Original Article

Significance of Mandibular Canine Index in Sex Determination

Aarathi Vijayan, Jayanth Jayarajan[1], Bushra Naaz Fathima Jaleel[2]

From the Departments of Public Health Dentistry and [2]Orthodontics, Azeezia College of Dental Sciences and Research, Kollam, Kerala, [1]Department of Public Health Dentistry, Oxford Dental College, Bengaluru, Karnataka, India

ABSTRACT

Background: Mandibular canines exhibit greatest sexual dimorphism compared other teeth in the oral cavity. Morphometry of Mandibular Canine plays a major role in sex determination in case of mass disaster.
Aim: This study was aimed to compare mesiodistal canine measurements in male and female.
Materials and Methods: This study was conducted among 100 undergraduate dental study with 50 male and 50 female participants. A study model of the mandibular arch were made and the canine measurements (MCI) were obtained using a divider and ruler.
Results: There was a significant difference in the mesiodistal and intercanine width of right and left canine among males and females. The mean difference in mandibular canine index was highly significant among gender and on both sides (right and left).
Conclusion: Determination of gender by mesiodistal measurement of mandibular canines is a relatively quick, easy, and inexpensive method and can aid in identifying persons from fragmented jaws and dental remains.

KEY WORDS: *Forensic odontology, mandibular canines, sex determination*

INTRODUCTION

Teeth are an excellent material in living and nonliving populations for anthropological, genetic, odontologic, and forensic investigations. These 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. Their durability in the face of fire and bacterial decomposition makes them invaluable for identification.

"Sexual dimorphism" refers to those differences in size, stature, and appearance between males and females that can be applied to dental identification because no two mouths are alike. Gender determination of skeletal remains is part of archeological and many medicolegal examinations.[1] The methods vary and depend on the available bones and their condition. The only technique that can give a totally accurate result is the DNA technique, but in many cases, for several reasons, it cannot be used. Anthropological measurements of the skeleton and the comparison with existing standard data must then be applied and may help to differentiate between male and female remains.

On an individual basis, however, gender differences are not always distinctive. But taken collectively, they can give a good indication in majority of the cases. When jaws are at hand, teeth may be used for gender determination with the aid of odontometric analysis. Odontometry has been performed on various tooth groups with the objective of establishing measurements that can act as standards. This information would facilitate some procedures in dental surgery and also be extremely useful in forensic odontology. In addition to determination of age, sex can also be determined from the teeth.

The size of the teeth is of great importance, not only to indicate the different activities related to occlusion or to determine the frequency of dento-osseous anomalies applied to orthodontic treatment but also to establish sexual dimorphism. Out of the two proportions, width and length, the former is considered to be more important.

Mandibular canines are found to exhibit the greatest sexual dimorphism among all teeth. The mandibular canines have a mean age of eruption of 10.87 years. The canines are not only exposed to less plaque, calculus, abrasion from brushing, or heavy occlusal loading from other teeth, they are also less severely affected by periodontal diseases, and hence, are usually the last teeth to be extracted with respect to age. Canines are also better likely to survive severe trauma such as air disasters, hurricanes, or conflagration. These findings indicate that mandibular canines can be considered as the "key teeth" for personal identification.[1]

1. The identification of sex is of significance in case of major disasters where bodies are often damaged beyond

Address for correspondence:
Dr. Aarathi Vijayan, E-mail: aarathivijayan123@gmail.com

Access this article online

Quick Response Code:

Website: www.ijofo.org

recognition. Numerous studies have employed Mandibular Canine Index (MCI) in sex determination, as it is simple, reliable, inexpensive, and easy to perform.[2] The present study establishes the impact of the "sex factor" on the morphometry of the mandibular canines. Hence, the present study was undertaken to investigate the accuracy with which gender can be differentiated by using the MCI and to correlate with other studies. The objectives were as follows:

- To establish the gender using the MCI
- To compare the differences between the mesiodistal (right and left) canine measurements in male and female
- To compare the intercanine distance between male and female.

