Sex Determination Using Canine Dimorphism: Forensic Relevance

Zoya Kalim and Renu Tyagi*

Department of Anthropology,University of Delhi, India

*Corresponding author: Renu Tyagi, Department of Anthropology,University of Delhi, Forensic Science Section, India,
Email: renutyagiindia@gmail.com

Abstract

Aims and Objectives: Human body has various morphological variations among males and females thus, inthe cases of forensic relevance; sexual dimorphisms play an important role in gender determination of an individual. Teeth are the hardest and chemically most inert part of the human body and it resists putrefaction and decay and thus making it forensically relevant as evidence. The study is aimed at determining if there is any canine dimorphism in both the genders and also determining the percentage of dimorphism along with the quadrant that shows maximum dimorphism among males and females.

Materials and methods: This study was conducted on 101 respondents (50 females and 51 males) in the age group of 18-35 years. Canine measurements including mesio-distal, buco- lingual and inter canine distances were measured on each respondent. Statistical tests were conducted to study the gender dimorphism.

Results and Conclusion: Sexual dimorphism was reported in the canine measurements with males having greater canine dimensions as compared to the females.

Keywords : Forensic science; Canines; Gender dimorphism; Evidence; Identification

Introduction

Gender estimation is an important aspect of personal identification and thus, has an immense forensic relevance. When an unidentified human body is encountered at a crime scene, it becomes important to establish its identity, for further legal procedures and also to hand over the body to its authorized family. The personal identification is established by determining the gender, age, stature and race of an individual followed by individual features identification. The gender estimation being an important part of personal identification needs to be determined first. This is a crucial step in establishing the personal identity of an individual, because the age and stature determination is dependent on the gender of the individual. The process of personal identification begins by narrowing down a cluster of individuals step by step till the individual we are looking for is finally identified. Thus, the role of sexual dimorphism comes into play. Secondary sexual characteristics are one of the most easy and frequently used methods. However, it should[1-6].Canines and sex determinationbe kept in mind that in certain cases, the body encountered may be decomposed beyond recognition or may be mutilated, where secondary sexual characteristics may play no role. Hence, with forensic aspect, the dimorphism in the teeth can be of immense significance. It may be a great forensic tool for the determination of sex from the human remains,

because it is highly resistant to decay. In 1973, a study established certain differences in the canine teeth of both the human genders. [1] Subsequently, two more studies conducted in the year 1967 and 1989 respectively, further established the canine dimorphism among both the human genders.
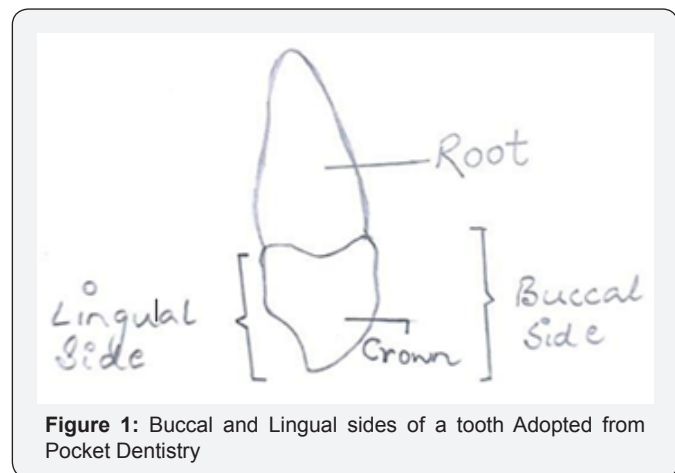
Canine is one of the most strongest and stable teeth among all other teeth, due to its shape, structure and the length of the root. Also, its position in the mandible and maxilla, and the presence of a single cusp makes it less prone to damage, or cavity formation. Thus, makes the canine teeth even more forensically relevant. The teeth being resistant to decay can be used as a forensic tool for the purpose of identification of individuals by narrowing down the search. Canines are the least extracted teeth and hence, are recovered from almost every mandible and maxilla. Canine teeth rarely contain any cavity, hence, does not interfere with the measurements. In cases of mass disaster, explosions etc. where the body is damaged beyond recognition, gender estimation from canine teeth may help narrow down the vast list. Bodies that are putrefied or completely skeletonized body may lack evidences for identification. Hence, teeth can be effectively used asevidence. Studies conducted in last one decade, used the mandibular canine dimensions for sex determination.

