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The Use of Canine Teeth in the Establishment of Sexual Dimorphism in the Madhya Pradesh (Mahakoushal Region) Population

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Authors' contributions

This work was carried out in collaboration between all authors. Authors Sreedevi, AKN and AD conceptualized and designed the study. Author AD conducted the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors Sreedevi, AKN and NB managed the analyses of the study. Author AD managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Forensic odontology plays an important role in establishing sex, age, and race of unidentified persons. It involves proper handling and examination of dental evidence, thorough scientific specimen evaluation, and an accurate reporting of the dental findings. Teeth can be selectively preserved and fossilized, thereby providing well-preserved records of the evolutionary process for anthropological, genetic, odontologic, and forensic investigations. Therefore, it follows that the canine tooth can be a useful tool in establishing sexual dimorphism.

Aims: The aim of this study was to assess the use of morphometric analysis of the canine teeth in determining gender determination in Madhya Pradesh (Mahakoushal region) population.

Materials and Methods: The present study included 200 subjects (100 males and 100 females)

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with age ranging from 16-28 years. All the subjects who participated in the study were recruited from patients attending the outpatient department at the Hitkarini Dental College and Hospital. It was made sure that who participated in the study were of Madhya Pradesh origin only. Maxillary and mandibular impressions were made using alginate and study models were prepared in dental stone. The mesiodistal width of all canines and inter-canine distances were measured using digital Vernier calipers of 0.01 resolution.

Results: Results showed that mesiodistal width of the right and left maxillary and mandibular canines was greater in males than in females ($p<0.001$). Inter-canine distance of maxillary and mandibular canines was also greater in males than in females ($p<0.001$). The standard mandibular canine index was slightly higher than standard maxillary canine index.

Conclusion: In our study we observed that sexual dimorphism was seen in all four canine teeth. It was most obvious in the mandibular right canine tooth.

Keywords: Forensic odontology; canines; sexual dimorphism.

1. INTRODUCTION

Forensic means legal or relating to courts: A word that comes from Latin, meaning “to the forum” [1]. According to Neilson (1970), Forensic odontology (FO) or forensic dentistry, may be defined as branch of forensic medicine which in the interest of justice, deals with the examination of dental evidence and also with proper handling, proper evaluation, and presentation of the dental findings” [1].

Forensic odontology is also defined as the art and science of dentistry that assists the legal authorities through the evaluation and presentation of dental evidence that is accepted by the court and the general scientific community, to resolve criminal issues and contribute scientific and objective data to legal processes [2]. When only dental structures are the source of information, the anthropologist and the odontologist play a major role in the identification of human remains [3]. Consequently, dentists play a major role in helping authorities with medical and legal issues concerning identification of human remains in civil or criminal cases [4]. Fingerprints, DNA analysis, and dentition examinations all play vital roles in the identification of the victims after any disaster [5]. Dental evaluation plays an important role in victim identification when the skull is the only human remain available [6]. When there is no other information available, the teeth can provide information on the sex of the deceased. The differences between size, stature, and appearance of males and females is referred to as sexual dimorphism.These concepts can also be applied to dental identification. The dentition of two individuals is not similar at any given time [7]. Teeth are excellent material for identification purposes in living and non-living populations as they can withstand fire as well as bacterial decomposition without damage [8]. Of all the permanent teeth, the canines best able to survive severe trauma such as air disaster, conflagration, or hurricane. Therefore, canines can be considered as the “key tooth” n cases of human identification [9,10].

Morphological analysis of teeth, the skull, and soft tissues of the oral and perioral regions along with DNA molecular analysis are the methods used for sex determination [7,11]. The major difference between the teeth of males and females is tooth size. On average, teeth in males, particularly canines, are larger than in females. Mesiodistal and buccolingual widths of the teeth are useful in gender determination [10]. These dimensions, however, can be affected by attrition, interproximal wear facets, crowding, cervical abrasions, and calculus in the cervical region [12]. Understanding and accepting those limitations, we undertook a study to establish sexual dimorphism in the central Indian population (Mahakaushal region) using a canine index.