MATERIALS AND METHODS

The present study was a cross-sectional study conducted on undergraduate students studying in The Oxford Dental College, Bengaluru.

The study population involved the undergraduate students of The Oxford Dental College. 100 students (50 males and 50 females) in the age group of 18–25 years were randomly sampled.

INCLUSION CRITERIA

Individuals with following status of teeth were included in the study:-
- Healthy state of gingiva and periodontium
- Caries free canine teeth
- Normal overjet and overbite (2–3 mm)
- Absence of spacing in the anterior teeth
- Class 1 molar and canine relationship.

EXCLUSION CRITERIA

- Presence of partially erupted/ectopically erupted teeth
- Patients with dental/occlusal abnormalities (such as rotation, crowding, and occlusal disharmony)
- Teeth showing physiologic or pathologic wear and tear (e.g., attrition, abrasion, erosion etc.)
- Patients with deleterious oral habits (like bruxism).

The pro forma used for the study contained questions regarding the demographic details (age, gender, date of birth, etc.) required for the study. The canine measurements needed for the study was recorded on the pro forma.

Ethical clearance to conduct the study was obtained from the Institutional Review Board, The Oxford Dental College and Research Centre, Bengaluru. Before start of the study, all the students were informed about the study and written informed consent was obtained from them.

TRAINING AND CALIBRATION OF THE EXAMINER

For the purpose of training for recording, ten sets of study models were made of dental stone after making impressions from ten volunteers. The various parameters required were measured from these casts from the Department of Public Health Dentistry under the guidance of the staff.

The findings recorded by the investigator and the staff were subjected for analysis. The results were obtained using Kappa statistics. The Kappa coefficient value (K) for interexaminer reliability for the examiner was 0.85 and 0.95 for the mesiodistal canine measurements and intercanine distance, respectively, and for intraexaminer variability, it was 0.82 for canine measurements and 0.94 for intercanine measurement. The values reflected high degree of conformity in observations.

Before commencing the study, a pilot study was performed in the month of May 2012 on 10% of the sample size taken for the main study. It served as a preliminary study to identify any organizational problems and to have a prior idea regarding the estimate of the time required for each student.

The sample consisted of ten students. The investigator recorded all the measurements from the casts that were made. No major modifications were made in the main study after the pilot study. Participants from the pilot study were not included in the main study.

EXAMINATION PROCEDURE

The examination was carried out from the Postgraduate Clinic of the Department of Public Health Dentistry. All the students were briefed about the purpose of the study and the examination procedure. A single investigator conducted all the examinations. The clinical examination was carried out under adequate artificial and natural light. The measurements were recorded on a specially designed pro forma.

MEASUREMENT PROCEDURE

The various parameters of the teeth were measured using a divider and a ruler.

Making of study casts

Impressions of the mandibular arches were taken in alginate impression material and later study casts were prepared with dental stone. The measurements were taken from these casts.

The mandibular canine width

It was taken as the greatest width between the contact points of the canine teeth on either side of the lower jaw.

The intercanine distance

It was measured as the linear distance between the tips of right and left mandibular canine in the lower jaw.

Mandibular Canine Index

It was calculated using the formula:

Mandibular canine width/intercanine distance.[3]

Sexual dimorphism in right and left mandibular canines

This was calculated using formula given by Garn and Lewis:

Sexual Dimorphism = $(X_m/X_f - 1) \times 100$

(X_m = mean value of male canine width; X_f = mean value of female canine width).

To ensure the standardization of instruments, the dividers and rulers were calibrated from the Department of Physics, The Oxford Engineering College, Bengaluru.

A total of 5–6 students were examined on each day. The clinical examination was carried out under adequate artificial

and natural light. The measurements were recorded on a specially designed pro forma.

STATISTICAL ANALYSIS

The data analysis and graphic preparations were performed using the SPSS and Microsoft Excel 2007 software (IBM Corporation, Armonk, New York, United States). The results were statistically analyzed using student *t*-test.