research conducted in the year 2009 to study and determine the dimorphism in human maxillary and mandibular canines in establishment of gender concluded statistically insignificant dimorphism. [7] Sexual dimorphism using canine measurement was reported in Gujarat population. This study concluded that sexual dimorphism was observed in mesio-distal width, canine arch width and canine index of permanent maxillary canine teeth and that sexual dimorphism in mesio-distal width and canine index is highly significant in right maxillary canine. [8] The mandibular anthropometric measurements were assessed to predict the gender in Iranians over the age of 20 years. The results of this study showed that the gender can be predicted with high rate of accuracy from mandibular measurements. [9] In another study, the mandibular canine and the canine index were used for the gender estimation. [10] Further, a research conducted in the year 2016, on sexual dimorphism in tooth morphometric using all teeth (i.e., incisors, canine, pre-molars and molars) concluded that the permanent maxillary canine showed significant dimorphism and could be effectively used for gender identification. [11] In (2017) a study conducted to assess the accuracy of mandibular canine index (MCI) and mandibular mesio-distal econometrics for sex estimation which concluded that canine dimorphism is population specific and among the Indian population, canine dimorphism can aid in sex determination. [12]Another study concluded that using the standard MCI, the gender estimation was found to be 73.33% in males and 80% in females. Canines and sex determination[13].
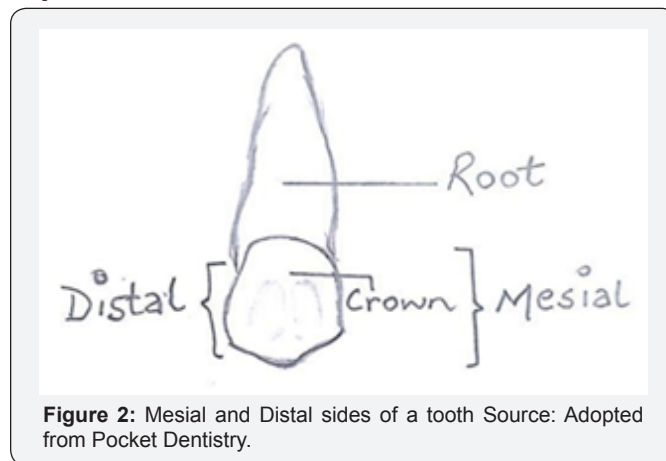
Methodology

The present study was conducted to estimate the gender dimorphism in canine measurements in the healthy Indian adult subjects, belonging to the age group of 20-35 years. The data and measurements was collected from the respondents with a sample size of 101 individuals, including 51 males and 50 females. The sample pool belonged to mixed population belonging to different ethnic groups. The work was done in accordance with the appropriate institutional review body and carried out with the ethical standards.

Tools and Techniques

Figure 1: Buccal and Lingual sides of a tooth Adopted from Pocket Dentistry

A pilot survey was conducted among 20 respondents prior to the main research data collection. This was done to standardize tools and techniques to be used for the final data collection. A purposive sampling was done on 51 males and 50 females aged between 20 years to 35 years. The individuals of this age group were chosen, since the teeth of such individuals show minimum attrition and thus will provide accurate results. An ethical approval was taken to conduct the study. A consent form was duly signed by the respondents prior to start the study, to take their consent to volunteer for the study after explaining the objectives of the study to them. The measurements of the canine teeth were taken by the instrument- sliding caliper. Dimensions studied were mesio-distal width, buco- lingual width and inter-canine distance of mandibular and maxillary canine (Figures 1&2). The Mesio-distal width was measured between the mesial surface and the distal surface of the canine teeth. Buco- lingual width was measured as the distance between buccal surface and lingual surfaces of a tooth.Inter-canine distance of mandibular and maxillary canine was measured as the distance between the two canines in the maxilla (upper jaw) and the mandible (lower jaw). The reading was noted down for each dimension(Figures 1&2). Respondents with canine teeth free of any decay, or any medical deformity/treatment were taken. Adequate precautions were followed for these measurements. Before initiating the process of measurement in the oral cavity, the extensions (bars) of the sliding caliper was carefully cleaned with Savlon to sterilize it from any kind of harmful germs and bacteria from the previous respondent.

