

# Sex determination using mesiodistal dimension of permanent maxillary incisors and canines

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## Introduction

Sex determination is one of the important parameters in forensic identification. Teeth being the central component of the masticatory apparatus of the skull are good sources of material for civil and medicolegal identification. Teeth provide resistance to damage in terms of bacterial decomposition and fire when rest of body is damaged beyond recognition which makes them valuable tool in forensic investigation.<sup>[1]</sup>

Sexual dimorphism refers to the systemic difference in the form (either in shape or size) between individuals of

## Abstract

**Background:** Sexual dimorphism refers to the differences in size, shape, etc., between males and females. The dentition's use in sex assessment has been explored and advocated owing to its strength and resistance to peri- and post-mortem insults.

**Objectives:** The study evaluated permanent maxillary incisors and canines for sexual dimorphism and estimated the level of accuracy with which they could be used for sex determination. **Materials and Methods:** The study was conducted on 100 subjects (50 males, 50 females). The mesiodistal dimension of permanent maxillary incisors and canines was measured and the data were subjected to statistical analysis.

**Result:** Univariate analysis revealed that all permanent maxillary incisors and canines exhibited larger mean values of mesiodistal dimension in males compared to females but only canines were found to be statistically significant for sexual dimorphism.

**Conclusion:** The study showed maxillary canines exhibiting significant sexual dimorphism and can be used for sex determination along with other procedures.

**Key words:** Anterior teeth, forensics odontology, mesiodistal dimension, sexual dimorphism

different sexes in the same species. Teeth of various species are known to exhibit sexual dimorphism.<sup>[2]</sup> The dentition in males is larger than in females in contemporary human populations.

Sex determination using dental features is primarily based upon the comparison of tooth dimensions in males and females, or upon the comparison of frequencies of nonmetric dental traits, like Carabelli's trait of upper molars. Mesiodistal and buccolingual diameters of the permanent tooth crown are the two most commonly used and researched features used in determining sex on the basis of dental measurements.<sup>[3]</sup>

Yuen *et al.* conducted a study on mesiodistal dimension of deciduous and permanent teeth of the Southern Chinese population and found that none of the primary teeth nor three of the permanent teeth were found to have significant sex differences in size. Percentage sexual dimorphism ranged from 0.06% to 1.97% for the primary teeth and from 0.36% to 5.27% for the permanent teeth.<sup>[4]</sup>

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The aim of the present study was firstly to investigate whether there is any sexual dimorphism observed between mesiodistal (M-D) dimension of permanent maxillary incisors, canines, and secondly, the accuracy with which these could be employed for the determination of sex in population.

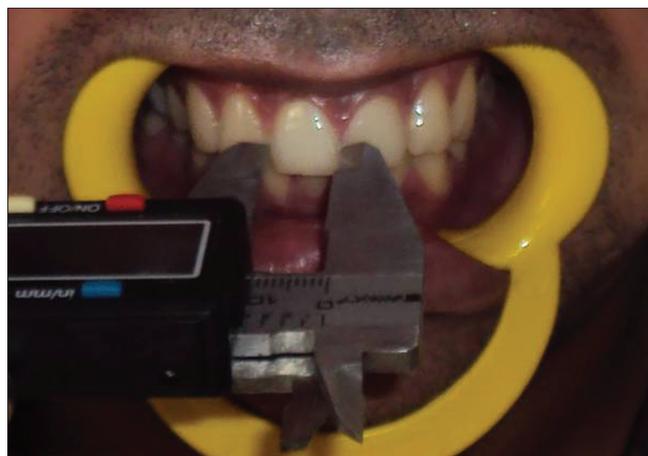
## Materials and Methods

The study sample consisted of 100 dental students (50 males and 50 females) selected from D.J. College of Dental Sciences and Research, Modinagar belonging to North India, who were selected based on the following criteria:

1. Age-20-30 years.
2. Complete set of fully erupted teeth.
3. Peridontally healthy teeth.
4. Noncarious teeth.
5. Nonattrited and intact teeth.
6. Satisfactorily aligned maxillary teeth, no spacing or diastema, and no crowding.
7. No history or clinical evidence of crown restoration, orthodontic treatment, trauma.