2. METHODOLOGY

The present clinical study was planned and designed in the department of Oral Medicine and Radiology, Hitkarini Dental College and Hospital, Jabalpur, Madhya Pradesh, India. Ethical clearance was obtained from the college ethical committee. This study was conducted over a period of 2 years from 2014-2016.

All the subjects participating in the study were recruited from patients attending the outpatient department of Hitkarini Dental College and Hospital. A detailed case history was recorded in a specially designed Performa for the study. 200 healthy adult subjects (100 males and 100 females) were recruited based on the following:

2.1 Inclusion Criteria

- Subjects of Madhya Pradesh origin (Mahakaushal region) only.
- Subjects of age group of 16- 28 years (This age group is less susceptible to attrition, abrasion or any periodontal disease).
- Subjects having a healthy gingiva and periodontium.
- Subjects having mandibular canines free from dental caries.
- Subjects having a normal overjet and overbite (2-3 mm).
- Subjects with an absence of spacing in the anterior teeth.
- Subjects having an Angle Class 1 molar and canine relationship bilaterally.

2.2 Exclusion Criteria

Following subjects were excluded from the study

- Subjects with partially erupted or ectopically erupted teeth and missing teeth.
- Subjects with dental or occlusal abnormalities such as rotation, crowding, or occlusal disharmony.
- Teeth showing physiologic or pathologic wear (e.g. attrition, abrasion, abfraction, or erosion).
- Subjects with deleterious habits such as bruxism.

Patients were informed of the study and a written consent was obtained.

A thorough clinical examination of oral cavity was performed with the patient seated upright under proper illumination. Measurements of the mesiodistal (MD) widths of the four canines (maxillary and mandibular) and inter-canine distances (ICD) between the right and left canines of maxilla and of mandible were made using a digital Vernier caliper with a resolution of 0.01 mm (Laboratory Product Co, Ltd.) Amabalacantt, INDIA).

Alginate impressions were then made and casts poured with type III dental stone.

Mesiodistal width (MD)of the four canines and ICD between the right and left maxillary and mandibular canines were measured on the dental casts using digital Vernier calipers with a least count of 0.01 mm (Fig. 1 and Fig. 2). Canine index (CI) was derived as the ratio of the average canine width to the corresponding arch width. Sexual dimorphism was also calculated. A mean value of the CI was calculated for males and females, which were then used to derive the standard maxillary and mandibular canine indices.

Fig. 1. Measuring mesiodistal width of maxillary canine

Fig. 2. Measuring intercanine distance of maxillary canine

The formula given by Garn and Lens (1967) is as follows [6]:

$$\text{Sexual dimorphism} = \left(\frac{Xm}{Xf} - 1\right)^{6}$$

$$\text{Canine index} = \frac{(\text{Mesiodistal width of canine})6}{\text{Inter canine distance}}$$

$$\text{Standard Canine Index} = \left(\frac{\text{Mesiodistal(Mean CI of males} - \text{SD of males)} + \text{(Mean CI of females} + \text{SD of females)/all width of canine}}{2}\right)^{6}$$

Where,

Xm = Mean of MD width of canine's of males
Xf =Mean of MD width of canine's of females
CI = Canine Index
SD = Standard Deviation

Data was entered in Microsoft excel 2016 for Windows. Frequencies, percentages, mean, standard deviation (SD), minimum and maximum values of variables were calculated.

Formulas given by Garn and Lens (1967) [6] were applied for further calculation.

The individuals with CI value less than the standard CI (SCI) were designated as females and those with higher values as males. The estimated gender was then compared with the known gender and percentage accuracy of the determination of sex using standard maxillary and mandibular canine indices were derived. Comparisons of age, mesiodistal (MD) width of canines, inter-canine distances, and the canine index between males and females was performed using unpaired t-test. P value <0.05 was considered statistically significant. Data analysis was performed using version 21.0 of the Statistical Package for Social Sciences (IBM Corporation, Armonk, New York, USA).

3. RESULTS AND DISCUSSION

The mesiodistal (MD) width of the canines in males was greater than that of females. This observed difference was statistically significant (p< 0.001).

In maxillary and mandibular canine index between males and females, the values were significantly higher in males (P < 0.001).

