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Sex Determination Potential from Canine Tooth Dimensions

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Authors' contributions

Authors AS and SAA designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors SNA and IA managed the analyses of the study. Authors BT and AU managed the literature searches. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aims:

- This study was conducted to know sex determination potential from mesiodistal dimensions of permanent canines.
- To find out the average size of canines in males and females of south Indian population.
- To compare the findings with National and International Studies.

Study Design: The subjects were selected based on the inclusion and exclusion criteria set forth for the study. Measurements of mesiodistal widths of the four canines were made on the dental casts of each of the 600 subjects with Digital caliper with 0.01 resolution and subjected to statistical analysis. Statistical methods used were statistical mean, standard deviation, Student's t-test ($p< 0.05$), step-wise discriminant analysis and cross validated discriminant analysis using SPSS version 11.00.

Place and Duration of Study: Department of Oral Medicine and Radiology, Al-Badar Rural Dental College and Hospital, Gulbarga, Karnataka, India, between May 2008 and May 2011.

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Methodology: We included 600 patients (300 men, 300 women; age range 17-25 years)
Results:

- The mesiodistal width of canines of both the jaws is significantly greater in males than females.
- The mean maxillary canine width in males and females is 7.73 mm. The mean mandibular canine width in males and females is 6.825 mm.
- The mean (male and female), maxillary and mandibular canine width is found to be less in South Indian Population as compared to Central Indian population.
- The mean (male and female), maxillary and mandibular canine width is found to be less in South India Population as compared to values given by Wheelers and similar to the study done in the Saudi population.

Conclusion: The present study measured only linear dimensions because of simplicity, reliability, inexpensibility and in a setup where latest technology utilizing DNA methods are not available and gender estimation has to be managed based on jaw fragments.

Keywords: Canines dimorphism; sex determination; gender; forensic odontology.

ABBREVIATIONS

SD=Standard deviation; Min=Minimum; Max=Maximum; Signi.=Significance

1. INTRODUCTION

Human beings are born with an identity and deserve the right to die with an identity [1]. Identity means the determination of the individuality of a person [2]. United Nations Declaration of Human Rights states that every freeborn person has the right to be identified even after death [3,4]. The identification of a dead body may be required in cases of sudden and unexpected death, fires, explosions, railway or aircraft accidents, mutilated or hidden decomposed bodies, or foul play and often needs great medico-legal acumen [2]. The law enforcement community expects and requires that forensic scientist report the identification of partial or complete remains of an individual to the best of his or her ability [5]. Various methods are used to establish the identity of unknown remains. The reliability of each method varies [1]. The methods vary and depend on the available bones and their condition [6]. The only method that can give a totally accurate result is the DNA technique, but in many cases and for several reasons it cannot be used [2,6].

Gender determination of skeletal remains is part of the archaeological and many medico legal examinations [6]. An important initial step in identification of the dismembered remains of mass disaster victims is the separation of sexes [7]. Complete skeletons with or without soft tissue present fewer problems. Those bodies, which are, less complete and consisting of parts of a skeleton only, present more problems in identification and in many instances may not be identified at all [8]. Anthropological measurements of the skeleton and the comparison with the existing data must then be applied and may help to differentiate between male and female remains [6]. Osteometry is considered the preferred technique because it is more effective in determining sex [9]. On an individual basis however, gender differences are always distinctive, but taken collectively can give a good indication in majority of the cases [6]. The determination of sex is among the important aspect of forensic anthropology. These characteristics display population specific variation and therefore, need further attention for major populations of the world [10].

Many authors have done the measurements of crown in teeth between males and females and found certain variations. Though the morphology of the structure is similar to male and female, there is no need that, the size of the structure should remain same, as the size of structure is determined by various factors like exercise, nutrition, metabolic activities etc. Measurements of tooth dimensions are quick, less time consuming, non-invasive and can be easily performed compared to DNA technique.

The study aims to fulfill the following objectives:

- Determination of sex by measuring Mesiodistal dimension of maxillary and mandibular permanent canines.
- To find out the average size of canines in males and females of south Indian population.
- To compare the findings with National and International Studies.

