)*X5 – (385.38)*X6 + (120666.72)*X7 + (71058.19)*X8

DOI: 10.46376/IJMR/2.3.2021.

F = C + (1877.68)*X1 + (6.23)*X2 – (4588.68)*X3 – (2845.50)*X4 + (39.77)*X5 – (372.97)*X6 + (120743.66)*X7 + (71047.75)*X8

DISCUSSION

The determination of sex is an important concern of the osteologist and the forensic anthropologist as it is critical for individual identification. [14] Teeth exhibit the least turnover of natural structure and are readily accessible for examination. Being the hardest and chemically the most stable tissues in the body they are selectively preserved and fossilized, thereby providing by far the best record for evolutionary change.[15]

Sexual dimorphism represents a group of morphologic characteristics that differentiate male from a female. Sexual dimorphism in tooth size has been explored over the past half-century, with odontologists and anthropologists.[13]

Among the teeth, canines have consistently shown the greatest sexual dimorphism; moreover, canines are robust in terms of resistance to disease and trauma and more likely to remain intact in postmortem scenarios.[11] Most studies have found mandibular canines to exhibit the greatest sexual dimorphism among all teeth.[16] The present study aimed to delineate sexual dimorphism existing in the permanent mandibular canines. The present study included subjects of age between 18-25. The rationale for selection within the said age group being the fact that all permanent canines are fully erupted and attrition is minimal in this age group.[17] In the present study, measurements made intraorally and on the casts did not differ and was statistically insignificant. In the present study measurements were made mesiodistally at the contact point for obtaining mandibular right canine width and left canine width. Various studies found measurements of mesiodistal width at contact point accurate. But, in a study conducted by Johanna Morgan[18] to overcome the limtations of measuring mesiodistal width at contact point of mandibular canine like interstitial wear, measurements were made at the cervical buccolingual and mesiodistal. t-test/ Mann- Whitney test was applied to compare different parameters between males and females. In our study all the following parameters were greater in males compared with females and statistically significant. In the present study the mandibular canine width values were greater in males compared

DOI: 10.46376/IJMR/2.3.2021.

with females and was statistically significant. But reverse dimorphism was observed in study conducted by Karen Boaz et al[17] in south Indian population who considered mesiodistal and buccolingual dimensions.

In our study measurements of left mandibular canine width was higher, compared to right mandibular canine width in both males and females. This difference was in agreement with studies conducted by Karen Boaz et al,[17] Garn et al,[19] Krishnamurthy Anuthama et al[20] in permanent mandibular canines.

In the present study the left mandibular canine showed a greater sexual dimorphism (6.96%) when compared to the right mandibular canine (6.90%). This finding was consistent with studies conducted by Rishab Kapila et al[70] and Kaushal et al[15].

In our study the values of canine index were greater in males compared with females and

statistically significant. We found the mandibular canine index relevant in determining

sexual dimorphism of mandibular canines. This finding was consistent with studies conducted by Kaushal et al,[15] Vandana M Reddy et al,[12] Irfan Ahmed Mughal et al.[23] M.Muller et al[24] conducted a study and concluded that when mandibular anterior teeth alignment is not correct, gender determination is not possible using mandibular canine index. Contrasting results were got by Ashith B. Acharya et al,[25] who conducted a study in Nepalese population to validate mandibular canine index as a sex predictor. Their results suggest that mandibular canine index has little reliability in sex assessment and its application should be restricted.

In the present study intraoral and cast measurements of mandibular canines were exact and equally good. So either of the two can be used for calculations. All parameters of mandibular canines namely inter canine distance, canine width and canine index were greater in males compared to females suggesting significant sexual dimorphism of mandibular canines. The left mandibular canine width was greater compared with right mandibular canine width in both males and females suggesting left mandibular canine to be more sexually dimorphic. This method is relatively simple, time saving and economical. Mandibular canine dimensions can be useful to corroborate gender of human remains with a high degree of certainty

DOI: 10.46376/IJMR/2.3.2021.

especially in cases of major catastrophes when bodies are often damaged beyond recognition.

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