Standard mandibular canine index was significantly higher than the standard maxillary canine index.

Table 1. Comparison of mesiodistal width of right and left maxillary and mandibular canines, maxillary and mandibular inter-canine distance between males and females

Parameters (mm)		Groups		Unpaired t-test
		Males	Females	
Right maxillary canine (13)	Mean ± SD Min- Max	6.64 ± 0.10 6.49-6.94	6.24 ± 0.05 6.12-6.38	t = 36.568, P = 0.000 (<0.001), Sig. diff.
Left maxillary canine (23)	Mean ± SD Min- Max	6.60 ± 0.13 6.16-6.97	6.25 ± 0.08 6.12-6.66	t = 23.214, P = 0.000 (<0.001), Sig. diff.
Maxillary intercanine distance	Mean ± SD Min- Max	32.11 ± 1.78 31.00-37.67	31.32 ± 0.26 30.72-32.00	t = 4.390, P = 0.000 (<0.001), Sig. diff.
Right mandibular canine (43)	Mean ± SD Min- Max	6.32 ± 0.26 5.38-6.76	5.62 ± 0.35 5.21-6.52	t = 16.063, P = 0.000 (<0.001), Sig. diff.
Left mandibular canine (33)	Mean ± SD Min- Max	6.29 ± 0.35 5.60-6.79	5.70 ± 0.36 5.20-6.78	t = 11.957, P = 0.000 (<0.001), Sig. diff.
Mandibular intercanine distance	Mean ± SD Min- Max	23.67 ± 1.75 20.10-29.83	23.04 ± 1.21 20.72-29.72	t = 2.935, P = 0.004 (<0.01), Sig. diff.

Table 2. Comparison of observed maxillary canine index between males and females

Parameters		Groups		Unpaired t-test
		Males	Females	
Maxillary canine index	Mean ± SD Min- Max	0.207 ± 0.009 0.180-0.218	0.199 ± 0.002 0.195-0.202	t = 8.668, P = 0.000 (<0.001), Sig. diff.
Mandibular canine index	Mean ± SD Min- Max	0.268 ± 0.022 0.217-0.323	0.244 ± 0.018 0.180-0.286	t = 8.422, P = 0.000 (<0.001), Sig. diff.

Using maxillary canine index (86%) of males and (76%) of females were correctly predicted. Using mandibular canine index (72%) of males and (70%) of females were correctly predicted.

Table 3. Standard maxillary and mandibular canine index

Standard maxillary canine index	0.200
Standard mandibular canine index	0.254

Table 4. Prediction of gender using maxillary and mandibular canine index

Groups	Cases correctly predicted {n (%)}	
	Maxillary canine index	Mandibular canine index
Male (n = 100)	86 (86%)	72 (72%)
Female (n = 100)	76 (76%)	70 (70%)
Total (n = 200)	162 (81%)	142 (71%)