Figure 2: Mesial and Distal sides of a tooth Source: Adopted from Pocket Dentistry.

The same cleaning procedure for the instrument was followed after measurements were taken. This was done for each respondent before and after the measurement.After the collection of data, it was entered in MS Excel sheet. It was then analyzed using Statistical Package for Social Sciences (SPSS, 17.0). Student t-test and logistic regression was used for the analysis of the data. Garn and Levis Formula were used to calculate the percentage of dimorphism[14]. Thus, this formula helps isCanines and sex determinationestimating whether the canine measurements, among the males and females, are significantly dimorphic or not and also to determine the percentage of dimorphism. Garn and Lewis Formula for gender dimorphism is as follows-(-)

Where,

= Mean value of measurement for males,

= Mean value of measurement for females

This formula was applied individually to each set of dimensions i.e. Mesio Distal width, and Buco Lingual width (of each quadrant), and the Inter- Canine distance of the Mandible and the Maxilla. The limitation of this study is that the Vernier caliper was the preferred instrument in terms of accuracy. However, sliding caliper was used to measure the dimensions. The sample distribution has been displayed as Table 1.

Table 1: Sample population frequency distribution.

Respondent	Frequency (n)	Percentage (%)
Male	51	50.5
Female	50	49.5
Total	101	100

Result and Discussion

Table 2: t- Test result of the canine measurements.

S.No.	Dimensions	Mean ± SD		t- Test
		Male	Female	
1	(R) Ma. Mesio-Distal Width	0.68±0.09	0.62±0.08	3.31***
2	(R) Ma. Buco-Lingual Width	0.42±0.07	0.41±0.07	0.74 NS
3	(L) Ma. Mesio- Distal Width	0.69±0.07	0.63±0.06	3.85***
4	(L) Ma. Buco- Lingual Width	0.41±0.08	0.39±0.09	0.97 NS
5	(R) Mx. Mesio- Distal Width	0.70±0.09	0.69±0.08	0.48 NS
6	(R) Mx. Buco- Lingual Width	0.49±0.09	0.49±0.12	0.33 NS
7	(L) Mx. Mesio- Distal Width	0.64±0.09	0.62±0.09	1.06 NS
8	(L) Mx. Buco- Lingual Width	0.50±0.09	0.47±0.11	1.37 NS
9	Ma. Inter Canine Distance	3.24±0.23	3.09±0.20	3.33***
10	Mx. Inter Canine Distance	3.99±0.30	3.75±0.28	4.11***

***P<0.001; NS- Non Significant; Note: (R) and (L) is the right and left quadrant respectively of the jaw. Ma: mandible/lower jaw; Mx: maxilla/upper jaw.

The present study used the canine measurements to establish the gender dimorphism among human population. The test for significance was applied on all the measurements taken, i.e., the buco-lingual and mesio-distal width of the canine teeth of all the four quadrants and the inter-canine distance of the mandible and the maxilla. According to Table 2, the present study shows significant dimorphism in the mesio distal width of the right and left mandibular canines and the mandibular inter canine distance. This table suggests significant dimorphism at p<0.001, for all the studied measurements (Table 2). Thus, according to the results of the t-test, it can be concluded that the mandibular canines are significantly sexually dimorphic with respect to the mesio-distal width and the Inter-canine distance. This finding is in accordance with the previous finding which suggests that male and female canines are significantly dimorphic and also concluded that the greatest dimorphism is exhibited by the left canine. [10] Another study on canine dimorphism also suggests significant difference in the mesio distal width measurement of mandibular canine [5] (Table 3).