2. MATERIALS AND METHODS

This study was conducted in the Department of Oral Medicine & Radiology, Al-Badar Rural Dental College & Hospital, Gulbarga, Karnataka, India the ethical approval for which was taken from Institutional Review Board.

The study population constituted 300 males and 300 females in the age group of 17 to 25 years, reporting to the Department of Oral Medicine & Radiology, Al-Badar Rural Dental College & Hospital, Gulbarga, Karnataka, India.

The subjects for the study were selected based on simple random sampling technique and those who willingly consented to be a part of the study with following inclusion & exclusion criteria & the legal age of the subject was confirmed using one of following documents: birth certificate, driving license, college or other identity card, 10th class certificate.

2.1 Inclusion Criteria

The subjects having complete set of fully erupted, morphologically well-formed, periodontally healthy, non-carious, non-attrited, intact and satisfactorily aligned maxillary and mandibular teeth with Angle's class I Malocclusion and no history of orthodontic treatment and no evidence of cleft palate or crown restorations were included in the study.

2.2 Exclusion Criteria

1. The Individuals who wear bridges, crowns and other appliances or had any anomalies that could influence the measurements.
2. Conservative treatment other than Class I occlusal restorations and class V on teeth other than canine.
3. Individuals with anodontia, partially edentulous, malformed /hypoplastic teeth and positional variations in any of the segments.

- Individuals with clinical features suggestive of developmental disturbances, metabolic disorders, history of prolonged illness and medically compromised states were excluded from the study.

An informed written consent was obtained from each of the subjects followed by full arch maxillary and mandibular impressions were taken by Irreversible Hydrocolloid impression material (Hydrogum soft; Zhermack clinical, Germany) and poured immediately by Type III Gypsum product, dental stone (Stone plaster; Neelkanth Healthcare Pvt. Ltd, India).

The following parameters were determined on casts by using electronic digital sliding caliper to the nearest 0.01mm (Mitutoya Co., Utsunomiya, Japan).

- Mesiodistal crown width of right maxillary canine;
- Mesiodistal crown width of left maxillary canine;
- Mesiodistal crown width of right mandibular canine;
- Mesiodistal crown width of left mandibular canine.

Intra-observer reliability or precision (differences between the repeated measurements) and inter-observer errors (differences between the means of two sets measurements) were 0.08mm and 0.16mm, respectively; representing only 1.2% and 2.1% of the mean measurements.

The readings obtained were subjected for analysis to derive conclusions. Sexual dimorphism in right and left mandibular and maxillary canines was calculated using a formula given by Garn et al. [11].

Sexual dimorphism=[(xm/xy)–1]×100
xm=mean value for males; xy=mean value for females

The results obtained were subjected to statistical analysis (Mean, Standard deviation and co-efficient of variation, t-test, step-wise discriminant analysis and percentage accuracy of reporting gender identity by cross validated discriminant analysis and computed for both sexes using SPSS (Statistical Package for the Social Sciences) Version 11.00.

3. RESULTS

It was observed that the mean value of the mesiodistal crown width of right maxillary canines was 7.90±0.54mm in males and 7.60±0.37mm in females, while the mean value of the mesiodistal crown width of left maxillary canines was 7.85±0.64mm in males and 7.60±0.37mm in females (Table 1). The differences in these values are statistically significant (P<0.001).

The mean value of the mesiodistal crown width of right mandibular canines was 7.00±0.31mm in males and 6.65±0.55mm in women and the mean value of the mesiodistal crown width of left mandibular canines was 7.00±0.32mm in the males and was 6.65±0.55mm in females (Table 1). The differences in these values are statistically significant (P<0.001).

