Sexual dimorphism using permanent maxillary and mandibular incisors, canines and molars: An odontometric analysis

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Abstract

Introduction: Sex identification of skeletal remains is one of the prime factors employed in identification of an individual. Teeth, the most hard and stable human tissue, which is resistant to physical insults, serve as a valuable material for forensic, anthropological, odontologic and genetics. Among the four main attributes of biological identity, gender determination is usually the first step in the human identification process. Hence, the main objective of the present study was to assess the dimorphic status of mesiodistal (MD) width, labiolingual (LL) width as well as cervicoinal (CI) length of the crown in both maxillary and mandibular permanent incisors, canines and first molars.

Materials and Methods: The present study comprised a set of 100 casts (50 males and 50 females) between the age group of 20–50 years of age. Impressions were made using alginate impression and study models were prepared using dental stone. The CI length of the crown, maximum MD width and maximum LL width of both maxillary and mandibular permanent incisors, canines and first molars were evaluated using digital Vernier calipers. The obtained data were analyzed using linear discriminant analysis and logistic regression method.

Results: This study concludes that MD dimension of maxillary canine and CI dimension of mandibular first molar as reliable indicators for gender determination than mandibular canine, maxillary and mandibular central incisors and maxillary first molar dimensions.

Conclusion: This study concludes that MD dimension of maxillary canine and CI dimension of mandibular first molar as reliable indicators for gender determination than mandibular canine, maxillary and mandibular central incisors and maxillary first molar dimensions.

Keywords: Cervico-incisal length of the crown, labio-lingual width, mesiodistal width, morphometry, sexual dimorphism
and sex determination. The tooth crown size is a valuable tool and provides significant information on human evolution, biological alterations in forensic evaluation and clinical odontology.\textsuperscript{[2]} The first step for a trained forensic odontologist is to identify the gender from whatever human dental remains are presented as specimen. In severe cases of devastation and body fragmentation or decomposition, dental identification is the most commonly used biometric method for human identification.\textsuperscript{[3]}

Sexual dimorphism usually refers to those differences in sizes, stature and appearance between males and females that can be applied to dental identification because no two mouths are alike.\textsuperscript{[3]} Various features such as tooth morphology and crown size are characteristic of males and females.\textsuperscript{[4]} Hence, sex determination using dental features is mainly based on the comparison of tooth dimensions in males and females. Males possess larger tooth crowns than females in contemporary human populations. This may be due to a longer period of amelogenesis for both deciduous and permanent dentitions in males.\textsuperscript{[5]}

Various odontometric parameters have been used for gender determination such as mandibular canine indices, mandibular canine dimension, maxillary first molar dimensions and cumulative dimensions of all teeth. Despite being reliable, sex determination using parameters such as cervico-incisal (CI), labio-lingual (LL) and mesiodistal (MD) among permanent maxillary incisors, canines and molars with permanent mandibular incisors, canines and molars has not been established.

Hence, the purpose of this present study was to evaluate the probability of determining gender using CI, LL and MD of permanent maxillary and mandibular incisors, canines and first molars and to compare the efficacy of these parameters with each other.

**MATERIALS AND METHODS**

The present study was conducted in our Institution. One hundred patients were selected based on inclusion criteria outlined below for the study of permanent dentition in the age group of 20-50 years of which 50 were male and 50 were female.

**Inclusion criteria**

1. Healthy state of gingiva and periodontium
2. Teeth with no gross abnormalities
3. Teeth with no loss of tooth substance due to attrition
4. Teeth with no restoration affecting MD diameter of the crown
5. Teeth with intact MD diameter of the crown of both sets of dentition
6. Caries free teeth
7. Absence of spacing in the anterior teeth.

Impressions of both maxillary and mandibular arch were made using irreversible hydrocolloid-alginate material and poured using type II dental stone immediately to avoid any distortion. On the study models, the following measurements were taken using a digital Vernier caliper.

The three different measurements were defined as follows:

CI length: the portion of the enamel from the cervical line to the incisal edge.

Maximum MD diameter: the distance between two parallel planes, tangential to the most mesial and distal points of the crown side.

Maximum buccolingual breadth: the maximum distance between two parallel planes, one tangential to the most lingual/palatal point of the crown side, and the other tangential to a point on the buccal/labial side [Figure 1].\textsuperscript{[6]}

These measurements were then subjected to linear discriminant analysis using SPSS software version 11 (Manufacture:SPSS Inc. IBM, Chicago,year 2009) ($P < 0.005$) and logistic regression (sexual dimorphism).

**RESULTS**

Linear discriminant analysis was used in our study to predict the overall gender accuracy. Table 1 shows that 36_CI was found to be the most reliable parameter for predicting gender (overall accuracy = 72.5%). However, it did not have good accuracy in predicting females as

![Figure 1: Recording measurement using digital vernier caliper](image-url)
females (accuracy = 56.1\%) but had very high accuracy in predicting males as males (accuracy = 89.7\%). In Table 2, statistically significant difference was observed between males and females for the parameter 36_CI (P < 0.001) with males recording a higher mean value compared to females. In Table 3, MD_13 and CI_36 were found to be statistically
Sexual dimorphism has been explained through the following theories:

- Moss suggested that because of the longer period of amelogenesis there is a greater thickness of the enamel in males compared to females, leading to a difference in dimensions.

- Sex chromosomes are also responsible for the different effects on tooth size. Compared to the “X” chromosome, the “Y” chromosome influences the timings and rate of body development, thus producing slower male maturation.