Descriptive statistical analysis has been carried out in the present study. Results on continuous measurements are presented on mean ± standard deviation (SD) (Min-Max) and results on categorical measurements are presented in number (%). Significance is assessed at 5% level of significance.

RESULTS

Of the 100 participants studied, 34 participants were 18 years, 26 were 20 years, and the remaining 40 were 21 years of age. The present study was undertaken on 100 participants in that 50 participants were male and the remaining 50 were female.

Among males, the mesiodistal measurements of the right canines had a mean ± SD value of 7.42 ± 0.32, and among females, the mean ± SD value was 6.08 ± 0.08 (*t* = 28.179). The difference was highly statistically significant ($P \leq 0.001$). The mesiodistal measurements of the left canines in males revealed a mean ± SD of 7.47 ± 0.34, and in females, it was 6.15 ± 0.12 (*t* = 25.626). The difference was highly statistically significant ($P \leq 0.001$). The intercanine measurements of males depicted a mean ± SD value of 16.70 ± 0.68, and in females, it was 11.70 ± 0.46 (*t* = 43.082). The difference was highly statistically significant ($P \leq 0.001$) [Tables 1 and 2].

The MCI for males revealed a mean ± SD value of 0.89 ± 0.02, and for females, it was 1.05 ± 0.03 (*t* = 29.07). The difference was highly statistically significant ($P \leq 0.001$). Among males, the MCI computed for the right side showed a mean ± SD value of 0.444 ± 0.010. Among the females studies, the mean ± SD value for the right side was 0.521 ± 0.012 (*t* =0.26.948). For the left side, the mean ± SD was 0.447 ± 0.012 and 0.526 ± 0.014 for males and females, respectively (*t* = 30.905). The difference was highly significant on both the sides ($P \leq 0.001$) [Tables 3 and 4].

DISCUSSION

It is a known fact that teeth provide excellent models to study the relationship between ontogeny and phylogeny. Eimerl and De Vore postulated that in the evolution of primates, the canines are functionally not masticatory but are related to threat of aggression actual aggression. A transfer of this aggressive function occurred from the teeth to the fingers in man, and until this transfer was completed, survival was dependent on canines, especially in males. Canines differ from with respect to survival and sex dichotomy. Thus, in the present-day humans, sexual dimorphism in mandibular canines is not merely a coincidence but can be expected to be based on the functional activity. The determination of sex makes identification easier, and it is of immense forensic importance. In fact, it has been suggested that the first reported crime in

Table 1: Mesiodistal measurements of the right and left canines in males and females

	Gender	Mean (mm)±SD	T	P	Significance
Right canine	Male	7.42±0.032	28.179	<0.000**	Highly significant
	Female	6.08±0.08			
Left canine	Male	7.47±0.34	25.626	<0.000**	Highly significant
	Female	6.15±0.12			

**Highly significant. SD: Standard deviation

Table 2: Intercanine distance in males and females

	Gender	Mean (mm)±SD	t	P	Significance
IC	Male	16.70±0.68	43.082	<0.000**	Highly significant
	Female	11.70±0.46			

**Highly significant. IC: Intercanine distance, SD: Standard deviation

Table 3: Distribution of participants according to mean values using Mandibular Canine Index

	Gender	Mean (mm)±SD	t	P	Significance
MCI	Male	0.89±0.02	29.07	<0.000**	Highly significant
	Female	1.05±0.03			

**Highly significant. MCI: Mandibular Canine Index, SD: Standard deviation

Table 4: Mandibular Canine Index in males and females

	Gender	Mean (mm)±SD	t	P	Significance
Right	Male	0.444±0.010	26.948	<0.000**	Highly significant
	Female	0.521±0.012			
Left	Male	0.447±0.012	30.905	<0.000**	Highly significant
	Female	0.526±0.014			

**Highly significant. SD: Standard deviation

the history of humankind was solved when bite marks were discovered in the remains of forbidden fruits in the garden of Eden and identified as those of Adam and Eve.[4]