Table 1. Mesiodistal crown width of maxillary and mandibular canines – genderwise distribution in mm

Variable	Gender	Min (in mm)	Max (in mm)	Mean (in mm)	SD	t-value	p-value
Maxillary	Male	7.0	9.0	7.9000	0.5394	7.9108	<0.0001
Right Canine	Female	7.0	8.0	7.6000	0.3748		
Maxillary Left	Male	7.0	9.0	7.8500	0.6355	5.8692	<0.0001
Canine	Female	7.0	8.0	7.6000	0.3748		
Mandibular	Male	6.5	7.5	7.0000	0.3168	9.5394	<0.0001
Right Canine	Female	6.0	7.5	6.6500	0.5509		
Mandibular	Male	6.5	7.5	7.0000	0.3168	9.5394	<0.0001
Left Canine	Female	6.0	7.5	6.6500	0.5509		

SD=Standard deviation; Min=Minimum; Max=Maximum; Signi.=Significance;mm=Millimeter

The sexual dimorphism from the mesiodistal crown width of the canine tooth was calculated by the formula Xm/Xf−1×100; Xm is the mean mesiodistal width of canines in men and Xf is the mean mesiodistal width of canines in women.

The sexual dimorphism of right maxillary canines was 3.947% and that of left maxillary canines, 3.28% and the sexual dimorphism was 5.263% for the right mandibular canine and 5.263% for the left mandibular canine.

We derived the mean measurement of right and left maxillary canines for males and females and mean of these measurements were taken to arrive at a single value for maxillary canine. Similarly one single value was measured for mandibular canine. These values were compared with the values given by Wheeler's [12]. (Table 2 & 3) Both the maxillary and mandibular canine measurements in the present study were found to be less than the Wheeler's. This finding is very important as it indicates that normative data based on one population cannot be used for other population.

Table 2. Comparing maxillary canine width with the Wheeler's study results

Maxillary canines	Male right (in mm)	Male left (in mm)	Female right (in mm)	Female left (in mm)
Mean	7.90	7.85	7.60	7.60
Maxillary right ,left mean	7.875		7.60	
Combined male female mean	7.73			
According to Wheeler	7.5			

Table 3. Comparing Mandibular canine width with the Wheeler's study results

Mandibular canines	Male right (in mm)	Male left (in mm)	Female right (in mm)	Female left (in mm)
Mean	7.00	7.00	6.65	6.65
Mandibular right ,left mean	7.00		6.65	
Combined male female mean	6.825			
According to Wheeler	7.0			

Comparing the mean canine measurement of our findings with other studies, the values of our study on South Indian population are similar to the other studies (Table 4).

Table 4. Comparison with other studies

Author	Year	Population	M/F	MxRt (mm)	MxLt (mm)	Mn Rt (mm)	Mn Lt (mm)
Present study	2014	South Indian	M	7.90	7.85	7.00	7.00
			F	7.60	7.60	6.65	6.65
Madhavi	2013	Central	M	8.04	8.32	7.76	8.01
Yuwanati [20]		Indian	F	7.73	8.01	7.44	7.74
Gorea &	2010	North Indian	M	7.61	7.67	6.78	6.71
Sharma [27]			F	7.31	7.39	6.39	6.41
Karan	2009	South Indian	M			7.05	6.98
Boaz [19]			F			7.00	6.90
Kaushal [15]	2004	North Indian	M			7.32	7.198
			F			6.69	6.67
Mohd QA &	1997	Saudi	M	7.53	7.53	6.90	6.93
Abdulla [28]			F	7.55	7.36	6.83	6.80

4. DISCUSSION

Teeth form an excellent material in living and non-living populations for anthropological, genetic, odontogenic and forensic investigation. Measurements of tooth dimensions are quick, less time consuming, non-invasive and can be easily performed. Tooth dimensions are used to establish the sex of a victim in major accidents/disasters, medico-legal cases and natural disasters. Sex can be determined well in mature individuals if the human skeletal remains are intact [2].