After obtaining informed consent, the maximum mesiodistal dimension of each tooth was measured between the anatomic contact points directly on the subject, with the help of a digital vernier caliper accurate to 0.01 mm (Mitutoyo Digital Caliper, Japan) held parallel to the occlusal plane. If it was difficult to place the vernier caliper, manual divider was used with very fine tips to measure the dimension; later we measured the divider distance with the same digital vernier caliper [Figure 1].

All the measurements were done by a single examiner to eliminate interobserver error. Each reading was taken three times and the average of three values was obtained to minimize the intraobserver error. The data thus collected were subjected to statistical analysis. The SPSS software package version 17 was used for statistical analysis. The



**Figure 1:** Measuring the mesiodistal dimension of the maxillary right central incisor clinically on the patient with an electronic vernier caliper

mean, range, and standard deviation were calculated for the size of the teeth. A two-sample *t*-test was used to test for statistical difference between means.

## Results

Table 1 shows detailed description of each tooth selected for study such as a mean value and standard deviation and *P* value both for males and females separately.

Males showed greater mean mesiodistal dimensions for each tooth in comparison to females. Statistical analysis of permanent maxillary incisors and canines showed that the mesiodistal dimensions of only right and left maxillary canines were significantly different in males compared to those in females.

Several stepwise discriminant function statistics have been used to develop formulas to determine sex. The group centroids indicate the average discriminant scores for each sex.

Raw coefficients are the discriminant function coefficients used to calculate the discriminant score. To assess the sex, tooth dimensions are multiplied with the respective raw or unstandardized coefficients and added to the constant. If the values thus obtained were greater than the sectioning point the individual was considered a male and if less than the sectioning point the individual was considered female. i.e.,  $y = a + b(p1) + b(M2)$

where *a* = constant of function between right and left maxillary canines, *b* = unstandardized coefficient of that particular tooth [Table 2].

Tables 3a-c shows the level of determining sex accurately in males and females when right and left maxillary canines are considered separately and in combination respectively.

When the level of accuracy for sex determination was measured using right maxillary canine separately, it was found that 44% females and 54% males were classified correctly whereas when the level of accuracy for sex determination was measured using left maxillary canine separately, 60% females and 60% males were classified correctly. When the level of accuracy for sex determination was measured using right and left maxillary canines together, it was found that 64% females and 58% males were classified correctly.

**Table 1: Mean and SD**

Tooth	Mean value male	Mean value female	SD male	SD female	<i>P</i> value
11	8.57	8.37	0.821	0.526	0.11379
12	6.69	6.69	0.654	0.635	NA
13	7.63	7.38	0.604	0.641	0.051*
21	8.57	8.51	0.521	0.518	0.28448
22	6.8	6.83	0.699	0.678	0.75000
23	7.72	7.45	0.569	0.639	0.028*

SD – Standard deviation, \*values which are significant at 5% level of significance

**Table 2: Canonical discriminant function coefficient**

Tooth	Standardized coefficient	Structure matrix	Unstandardized coefficient	Raw coefficient (constant)	Group coefficient		Sectional point
					Female	Male	
Tooth 13	0.306	0.979	0.492	-13.115	-0.221	0.235	0.0065
Tooth 23	0.751	0.864	1.243				

Table 4 shows the range of the measured mesiodistal dimension of right and left maxillary canines (which shows sexual dimorphism) for both males and females.

**Percentage of dimorphism**

The percentage of dimorphism is defined as the percentage by which the tooth size of males exceeds that of females. The percentage of dimorphism for each tooth was calculated using the following formula:

$$\text{Percentage of dimorphism} = \{(X_m/X_f)-1\} \times 100$$

where  $X_m$  = mean male tooth dimension;  $X_f$  = mean female tooth dimension. Table 4 shows percent of dimorphism as observed for right and left maxillary canines.