The usefulness of the canines as an aid in gender determination by odontometric analyses, in forensic dentistry, for example, is supported by their high level of survival in the dentition. The notable difference between canine in determining sex was noted to be due to the influence of the Y-chromosome which was not uniform in all teeth. On the other hand, the X-linked genetic influence on tooth width was rather uniform for all teeth. It is the Y chromosome which intervenes most in the size of teeth by controlling the thickness of dentine, whereas the X-chromosome, for a long time considered to be the chromosome responsible, only comes into play concerning the thickness of enamel.[4-11]

The findings in this study are supported by a study conducted by Kaushal *et al.* who have reported mean right canine width in males 7.229 ± 0.280 mm and in females 6.690 ± 0.256 mm, and left canine width in males 7.299 ± 0.292 mm and in females 6.693 ± 0.323 mm in their study on 60 participants (males: 30 and females: 30) of 17–21 years age group, respectively. Similar observations are also being noted by a number of research workers.[12]

Lund and Mörnstad studied 58 dental casts of Swedish individuals and found the canines to be the most dimorphic of all the teeth.[13] Lysell and Myrberg in an extensive study of more than 1000 participants concluded that the mandibular canine demonstrated the greatest sexual dimorphism (5.7%) among all teeth.[14] Another study was carried out by Hashim and Murshid on pretreatment orthodontic casts of 720 Saudi male and female participants in the age group of 13–20 years and found that the mandibular canines were only teeth to exhibit sexual dimorphism.[1,15] The results of these studies are in total agreement with the present study.

Boaz and Gupta by evaluating dental cast of 100 South Indian patients (50 males and 50 females) in the age group of 14–20 years have observed mean right canine width in males 6.9880 ± 0.56773 mm and in females 7.0520 ± 0.53117 mm and left canine width in males 6.9880 ± 0.56230 mm and in females 7.0080 ± 0.55138 mm, respectively.[16,17] Their observations too are in conformity with our findings as far as sexual dimorphism is concerned. But in contrast to our observations, the mean values of mesiodistal widths of right and left canine are greater in females than in males. However, in their study, they have noted no statistical significance to the observed difference between males and females for mesiodistal measurements of each of the mandibular canines. In the present study, comparison of the right canine width with left canine width in males has shown no difference, and a similar observation is noted in females when right canine width is compared with left canine width. Thus, it can be clearly stated that the canine width of either side both in males and females depicts no significant differences. Our findings are well supported by other study who have also observed significant difference in canine width of either right or left side among people in Uttar pradesh.[18] Such observations of the present study has medicolegal repercussions in that if only right or left side of mandible is available, we can construct the other half because canine width remains almost the same.

Reverse dimorphism (where the females showed larger teeth than males) was found in studies carried out by Acharya and Mainali on mandibular second premolar in the Nepalese population and by Yuen *et al.* on mandibular incisors in a longitudinal study on the Chinese population.[19,20]

It must be noted, however, that the method of sex determination via canine measurement has its limitations; the sex of the subject to whom the fragment of the mandible belongs can be determined satisfactorily only when the fragment is found in the geographical area where the individual was born. The present study measured only the linear dimensions, more accuracy could be obtained by the application of the Moire's topography and Fourier's analysis that require sophisticated equipment and the use of complex mathematical equations, respectively.

The present study establishes a statistically significant sexual dimorphism in mandibular canines. Determination of sex by mesiodistal measurement of mandibular canines is a relatively quick, easy, and inexpensive method and can aid in identifying persons from fragmented jaws and dental remains.

CONCLUSION

This study conclusively establishes the existence of a definite statistically significant sexual dimorphism in mandibular canines. The parameters measured in the present study will be of immense help in identification of gender in forensic investigations. Determination of gender by mesiodistal measurement of mandibular canines is a relatively quick, easy, and inexpensive method and can aid in identifying persons from fragmented jaws and dental remains. The findings of this study support the usefulness of employing odontometric analysis and dental indices of the canine teeth in gender determination as it is an easy, reproducible, and objective method.