The dentition takes precedence particularly when preferred parameters such as the pelvis are unavailable and cranial and long bones fragmentary. However, linear tooth measurements usually give moderate levels of accuracy in sex identification [3,4].Two approaches to sex identification have been described. The first is based on a visual assessment of the shape or relative proportions of sexually dimorphic features. The second is a metric approach, which offers advantages over the visual approach as it is inherently more objective, has higher reliability, is less dependent on the previous observer experience and is more readily amenable to statistical analysis and thus helps comparisons within the sample as well as with previous studies [5]. The present study was based on the second approach of sex identification and the advantages quoted for the metric method hold good for it too. This study was intended to analyze the sexual dimorphism in the maxillary and mandibular permanent canines. Permanent canines were considered as the canines erupt by the age of 12years with mean age of eruption being 10.87years [6] and canines are less affected than other teeth by periodontal disease [7,8] and are the last teeth to be extracted with respect to age [9]. Canines are also better likely to survive severe trauma, such as air disasters, hurricane and accidents. The present study utilized a Vernier Caliper with 0.01 mm resolution. Since the anatomic landmarks are standardized and the instruments calibrated, little variation may be expected in the measurements. In other words, the values reported may be comparable to previous studies. The measurements were made on the dental casts of all the subjects. It is advantageous to measure the tooth dimensions on the casts as they may be examined at a later date to eliminate errors due to fatigue during

measurements. Also, it provides convenience for the second investigator to make measurements at a later date.

Garn et al. [13] revealed the magnitude of sexual dimorphism in tooth size as well as percentage dimorphism in 117 subjects from Southwest Ohio, representing 75 families. The largest sexual dimorphism in mesiodistal tooth size was exhibited by the mandibular first and second molars, 7% and 6.2%, respectively, with the mandibular and maxillary canines next in order with 6.2% and 6%, respectively. On percentage basis, dimorphism was greatest for canines and least for mandibular incisors. But canine dimorphism was specific to mesiodistal diameter. Mesiodistally the lower canines showed the greatest difference between the sexes.

Lysell and Myrberg [14] studied the records of 530 boys and 580 girls who were born to Swedish parents and grew up in the Stockholm area, and reported expression of sexual dimorphism in the deciduous dentition as well as in the permanent dentition. Boys exhibited larger mesiodistal tooth widths than girls in both deciduous and permanent dentitions. The largest male and female tooth widths were found in permanent canines (5–6%).

Kaushal et al. [15] found a statistically significant dimorphism in the mandibular canines in 60 subjects in a North Indian population, where the mandibular left canine was seen to exhibit greater sexual dimorphism. They also concluded that if the width of the canine is greater than 7 mm, the probability of the sex of the person under consideration being male was 100%.

Hashim and Murshid, [16] conducted a study on Saudi males and females in the age group of 13-20 years to determine the teeth in human dentition with the highest likelihood of dimorphism and found that only the canines in both the jaws exhibited a significant sexual difference while the other teeth did not. In a continuation of the same study, they also determined that there was no statistically significant difference between the left and right sides suggesting that measurements of teeth on one side could be truly representative when the corresponding measurements on other side was unobtainable.

Schield et al. [17] observed sexual difference in tooth size among American black, European and Mongoloid populations. The degree of sexual dimorphism of mandibular canine width was more in Ohio Caucasians and Australian aborigines than in Pima Indians and Tristanite population [11].

Acharya and Mainalli [18] found reverse dimorphism in the mesiodistal dimension of mandibular second premolar in Nepalese population. The finding could be attributed to evolution resulting in a reduction in sexual dimorphism, causing an overlap of tooth dimension in modern males and females. Similar finding was observed by Karen Boaz and Chaavi Gupta [19] in a dimorphic study of maxillary and mandibular canines in 100 subjects in South Indian population and revealed the lack of significant dimorphism in canines and also the finding of reverse dimorphism where the females exhibited larger canines than males.

Madhavi yuwanati et al. [20] conducted a study on 100 cases in 17-21years in central Indian population with mean maxillary canine width in males and females was 8.02mm and the mean mandibular canine width in males and females was 7.73mm.

In this study an attempt has been made to establish the sex of a person by using the mesiodistal width of canine teeth in the Karnataka population.