Several indices are available for the determination of gender such as maxillary incisor width, maxillary CI, maxillary canine width, mandibular CI, mandibular canine width, molar width, molar cusp diameter and cumulative width of all teeth. In our study, we have taken maxillary and mandibular central incisors, maxillary and mandibular canines and maxillary and mandibular first molars with parameters such as LL, MD, and CI measurements only. Variations in tooth sizes between genders and among different racial and ethnic groups have been reported by several authors.

| Parameter | β     | SE of β | P     | OR   | 95% CI for OR |
|-----------|-------|---------|-------|------|--------------|
| Constant  | −17.506 | 14.237 | 0.219 | <0.001* | -            |
| LL_11     | −1.387  | 1.587   | 0.382 | 0.250 | 0.01         | 5.61         |
| MD_11     | 1.829   | 1.392   | 0.189 | 6.229 | 0.41         | 95.42        |
| CI_11     | 0.064   | 1.206   | 0.958 | 1.066 | 0.10         | 11.34        |
| LL_31     | −3.037  | 2.052   | 0.139 | 0.048 | 0.00         | 2.68         |
| MD_31     | −1.606  | 1.487   | 0.280 | 0.201 | 0.01         | 3.70         |
| CI_31     | 1.554   | 1.195   | 0.194 | 4.730 | 0.45         | 49.26        |
| LL_13     | −0.992  | 1.311   | 0.449 | 0.371 | 0.03         | 4.84         |
| MD_13     | 2.865   | 1.421   | 0.044*| 17.544| 1.08         | 284.40       |
| CI_13     | −1.036  | 1.222   | 0.396 | 0.355 | 0.03         | 3.89         |
| LL_33     | 0.086   | 1.194   | 0.943 | 1.089 | 0.10         | 11.30        |
| MD_33     | −0.233  | 0.831   | 0.792 | 0.09  | 6.75         |
| CI_33     | 0.910   | 0.995   | 0.360 | 2.485 | 0.35         | 17.48        |
| LL_16     | −2.096  | 1.929   | 0.277 | 0.123 | 0.00         | 5.40         |
| MD_16     | 1.344   | 1.099   | 0.221 | 3.835 | 0.45         | 33.03        |
| CI_16     | 0.756   | 1.052   | 0.472 | 2.129 | 0.27         | 16.72        |
| LL_36     | 1.922   | 1.674   | 0.251 | 6.837 | 0.26         | 181.94       |
| MD_36     | −1.785  | 1.226   | 0.145 | 0.168 | 0.02         | 1.86         |
| CI_36     | 2.926   | 1.309   | 0.025*| 18.649| 1.43         | 242.37       |

* A significant factor. OR: Odds ratio, CI: Confidence interval, SE: Standard error, LL: Labiolingual width, MD: Mesiodistal width, CI: Cervicoincisal

**DISCUSSION**

The human identification is the recognition of an individual based on physical characteristics unique to the individual. Although many bones such as the pelvis and skull give the most reliable results of sexual dimorphism by morphological and metric analysis, rarely, the only evidence available for gender determination maybe teeth. They are one of the strongest human tissues and are known to resist a variety of antemortem and postmortem insults. Sex determination is one of the prime factors employed to assist with the identification of an individual.
The anterior teeth are esthetically important as they are readily seen during eating, speech, mastication and facial gesticulation. The dominant feature of numerous anterior dentitions is the maxillary central incisor. Its size, shape, color and position add to determine and create a definite coherence and order in the arrangement of natural anterior teeth.\[9\]

According to study carried out by Kaushal, sexual dimorphism in the MD width for the right maxillary central incisor was 3.84%, whereas for the left maxillary central incisor was 4.52% among North Indian population which was statistically insignificant.\[9\]

In our study too there was no statistical significant difference among maxillary central incisors. However, none of the previous studies had considered mandibular incisors for determining sexual dimorphism. Whereas in our present study we have included mandibular central incisors for the sexual dimorphism but there was no statistical significant difference among them too.

The measurements of linear dimensions which include the MD width of canine teeth have the advantage of being able to use a large sample of population because it is simple, inexpensive and easy to perform. Aggarwal found that males exhibit larger MD width than females. The studies conducted by Ghose and Baghdady on the Iraqi population and by Bishara on populations of Egypt, Mexico and Iowa showed consistent findings that the MD width of the mandibular canines is more in the males than the females and the difference is statistically significant.\[10\]

In the present study, CI of 36 was found to be the most reliable parameter for predicting gender (overall accuracy = 72.5%). However, it did not have good accuracy in predicting females as males (accuracy = 56.1%) but had very high accuracy in predicting males as males (accuracy = 89.7%).

According to logistic regression, results in our study shows MD_13 and CI_36 as significant factors in determining gender ($P < 0.05$). As per prediction accuracy of logistic regression model, the overall accuracy in predicting gender was found to be 81%. The method in the present study implemented is economical and simple to conduct and hence can be applied in forensic odontology for establishing sex identity of an individual.

**CONCLUSION**

This pioneer study provides normative morphometric data and establishes the existence of statistically significant gender dimorphism ($P > 0.05$) for the maxillary canines and mandibular first molars among studied population. Future studies on varied population groups with higher sample size might further establish the usefulness of mandibular first molar and canines dimensions in gender determination.

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**Conflicts of interest**

There are no conflicts of interest.

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