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ORIGINAL ARTICLE

Journal Section

A gender determination using mandibular canine index – a prospective study on Mumbai population and comprehensive review

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Abstract

Background: Teeth is considered a necessitous auxiliary in skeletal age, and determination of gender because teeth have post-mortem destruction and fragmentation resistance and they are last to be destroyed under extreme conditions like temperature, acid, or putrefaction. **Aims**: To evaluate the differences in odontometrics of mandibular canine between males and females and assessment of gender by calculating differences in the mandibular canine index (MCI) of male and female subjects. **Settings and Design**: Prospective, cross-sectional study. **Materials and methods**: This study focus on evaluation of the existence of sexual dimorphism in the Mumbai population which included permanent mandibular canine of 100 male & 100 female subjects of age group 21 to 28 years. The mesio-distal width (MDW) of right and left canine and inter-canine distance (ICD) were measured. Subsequently, the mandibular canine index was calculated. **Results**: No evidence of any significant statistical difference between the right and left mandibular canines among the same gender, but when compared between male and female, greater sexual dimorphism (10%) was seen with mandibular left canine as compared with the right.(9.2 %). The standard MCI value was 0.24 for the Mumbai population. **Conclusions**: MCI technique can be used as one of the simple, reliable, and adjuvant diagnostic method for gender determination in forensic dentistry. As it is influenced by various factors like genetics, epigenetics, geographical locations, etc.; it is recommended to carry out population based studies so that standardized values will help in gender determination precisely.

KEYWORDS

Forensic science; mandibular canine index; forensic odontology; odontometrics; sexual dimorphism; intercanine distance

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1 | INTRODUCTION

Dental tissues particularly teeth are used extensively for anthropological, odontology, evolutionary, and forensic investigations as they are resistant to putrefaction and destruction of soft tissues caused by external agents and hence, serve as an excellent forensic tool for gender determination.[1] Keiser-Nielson described forensic odontology as a "branch of forensic medicine which deals with the proper handling and examination of dental evidence in the interest of justice, and with the proper evaluation and presentation of the dental findings".[2] Forensic odontology has a vital role in investigations such as identification of people in natural disasters, mass fatality, accidents, in cases where victim cannot be identified visually, young individuals with immature skeletal characters, and also when prognosticators such as the skull, pelvis, or long bones are fragmented or destroyed.[3] Various methods are used for gender identification like odontometrics, cheiloscopy, rugoscopy, cemental annulations, DNA analysis, bite marks analysis, tooth prints, etc. Teeth may be used for differentiating gender by measuring their odontometric parameters which include the study of tooth size, by root length, and crown diameters like mesio-distal, buccolingual width, and inciso-gingival height, or by gender determination by canine sexual dimorphism.[4] Sexual dimorphism is systematic difference in morphological characters like, size, stature, and appearance that differentiate male from female. As tooth size is determined by cultural, environmental, racial and genetic factors, it has been used as a viable tool in anthropologic and forensic investigations. Sexual dimorphism is present in all teeth in variable amounts but Canine shows maximum sexual dimorphism. They are sturdy teeth with capability to withstand extreme conditions and minimal extraction frequency [as are least prone for caries and periodontal disease and hence, are "key tooth" for personal identifications.[5] The enamel of tooth resist post-mortem, physical, chemical, mechanical, and thermal types of destruction, prolonged immersion, desiccation, extensive trauma as well as an advanced stage of decomposition.[6] This study was done to evaluate the differences in odontometrics of mandibular canine between males and females, to co-relate the gender by calculating differences in mandibular canine index of male and female subjects, and to investigate the accuracy with which gender can be differentiated by using MCI. The accuracy of odontometric gender prediction vary in different populations and therefore, it is mandatory to determine specific population values to make identification possible. Hence, this study was undertaken to evaluate the existence of sexual dimorphism in the Mumbai community.

2 | METHOD

This study was conducted in the Department of Oral Medicine and Radiology. The subjects selected for the study, include 200 individuals (100 males and 100 females) coming to the hospital in Mumbai. Voluntary participation with proper informed consent was considered. Institutional Ethics Committee approval was taken (GDC&H/EC Meet/1088/2018 dated 06.03.2018). It was framed on the principles mentioned in the Declaration of Helsinki and followed guidelines of Good Clinical Practice provided by the International Conference of Harmonization (ICH-GCP).[7] The inclusion criteria were as follows[8]:

1. Healthy gingiva and periodontium
2. Non carious anterior teeth
3. Malocclusion like spacing or crowding in anterior teeth not present.
4. Normal overjet and overbite (2-3 mm)
5. Normal molar and canine relationship (Angle's classification)
6. Completely erupted all permanent teeth.