Table 3: Calculated percentage dimorphism in the mandibular and maxillary canine (in percentage).

	Right Mesio-Distal Width	Right Buco-Lingual Width	Left Mesio-Distal Width	Left Buco-Lingual Width	Inter-Canine Distance
Mandibular Canine	8.87	2.54	8.091	4.2	4.72
Maxillary Canine	1.13	1.45	3.22	6.38	6.32

Canines and sex determinationAccording to Garn and Lewis [2], the percentage of dimorphism (among males and females) in the canine teeth was calculated. (Table 3) suggests that males have broader individual teeth dimensions and also wider distance between both the canine teeth of the mandibular jaw, as compared to the females. The table shows that the mesio-distal width of the right and left mandibular canine shows maximum dimorphic percentage at 8.87% and 8.09% respectively, as compared to the percentage dimorphism for other mandibular canine dimensions. Similarly, the percentage of dimorphism in mesio distal width of the right mandibular canine was found to be 10.11% and 4.44% in the left mesio distal canine width[15] The present study was found to be similar in terms of percentage dimorphism in mesio-distal measurement of the right mandibular canine width, with percentage dimorphism at 8.87≈10.11. However, percentage dimorphism for the mandibular left mesio distal width was found to vary in the present study.Left buco-lingual width of the canine and inter canine distances of the two canines in the upper jaw shows maximum dimorphism. The percentage dimorphism of Buco-Lingual Width of the Left canine teeth and Inter Canine distance shows a value greater than 5%, i.e., 6.38% and 6.32%, respectively (Table 3).

The other canine dimensions of the maxilla do not show significant percentage of dimorphism among males and females, with the percentage dimorphism for Mesio-Distal Width, Buco-Lingual width of the right canine and Mesio Distal Width of the left canine being 1.131%, 1.45%, and 3.22%, respectively. The mandibular canines show greater dimorphism as compared to the canines of the maxilla (Table 3). Further, it suggests that the canine of the right mandible shows greater percentage of dimorphism with respect to mesio-distal width measurement among males and females. However, it was established that the left mandibular canine shows maximum sexual dimorphism with

percentage dimorphism of 7.7%, followed by right mandibular canine with percentage dimorphism of 6.2%. [16] Similarly, another study also suggested that the left mandibular canine was more dimorphic with a percentage of 8.89% followed by the right mandibular canine with a percentage dimorphism of 7.44%. [17] A study similar to the present study reported that the percentage dimorphism for the left mandibular canine is 9.79% followed

by the right mandibular canine with a dimorphism percentage of 7.96%. [10]The logistic regression analysis revealed that the likelihood of being males is about 3 times more with respect to Buco-Lingual Width of the right maxilla and about twice more for the Buco-Lingual width of the right mandible and Mesio-Distal width of the left maxilla.

Table 4: Multinomial logistic regression for gender differentiation.

Male	Std. Error	Sig	Exp (B)	95% Confidence Interval for Exp (B)	
				Lower Bound	Upper Bound
Intercept	1.199	0.064			
Ma. (R) Mesio Distal Width	0.57	0.766	0.844	0.276	2.577
Ma. (R) Buco- Lingual Width	0.636	0.459	1.602	0.461	5.571
Ma (L) Mesio Distal Width	0.603	0.003	0.166	0.051	0.54
Ma. (L) Buco- Lingual Width	0.672	0.152	0.382	0.102	1.424
Mx.(R) Mesio Distal Width	0.565	0.688	0.797	0.263	2.411
Mx. (R) Buco- Lingual Width	1.007	0.313	2.76	0.383	19.875
Mx. (L) Mesio Distal Width	0.566	0.316	1.763	0.582	5.341
Mx. (L) Buco-Lingual Width	0.798	0.302	0.439	0.092	2.096
Ma. Inter Canine Distance	0.671	0.58	0.69	0.185	2.571
Mx. Inter Canine Distance	0.583	0	0.103	0.033	0.323