The emerging field of forensic odontology in India relies a lot on such inexpensive and easy means of identifying persons, and in such situations, the dentist can be called upon to render expertise in forensic science. A database may be established of dental morphometric measurements using intraoral periapical radiographs with a view to determine variations among large populations that may be beneficial for anthropological, genetic, legal, and forensic applications.

FINANCIAL SUPPORT AND SPONSORSHIP

Nil.

CONFLICTS OF INTEREST

There are no conflicts of interest.

REFERENCES

1. Vishwakarma N, Guha R. A study of sexual dimorphism in permanent mandibular canines and its implications in forensic investigations. Nepal Med Coll J 2011;13:96-9.
2. Aggarwal B, Kaushal S, Vasudeva K. Significance of mandibular canine index in sexual dimorphism. J Indo Pac Acad Forensic Odontol 2010;1:1-4.
3. Rao NG, Rao NN, Pai ML, Kotian MS. Mandibular canine index – A clue for establishing sex identity. Forensic Sci Int 1989;42:249-54.
4. Mughal IA, Saqib AS, Manzur F. Mandibular Canine Index (MCI). Prof Med J 2010;17:459-63.
5. Yadav S, Nagabhushana D, Rao BB, Mamatha GP. Mandibular canine index in establishing sex identity. Indian J Dent Res 2002;13:143-6.
6. Parek D, Zalawadia A, Ruparelia S, Shailesh.P. Morphometric Study Of Mandibular canine in Dry Skull of Gujarat Region. Natl J Integr Res Med 2011;2:6-9.
7. Duraiswamy P, Tibdewal H, Patel K, Kumar S, Dhanni C, Kulkarni S. Sex determination using mandibular canine index in optimalfluoride and highfluoride areas. J Forensic Dent Sci 2009;1:99-103.
8. Ahmed SA, Muni Sekhar MS. Mandibular canine index A tool for sex determination. Nepal Med Coll J 2010;12:16-9.
9. Sharma M, Gorea RK. Importance of mandibular and maxillary canines in sex determination. J Punjab Acad Forensic Med Toxicol 2010;10:12-6.
10. Kapila R, Nagesh KS, R Iyengar A, Mehkri S. Sexual dimorphism in human mandibular canines: A radiomorphometric study in south Indian population. J Dent Res Dent Clin Dent Prospects 2011;5:51-4.
11. Omar A, Azab S. Applicability of determination of gender from odontometric measurements of canine teeth in a sample of adult Egyptian population. Cairo Dent J 2009;25:167-80.

12. Kaushal S, Patnaik VV, Agnihotri G. Mandibular canines in sex determination. J Anat Soc India 2003;52:119-24.

13. Lund H, Mörnstad H. Gender determination by odontometrics in a Swedish population. J Forensic Odontostomatol 1999;17:30-4.

14. Lysell L, Myrberg N. Mesiodistal tooth size in the deciduous and permanent dentitions. Eur J Orthod 1982;4:113-22.

15. Hashim HA, Murshid ZA. Mesiodistal tooth width. A comparison between Saudi males and females. Part 1. Egypt Dent J 1993;39:343-6.

16. Srivastava PC. Correlation of odontometric measures in sex determination. J Indian Acad Forensic Med 2009;32:56-61.

17. Boaz K, Gupta C. Dimorphism in human maxillary and mandibular canines in establishment of gender. J Forensic Dent Sci 2009;1:42-4.

18. Reddy V, Saxena S. Mandibular canine index as a sex determinant a study on the population of Uttar Pradesh. J Oral Maxi Pathol 2008;12:56-9.

19. Acharya AB, Angadi PV, Prabhu S, Nagnur S. Validity of the mandibular canine index (MCI) in sex prediction: Reassessment in an Indian sample. Forensic Sci Int 2011;204:207.e1-4.

20. Acharya AB, Mainali S. Limitations of the mandibular canine index in sex assessment. J Forensic Leg Med 2009;16:67-9.