**Discussion**

Gender determination in damaged and mutilated dead bodies or from skeletal remains constitutes the foremost step for identification in medico-legal examination and bioarcheology. Whenever it is possible to predict the sex, identification is simplified because then missing persons of only that sex need to be considered.<sup>[2]</sup>

Although the DNA profile gives accurate results yet measurement of linear dimensions such as arthropometric or odontometric parameters can be used for determination of sex in a large population because they are simple, reliable, inexpensive, and easy to measure.

Considering the fact that there are differences in odontometric features in specific populations, even within the same population in the historical and evolutionary context, it is necessary to determine specific population values in order to make identification possible on the basis of dental measurements.<sup>[3]</sup> Thus the study evaluated mesiodistal dimension of permanent maxillary incisors and canines specific for males and females of the North Indian population.

Doris *et al.* have indicated that the early permanent dentitions provide the best sample for tooth size measurements because early adulthood dentition has less mutilation and less attrition in most individuals. Consequently, the effect of these factors on the actual mesiodistal tooth width would be minimum.<sup>[5]</sup> Thus only subjects in the 20-30 years' age group were included in the study sample.

**Table 3a: Accuracy of determination of sex using teeth 13**

Sex	Correctly classified		Misclassified	
	No.	% Age	No.	% Age
Female	22	44.00	28	56.00
Male	27	54.00	23	46.00
Total	49	49.00	51	51.00

**Table 3b: Accuracy of determination of sex using teeth 23**

Sex	Correctly classified		Misclassified	
	No.	% Age	No.	% Age
Female	30	60.00	20	40.00
Male	30	60.00	20	40.00
Total	60	60.00	40	40.00

**Table 3c: Accuracy of determination of sex using teeth 13 and teeth 23**

Sex	Correctly classified		Misclassified	
	No.	% Age	No.	% Age
Female	32	64.00	18	36.00
Male	29	58.00	21	42.00
Total	61	61.00	39	39.00

**Table 4: Percent of dimorphism**

Tooth	Mean ±SD		P value	% Dimorphism
	Male	Female		
13	7.63±0.604	7.38±0.641	0.051	3.39
23	7.72±0.569	7.45±0.639	0.028	3.62

Various odontometric dimensions have been used for the purpose of sex estimation such as mandibular canine index,<sup>[6]</sup> buccolingual dimension of teeth,<sup>[7]</sup> and height of tooth.<sup>[8]</sup>

In this study, all the required dental measurements were taken directly on the subjects. As it was difficult to accurately measure the buccolingual width, of maxillary incisors, and canines, under indirect vision, only the mesio-distal width of these teeth was evaluated for sexual dimorphism.

Univariate analysis of the study showed that M-D dimensions of male dentition are greater than those of females which is in accordance with previous studies. Richardson *et al.* found that teeth of males tend to be larger than those of females for each type of tooth in both the arches.<sup>[9]</sup> Sanin and Savara reported differences in crown

size patterns even among good occlusion cases.<sup>[10]</sup> Howe *et al.* in their study found combined mesiodistal width for males to be more compared to females.<sup>[11]</sup>

In this study, statistically significant dimorphism was exhibited by only two permanent maxillary anterior teeth, i.e., right and left maxillary canines. The Hashim and Murshid study in 1993 also showed that the canines were the only teeth to exhibit sexual dimorphism.<sup>[12]</sup>

Garn *et al.*, studied the magnitude of sexual dimorphism by measuring the mesiodistal width of the canine teeth and showed that "the mandibular canine showed a greater degree of sexual dimorphism than the maxillary canine."<sup>[13]</sup> However, Minzuno reported that maxillary canine showed a higher degree of sexual dimorphism compared to the mandibular canine in a Japanese population.<sup>[14]</sup>

Maxillary left canine in the study conducted by Pratibha *et al.* also exhibited a sexual dimorphism which is in accordance with the studies conducted on Turks by Iscan.<sup>[15]</sup> A study conducted by Otuyemi and Noar<sup>[16]</sup> shows dimorphism in maxillary canines bilaterally and another by Lund and Monstad<sup>[17]</sup> shows dimorphism of maxillary canine.