Therefore, these three measurements were found to be important with respect to gender identification (Table 4), (Figure 3)[18,19]The Mandible shows highest percentage of dimorphism in the Mesio distal width of the right and left canine, the buco-lingual width of both the mandible and the maxilla show insignificant level of dimorphism. The inter-canine distance of both the mandible and the maxilla show some percentage dimorphism, with the maxillary inter-canine dimorphism being greater than

the mandibular inter canine dimorphism (Figure3). Forensic anthropological techniques are usually applied as supporting and supplementary methods, with final identification ultimately being based on forensic odonatological analyses, fingerprinting, and DNA-techniques.In a few instances, forensic anthropological methods may also by themselves achieveidentification and therefore continued testing of anthropological methods for evaluating sex is of paramount importance [20].
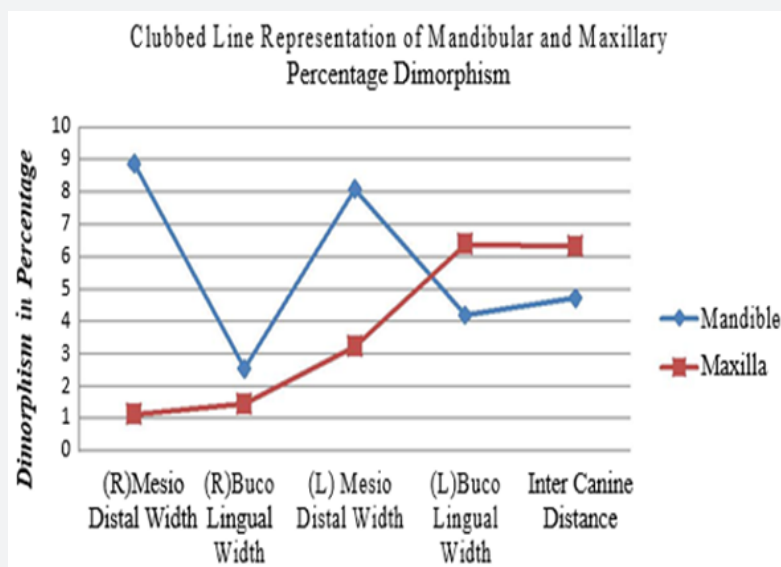

Figure 3: Percentage dimorphism of the mandible and the maxilla.

Conclusion

The Mesio distal width of the right and left mandibular canine, inter-canine distance in the mandible and the maxilla showed

statistically significant dimorphism among males and females. However, the greatest percentage of gender dimorphism was found in the medio distal width of the right mandibular canine

followed by the Mesio distal width of the left mandibular canine .The inter canine distance showed higher significant percentage dimorphism in the maxilla as compared to the mandible. It can be concluded that the ozonometric parameters being simple, inexpensive and easy to measure can be used for determining gender in relevant cases of forensic investigations.

References

1. Anderson DL, Thompson GW (1973) Interrelationships and sex differences of dental and skeletal measurements. Journal of Dental Research 52(3): 431-438.

2. Garn SM, Lewis AB, Kerewsky RS (1967) Buccolingual size asymmetry and its developmental meaning. The Angle Orthodontist 37: 186-193.

3. Rao NG, Rao NN, Pai ML, Kurian MS (1989) Mandibular canine index-a clue for establishing sex identity. Forensic Science International 42(3): 249-254.

4. Reddy M Vandana, Saxena Susmita, Bansal (2008) Mandibular canine index as a sex determinant: A study on the population of western Uttar Pradesh. Journal of Oral and Maxillofacial Pathology 12(2):56-59.

5. Nagesh KS, Iyengar R Asha, Kapila Rishabh, Mehari Sushma (2011) Sexual dimorphism in human mandibular canine teeth: A radio-morphometric study. Journal of Indian academy of oral medicine and radiology23(1):33-35.