The exclusion criteria were as follows[8]:

1. Any hard tissue pathology related to teeth
2. Missing anterior/posterior teeth
3. Orthodontically treated teeth
4. Any trauma to the canine teeth
5. Malaligned teeth
6. Age more than 28 years.

The subjects with permanent dentition were selected as dimensions of crown of permanent tooth do not change except when there is nutritional, functional, or pathological disorders that affect the morphology or structure of the teeth. Subjects in the age group of 21-28

years were only included in the study sample as this group shows minimal attrition and also because of complete development of tooth more stability is achieved in this age group.[9] Sample size calculation was done online using the Open-Epi operating system. To avoid a biased study, every subject was unknown to the investigator and one assistant was recording all the personal history of subjects. After taking a detailed case history and informed consent, the following intraoral measurements were taken using a Vernier calliper with resolution 0.02 mm as shown in Figure 1, and a double-ended divider to study the odontometric data of mandibular canine.

1. **Mesio-distal width (MDW):** The mandibular canine width was taken as the greatest mesiodistal width between the contact points of the teeth as shown in Figure 1A on both the side of the jaw (with the divider/caliper). Mesio-distal width of the right and left mandibular canine was calculated.
2. **Inter-canine distance (ICD):** It was measured as shown in Figure 1B, between the cuspal tips of both the canines in the lower jaw.
3. To study the gender prediction of individuals using these two above mentioned measurements mandibular canine index (MCI), both right and left sides were calculated based on the formula used by Rao et al.[9]

$$MCI = \frac{MDW}{ICD}$$

4. Standard MCI was calculated as follows Standard MCI = (Mean Male MIC+ SD)-Mean Female MIC+SD)/2
5. **Sexual dimorphism:** Calculation of sexual dimorphism was done in mesio-distal width of both right and left sided mandibular canine. Sexual dimorphism is nothing but the percentage dimorphism i.e. the percent to which the male tooth size exceeded that of female and is calculated by using the formula (Sexual dimorphism = (Mean values of mesio-distal width of mandibular canines in males/Mean values of mesio-distal width of mandibular canines in females-1)x 100) given by Garn et al.[5]

Statistical analysis was done using XLstat software with excel spread sheets on Microsoft excel 2010

3 | RESULTS

Table 1 (Appendix 1) depicts the difference in the MDW of mandibular canines (Figure 2), ICD (Figure 3), and MCI (Figure 4) between male and female. No statistically significant difference in MDW of mandibular canine of right & left side in males as well as females was seen. MDW and MCI of both right & left side lower canine, and ICD between males & females was statistically different. The MDW, MCI and ICD of mandibular canine in males were significantly greater than the females. Standard MCI for both right as well as the left side was found to be 0.24. Subjects with MCI up to the limit of standard MCI of the given population (0.24) are females & those with values above standard MCI are males. The percentage accuracy of gender identification was around 82% in male and 60% in female on the left side while it is 80% in male and 62% in female on the right side. The sexual dimorphism for the right mandibular canine was found to be 9.2% whereas, for the left it was 10%. Analysing these data, we could predict sex correctly in 71% of the cases.

4 | DISCUSSION

Several different techniques of identification of a person have been developed till today which includes fingerprints, bite marks, anthropometry, dactyloscopy, differentiation by blood grouping, and DNA analysis.[10] Gender determination of human remains, due to the decomposition is often a dilemma for forensic expert's factor. Though DNA analysis is the most accurate method for gender determination, it has multiple limitations like expense, long time involvement, not obtainable in certain cases due to decomposition, putrifaction, or contamination. Teeth are the most stable tissue in the body for contribution to evolutionary changes. They show resistant to decomposition, fire, or humidity that makes them a valuable tool in forensic dentistry.[9] Although the DNA profile is the most accurate test, yet the use of the odontometric parameters such as mesio-distal width, buccolingual dimensions, heights of teeth, and the mandibular intercanine index [5,8,11-14] in gender estimation is more structured, less subjective, simple, reliable, inexpensive and furthermore, it can be repeated to validate the obtained

results. Several other methods, which include Moiré's topography and Fourier's analysis, can also be used but are limited to small samples whereas linear dimensions of canine teeth measurement can be employed in a large population.[15,16] Most authors have concentrated on the use of mesio-distal and buccolingual dimensions of the permanent tooth crown for gender determination.[17-20] Considering the fact that odontometric features in specific populations differ as are genetically controlled, even within the same population in the historical and evolutional context, it is necessary to determine specific population values to make identification possible based on dental measurements.