The multivariate analysis of the data showed that when combination of values for right and left maxillary canines was taken 64% females were classified correctly and 58% males were classified correctly. However the study conducted by Al-Rifaiy showed that an average of 65.5% individuals could be classified correctly.<sup>[18]</sup>

Various theories have been given to explain canine dimorphism.

1. According to Moss, it is because of the greater thickness of enamel in males due to the long period of amelogenesis compared to females.<sup>[19]</sup>
2. Because of Y chromosomes producing slower male maturation.<sup>[20]</sup>

The variation in the magnitude of dimorphism can be a result of various factors. Some authors have explained that such variation could be due to environmental influences on tooth size. Variation in food resources exploited by different populations has been explained as one such environmental cause. Others have suggested the interference of cultural factors with biological forces. There can be a complex interaction between a variety of genetic and environmental factors that are responsible for the variation in the magnitude of dimorphism. According to Garn *et al.*, teeth have behaved in many ways through the course of evolution, ranging from reduction of the entire

dentition to reduction of one group of teeth in relation to another.<sup>[21]</sup>

## Conclusion

The study evaluated the use of a linear dimension (mesiodistal) of permanent maxillary incisors and canines because of simplicity and reliability. The study showed that right and left maxillary canines can be used for sex determination with 64% of accuracy in the case of females and 58% accuracy in the case of males. Thus this study indicates that maxillary canines show significant sexual dimorphism and can be used as an adjunct along with other accepted procedures for sex determination when fragmentary remains are encountered in mass disasters.

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## Announcement

### 9<sup>th</sup> National Conference of IAFO, Salem



The 9<sup>th</sup> National conference of Indian Association of Forensic Odontology was held on the 22<sup>nd</sup> and 23<sup>rd</sup> of October 2011 in the Vinayaka Missions University campus, Salem. The two days conference was hosted by the Vinayaka Missions University and was organized under the guidance of Dr. R. Thiruneervanan, M.D.S., Principal, Vinayaka Missions Sankarachariyar Dental College, the organizing chairman, and by faculty of Oral Pathology, headed by the conference secretary, Dr. S. Murali, M.D.S., Professor and Head, Oral Pathology.

The conference was venerated by eminent professor, Dr. P. Chandrashekar, Pro Vice Chancellor, National Law University, Jodhpur, veteran in the field of forensic sciences, who delivered the keynote address, Dr. B.S. Bagi, President, with other administrative members of IAFO, Dr. Ashith Acharya, Secretary, Dr. B. Sivapathasundaram, Editor-in-chief, *Journal of forensic dental sciences*, Dr. Raji Viola Solomon, Treasurer and Dr. S. Balagopal, President Elect. The conference also comprised of orations by the distinguished guest speakers, Prof. Dr. P. Chandrasekharan on lip prints, Dr. V. Vijayanath, Assoc Prof of Forensic Medicine, VMKVC, Salem on Forensic view on Forensic odontology and Prof. DR. T. Samraj, academic co-ordinator, Penang International Dental College, Salem, on consent for research.

Virtually 40 dental institutions throughout India, with an overwhelming registration of more than 500 delegates from various specialties of dentistry had participated in the conference. Over 135 scientific expositions, comprising of 95 papers and 40 posters were presented, based on the theme of the conference "Track the tooth – crack the crime". A panel of discussion had also taken place with conglomerate of specialists (Dr. B. Sivapathasundaram, Dr. P. Chandrashekar, Dr. Subba Rao, Dr. S. Balagopal, Dr. Ashith Acharya) to address contemporary issues in the field of forensic science. The conference was highly beneficial to students aspiring to specialize in forensic science and channel them in the right direction to pursue their dream.