6. Davoudmanesh Zeinab, Shariati Mahsa, Azizi Nasim, Remained Saeed, Hozhabr,et al.(2017) Sexual dimorphism in permanent canine teeth and formulas for sex determination. Biomedical Research 28(6):2773-2777.

7. Boaz Karen, Gupta Chhavi. (2009)Dimorphism in human maxillary and mandibular canines in establishment of gender. Journal of forensic dental sciences 1(1):42-44.

8. Parekh H Dhara, Patel VS, Malasada ZA, Patel MS (2012) Odontometric Study of Maxillary Canine Teeth to Establish Sexual Dimorphism In Gujarat Population. International Journal of Biological and medical research 3(3): 1935-1937.

9. Akilah Mitra, Vasigh Shayesteh, Khalighi Zahra, Yousefinejad Vahid (2014)The value of mandible measurements in gender prediction for the Iranian adult population. Australian Journal of Forensic Sciences46(2):127-135.

10. Bashir Taseer,Kandakurti Srinivas,Gupta Jyoti,Sachdeva SArti,Ahmad Naeem, et al.(2016) Use of mandibular canine index as a tool in gender dimorphism: A phenotypic study. Journal of Indian Academy of oral medicine and radiology 28(4):386-390.

11. Banerjee Abhishhek, Kamath V Venkatesh , Satelur Krishnan, Rajkumar Komali, Sundaram Lavanya (2016)Sexual dimorphism in tooth morphometrics: An evaluation of the parameters.JForensic Dent Sci 8(1): 22-27.

12. Kumawat MRamniwas,Dindgire L Sarika,Gadhari Mangesh,Khobragade G Pratima,Kadoo SPriyanka, et al. (2017) Mandibular canine: A tool for sex identification in forensic odontology.J Forensic Dent Sci 9(2): 109.

13. Gandhi Neha, Jain Sandeep, Kahlon Harkiranjot, Singh Arshdeep, Gambhir Singh Ramandeep, et al.(2017)Significance of mandibular canine index in sexual dimorphism and aid in personal identification in forensic odontology. Journal of Forensic Dental Sciences 9(2): 56-60.

14. Garn SM, Lewis AB, Swindler DR,Kerensky RS(1967) Genetic control of sexual dimorphism in tooth size. Journal of Dental Research 46(5):963-972.

15. Grover Maneel, Bal R Girja, Ram Tharaka, Puri Pooja Malik, Ghodke Kanchana R(2013)Anodontologist's key to sex determination: Study analysis of mandibular canine teeth in South Indian population. Journal of Orofacial research 3(3):157-160.

16. Nair P, Rao BB, Annigeri RG (1999) A study of tooth size, symmetry and sexual dimorphism. Journal of Forensic Medicine and Toxicology 16(2):10-13.

17. Kaushal S, Patnaik VG, Agnihotri G(2003) Mandibular canine in sex determination. J Anat Soc India52(2):119-124.

18. Reppien K, Sejrsen B, Lynnerup N (2006) Evaluation of post-mortem estimated dental age versus real age: A retrospective 21-year survey. Forensic Science International 159(1): S84-88.

19. Andersen L, Lynnerup N (2008) Unidentified bodies brought to the Section of Forensic Pathology, University of Copenhagen. Scandinavian Journal of Forensic Science14(1):10-13.

20. Lynnerup N(2013) Forensic anthropology and human identification. Scandinavian Journal of Forensic Science19(1): 16-38.

Your next submission with Juniper Publishers
will reach you the below assets

- Quality Editorial service
- Swift Peer Review
- Reprints availability
- E-prints Service
- Manuscript Podcast for convenient understanding
- Global attainment for your research
- Manuscript accessibility in different formats
  (Pdf, E-pub, Full Text, Audio)
- Unceasing customer service

Track the below URL for one-step submission
https://juniperpublishers.com/online-submission.php