Canines are excellent models for the study of the relationship between ontogeny and phylogeny. Rao et al. suggested canine as a "key tooth" for gender determination since they are consistently larger in males, more resistant to dental disease, and can survive post-mortem insults.[8] Hashim et al.conducted a study on Saudi males and females in the age group of 13-20 years and found that only the canines in both jaws exhibited a significant sexual difference while the other teeth did not. [6,5,22-24] Many studies have found mandibular canines having the greatest sexual dimorphism among all teeth.[21] Various studies have been reported on South India[25], North India[26], and Western Uttar Pradesh [27] where mandibular canines showed a highly significant canine index in sexual dimorphism [Table 2(a),(b),(c)](Appendix 1). Many authors found Mandibular canines to demonstrate the greatest percentage of sexual dimorphism in their mesio-distal width[5,11-12,28-29] however, few studies[30,31] have concluded that the buccolingual dimensions are more accurate as they are least susceptible to proximal wear. This study showed that mesio-distal dimensions of mandibular canines were significantly greater in males than females which is in harmony with previous studies done by Anderson et al.; Richardson et al.; Rao et al.; Lew et al.; Teschler-Nicola et al.; Muller et al. [8,11,31-34] [Table 3(a) and Table 3(b)](Appendix 1). Al-Rifaiy et al.[35] in their work on a Saudi Arabian sample of 503 school children also reported the same but, with no statistical differences. Acharya et al.[3] found reverse dimorphism in the Nepalese population where mesio-distal dimension of female canine was larger than male, which could be due to evolution causing an overlap of tooth dimension in modern males and females. Boaz et al.[36] also observed a similar finding. Few studies involving maxillary canines were also reported (Khangura et al, Gorea et al., Parekh et al., Abdullah et al., Khan et al., Srivastava et al., Sravya et al, Phulari et al.[14,26,37-42] The findings of the present study are consistent with the results of the studies conducted by Rao et al., Hashim et al., Nair et al., Kaushal et al., eddy et al., Duraiswamy et al., Kapila et al., Ayoub et al.[8, 21, 22, 25, 27, 43-45] Table 2(a),(b), 2(c), Table 3(a),(b) (Appendix 1) depict comparison of mandibular canine mesio-distal width, inter- canine distance, and mandibular canine index in different Indian and International populations respectively. However, in a study done by Saikiran et al.,[23] on Indian teeth, greater sexual dimorphism was seen in right mandibular canine than the left one. Also, many studies after interrogating the practicality of the MCI in gender assessment like Silva et al., Muller et al., Acharya et al., Hosmani et al.,[3,34,46-47] questioned the accuracy of it and, concluded that MCI does not reflect dental sex dimorphism precisely. Several theories have been given to explain canine dimorphism. According to the theory suggested by Moss because of the longer period of the amelogenesis process, enamel in male has greater thickness compared to females.[14] Sex chromosomes also play an important role. Compared to the 'X' chromosome, the 'Y' chromosome that controls the thickness of dentine produces slower maturation of enamel in males.[3] Biological variation, which is attributed to family, genetics, and environmental factors, may also cause dimorphism.[48] Sexual dimorphism is greater for the left side of the mandibular canine, which may be attributed to a nodal gene that decides the right, and left asymmetry of organs of the body.[49]

5 | CONCLUSION

Statistically significant values in permanent mandibular canine obtained in this study strengthen the previous studies in Indian and international populations. Determination of gender by the mandibular canine index is a relatively cheap, feasible, and reliable method, and can aid in proper identifications. However, gender determination via canine measurement has its limitations; sex de-

termination can be possible only when hard tissue remnants are found in the geographical area where the subject was born. In addition, the leeway of error in the cases where the normal dimension of the teeth is distorted can be seen. The present study measured only linear dimensions because of the dependability, stability, and non-invasiveness. Application of Moiré's topography and Fourier's analysis could have provided more accuracy. Studies involving larger samples are required for more definitive and conclusive results. Since the percentage accuracy of gender identification is to be around 80% as compared to pelvis and skull bones which shows accuracy of 95% and above.[50] The present study and literature review emphasises that MCI can be used as one of the reliable adjunct diagnostic aid; but as it is influenced by various factors like genetics, epigenetics, geographical locations etc.; we recommend carrying out population based studies so that standardized values will help in gender determination precisely.

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Nil

Conflict of interest

The authors have no conflicts of interest to declare.

Supporting Information

Additional supporting information may be found at the journal's website.

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