3.1 Discussion

The Federation Dentaire International stated that forensic odontology deals with identification, based on unique features present in an individual's dental structures [13]. There are various procedures for identification of human remains used in forensic medicine that include: Fingerprinting, physical anthropological examination of bones, serological and genetic (DNA analysis). Procedures used in forensic dentistry include: Rugoscopy, Cheiloscopy, Bite mark analysis, and tooth prints [14]. In the forensic context, sex determination is an important step in building the biological profile of skeletal remains. Determination of sex, to a major extent, can be determined from pelvic bones and skulls [15]. In our comparative dentition size study, the mesiodistal (MD) width of right and left maxillary canines was greater in males than in females. Our results were in agreement with the study conducted by Shireen et al. [16] where the mesiodistal (MD) width of the right and left maxillary canines was found to be greater in males than in females [12]. Tooth dimensions are due to a greater dentinal thickness in males as compared to females. The Y-chromosome increases the mitotic potential of the tooth germ and induces Dentinogenesis; whereas the X-chromosome induces Amelogenesis. Among the maxillary canines, we found that mesiodistal width of right maxillary canines was slightly greater than mesiodistal width of left maxillary canines. Similar to our study Prabhu S et al found that mesiodistal width of right maxillary canine was greater than left maxillary canine [15]. In contrast, Khangura et al found that the mesiodistal width of the left maxillary canine was greater than the right maxillary canine [17]. However, Acharya et al found no difference in the mesiodistal width between the right and left canines [18]. We found that the mesiodistal width of the mandibular canines, bilaterally, consistently exhibited a statistically significant greater dimension in males as compared to females ($P < 0.001$). These findings are similar to the findings found in the study conducted by Rao et al. [19] where subjects exhibited greater sex differences in the mesiodistal crown dimensions of mandibular canines. The mesiodistal width of mandibular canines was slightly higher in males than females. The reason why mesiodistal (MD) dimensions have better sex discriminatory ability could possibly be that these variables are related to the maxillary and mandibular arch dimensions considering the observations that anterio-posterior jaw measurements are statistically larger in males and that arch size influences tooth size. Consequently, one may infer that jaws in males result in correspondingly larger mesiodistal (MD) dimensions. Kaushal et al stated similar results in their study wherein mandibular canines exhibited the greatest sexual dimorphism [20]. In their study, Pramkusam et al found that there were statistical differences in all four canines with the values in males being higher compared to females [21]. This is so because sex chromosomes are also responsible for the different effects on the tooth size, as compared to the 'X' chromosome, the 'Y' chromosome influences the timing and rate of body development, thus producing slower male maturation [12].

Another factor to be considered in our study was the inter-canine distance, which showed greater dimensions in males as compared to females in both maxillary and mandibular dentition. This finding could be attributed to the fact that males, on average, have a larger body structure than females. In addition, sex chromosomes have a marked influence on tooth growth and size. These results were in agreement with the study conducted by Hosmani et al where inter canine distance was marginally higher in males compared to females [22]. Sherfudhin et al. [23] also reported similar observations where the mean value for the canine arch width for females was less than for males.

In our study, the maxillary canine index of the male group had a higher mean value than the

female group. These results were similar to those found in the study by Sabrad et al. [24] where maxillary canine index had a higher mean value in males than females. Likewise in the mandibular dentition, the canine index in males demonstrated higher values than in females. Grover et al reported similar findings in their study [25]. Paramkusam et al. [21] found that, when compared, the mandibular canine index was greater than maxillary canine index.

In our study, when the level of accuracy for sex determination was measured, it demonstrated a value of 86% in males and 76% in females in case of maxillary canines (M>F) and a value of 72% in males and 70% in females in case of mandibular canines (M>F). These results were similar to those reported in studies by Khangura et al and Paramkusam et al wherein they found that the level of accuracy was higher in males than females [17,21]. In contrast, Srivastava et al found that there was a higher accuracy seen in females when compared to males on measurement of mandibular canines [26]. Yuwanati et al. [27] conducted a similar study in which, they concluded that the mesiodistal width of canines in both jaws were significantly greater in males than females and concluded that these findings could be used help in sex determination in the Central Indian population. They also determined that mean values of maxillary and mandibular canine widths for males and females were found to be higher in the Central India population as compared to North Indian and South Indian populations.

There are some limitations of the current study in that the inter-canine arch width requires that all canines and incisors be present in the maxilla and mandible. If one of these teeth is missing the inter-canine arch width and, consequently, the standard canine index cannot be determined. Also, in skeletal specimens, canines may be mobile due to compromised periodontal support. In such instances, the inter-canine arch width measurement and the resulting SCI may be erroneous. Furthermore, the method presented is primarily dependent on the presence of the canine tooth. While this makes the method simple and convenient, if a canine is missing determination of an individual's sex may not be possible or compromised.

4. CONCLUSION

The present study substantiated that canine teeth can be used for human identification and sex determination. Thus, this method can be considered cost effective, easy, unique, and a reliable method to help with human identification. Canine teeth can also be used for sex determination as it has been shown that significant differences exist between males and females in the mesiodistal width and inter-canine distances. In our study we observed that sexual dimorphism was seen in all four of the canines. Dimorphism was more obvious in the mandibular right canine. More studies using larger populations are necessary for establishing sexual dimorphism using canine teeth.

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