In our study, there were no significant differences between the mesiodistal width of right and left, mandibular and maxillary canines among males. Similar observations were made among the female counterparts. These findings were in agreement with the studies conducted by Kaushal et al. [15] Garn et al. [11] Al-Rifaiy et al. [21] Acharya and Mainali, [18] and Anderson and Thompson [22].

The mean mesiodistal width of the right and left mandibular canines in our study was found to be greater in males (right: 7.00±0.31mm; left: 7.00±0.32 mm) than in females (right: 6.65±0.55mm; left: 6.65±0.55mm), which was statistically significant with a *P* value of <0.001. This greater dimension of mesiodistal width of canines in males can be attributed to the Y chromosome, which is responsible for the thickness of dentine, contributing to the width of a tooth [18,22] These findings are in agreement with the studies conducted by Kavitha [23] (males: 7.2–7.9mm and females: 6.7–7.6mm) for the Tamil Nadu population (South India), Kaushal et al. [15] (men: right 7.22±0.28mm; left 7.29±0.29mm and women: right 6.69±0.25mm; left 6.69±0.32mm) for the North Indian population and by Acharya and Mainali [18] (Males: right 6.96±0.39mm; left 7.00±0.4mm and Females: right 6.58±0.35mm; left 6.63±0.35 mm) for the Nepalee population on mandibular canines. However, the studies conducted by Ates et al. [24] and Al-Rifaiy et al. [21] on Turkish and Saudi populations did not find significant gender differences for the mesiodistal width of mandibular and maxillary canines.

The value for sexual dimorphism of maxillary canines in our study was 3.947% for the right canine and 3.289% for the left canine similar to the study done by Bakkannavar et al. [25] (3.31% right canine; 3.29% left canine) .The study conducted by Garn et al. on the Tristanite population showed the sexual dimorphism for maxillary canines to be 2.5%, which has lower dimorphic value than our study. However, Garn et al.'s study on different ethnic groups revealed the value to be 4.5% for Australian Aborigines, 5.3% for Pima Indians and 5.9% for Ohio Caucasians [11]. Their study showed the combined value for both canines.

In our study, the value for sexual dimorphism of mandibular canines was 5.263% for the right canine and 5.263% for the left canine as compared to the study done by Bakkannavar et al. (4.50% right canine; 4.61% left canine) [25], Garn et al. on the Tristanite population (4.1%) [11]. Garn et al.'s study further reported the values for sexual dimorphism in Ohio Caucasians (6.4%), Australian Aborigines (6.8%) and Pima Indians (6.3%). The higher sexual dimorphism values, 6.2% (right canines) and 7.7% (left canines), were computed for the South Indian population by Nair et al. [26] and 7.954% for the right canines and 8.891% for the left canines computed for the North Indian population by Kaushal et al. [15]. The higher values obtained in their studies could be attributed to the small sample size and use of dental casts for their study. The mandibular canines are considered to demonstrate the greatest percentage of sexual dimorphism among all teeth in their mesiodistal width [15,11,23].

5. CONCLUSION

The present study measured only linear dimensions because of simplicity, reliability, inexpensibility and in a setup where latest technology utilizing DNA methods are not available and gender estimation has to be managed based on jaw fragments. The mandibular canine index may also be used as an adjunct to enhance accuracy.

5.1 From the Present Study We Can Conclude That

- The mesiodistal width of canines of both the jaws is significantly greater in males than females.
- The mean maxillary canine width in males and females is 7.73mm. The mean mandibular canine width in males and females is 6.825mm.
- The mean (male and female), maxillary and mandibular canine width is found to be less in South Indian Population as compared to Central Indian population.
- The mean (male and female), maxillary and mandibular canine width is found to be less in South India Population as compared to values given by Wheelers and similar to the study done in the Saudi population.

Further investigations are desired with larger samples and in populations of varied ethnic origin in the direction of improving accuracy of using linear dimensions of teeth as a method of sex identification.

CONSENT

Not applicable.

ETHICAL APPROVAL

This study was approved by the Ethical Research Board of the Institution.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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