Anthropometric evaluation of mandibular canine width and intercanine distance in sex determination - A study

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Abstract: One of the major roles of forensics in human identification is establishment of sex of the individual. Teeth form an excellent material for anthropological, genetic, odontologic and forensic investigations. Amongst all the teeth, the mandibular canines are found to exhibit greatest sexual dimorphism. To define the morpho-metric criteria for mandibular canines in Central Indian population, the present study has been conducted in 80 subjects 40 males and 40 females in the age group of 18-23 years to investigate the possibility of dimorphism of the canines being used as a valid tool in the forensic and legal identification of an individual. These measurements were done with the aid of a vernier caliper while the mandibular indexes were derived by the division of the mandibular canine width by intercanine distance. The values were subjected to statistical analysis. Intercanine distance & width of both right with left mandibular canines were measured intra orally as well & the mandibular canine index was calculated. It was seen that a definite statistically significant sexual dimorphism exists in the mandibular canines. Out of the two canines, the left one exhibits greater sexual dimorphism as compared with the right one. It is also concluded that whenever the width of either canine is >7mm the 100% probability of sex being male. While if it is <7mm, the sex could be either male or female.

Keywords: canine width, canine index, inter-canine distance, mandibular canines.

INTRODUCTION

Apart from the hard chemical nature and the effective resistance of teeth to destruction, teeth are also readily accessible and also do not need special dissection (Bindu et al., 2008) therefore; teeth are invaluable elements for identification in living and nonliving populations for anthropological, genetic, odontologic, evolutionary 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. (Williams et al, 2000). (Williams et al., 2000). Teeth are the hardest and chemically the most stable tissues found in the body, are known to resist postmortem, mechanical, chemical, physical and
Studies on tooth morphology have in the past been conducted using either intra-oral measurements or measurements on casts. Barrett et al (1963) have observed that intra-oral measurements are less reliable. Garn et al (1967) and Nair et al (1999) have found the mandibular canines to exhibit the greatest sexual dimorphism amongst all teeth.

Tooth size standards based on odontometric investigations can be used in age and sex determination (Black, 1902). Whenever it is possible to predict the sex, identification is simplified because then only missing persons of one sex need to be considered. In this sense identification of sex takes precedence over age. (Camps, 1976) "Sexual Dimorphism" refers to those differences in size, stature and appearance between male and female that can be applied to dental identification because no two mouths are alike. (Keisu, 1990).

The mandibular canines have a mean age of eruption of 10.87 years and are less affected than other teeth by periodontal diseases. These are 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. (Dahberg, 1963).

The present study establishes the impact of the 'sex factor' on the anthropometry of the mandibular canines. The results indicate that the dimorphism in mandibular canines can be of immense medico legal use in identification. The study defines the morph metric criteria for mandibular canines in Central Indian population. This is of definite significance, as tooth morphology is known to be influenced by cultural, environmental and racial factors. (Halim, 2001).

**MATERIAL AND METHODS:**

Eighty subjects, 40 males and 40 females in the age group of 18-23 years were selected for the study. This age group was selected, as attrition is minimal in this age group and there are good chances of healthy periodontium. Such cases were identified with Class-I molar relationship, absence of incisor spacing with normal overjet and overbite. (Vacher and Gupta, 1966). The study was conducted on the B.D.S students of Bhabha College Dental Sciences, Bhopal. Cases with any doubt about age or oral pathology are excluded from the series.

**Measurements:**

After getting consent of the subjects, the following intraoral measurements were taken by using a Vernier Caliper with resolution of 0.02 mm. (Fig.1 and Fig.2)

**Fig.1 Measurement of inter-canine width**

**Fig.2 Measurement of canine width**

1. The mandibular canine width (RMCW and LMCW): With the subject in a sitting position, RMCW and LMCW were measured with Vernier
caliper as the greatest width between the contact points of the teeth on either side of the lower jaw.

2. The inter-canine distance (ICD): was measured as the linear distance between the tips of right and left mandibular canine in the lower jaw.

3. Mandibular canine index (RMCI and LMCI): Was calculated based formula adapted from Rao et al. (1989) who derived Mandibular Canine Index (MCI) for establishing sex identity was calculated using the formula –

\[
\text{Mandibular canine width / Inter-canine distance}
\]

**Table I: Showing Statistical Significance of Difference Parameters**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sex</th>
<th>Mean ± SD (mm)</th>
<th><em>p</em> value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inter-canine distance</td>
<td>Male</td>
<td>27.87</td>
<td>25.07</td>
</tr>
<tr>
<td>Right canine width</td>
<td>Male</td>
<td>7.11</td>
<td>6.06</td>
</tr>
<tr>
<td>Left canine width</td>
<td>Male</td>
<td>7.50</td>
<td>6.86</td>
</tr>
<tr>
<td>Right mandibular canine index</td>
<td>Male</td>
<td>0.255</td>
<td>0.241</td>
</tr>
<tr>
<td>Left mandibular canine index</td>
<td>Male</td>
<td>0.271</td>
<td>0.273</td>
</tr>
</tbody>
</table>

**OBSERVATIONS AND RESULTS:**

Table one shows sex related differences amongst various parameters. When the mean value of intercanine distance of the 80 subjects (40 males and 40 females) were compared, males showed higher value than the females and the difference was statistically highly significant (p value<0.001). However, the variance value for the females was more than the males. The width of the mandibular canine was slightly higher for males than females. When the mean values for left and right mandibular canine widths were compared between males and females, the females showed lesser value. Furthermore, variation in width of the right and left mandibular canine was more in the males than in females. The observed difference in the variation of the right and left canine width between males and females was statistically highly significant (p value<0.001). The right and left mandibular canine index were almost bilaterally symmetrical in both the males and females with more variation in females as compared to males. There was statistical significance of these observed differences between the genders for right and left mandibular canine indices (p value<0.001).

The results have been depicted in tables I and II,

(a) From table I, it is evident that these parameters as measured for males and females when compared are found to be statistically significant. This is irrespective of whether measurements

(b) Further in males or females i.e. for the same sex (tables II and III) when these parameters as measured intraorally or on casts, are compared, they are found to be statistically insignificant.

From these findings, it can be inferred that there exists a definite statistically significant sexual dimorphism in the mandibular canines. This influence of the ‘sex factor’ on morphometry in North Indian population is demonstrable irrespective of whether measurements are taken intraorally or on casts.

**Table-1 Sex related differences amongst various parameters**

**Table-2 Percentage of sex correctly predicted using MCI**

<table>
<thead>
<tr>
<th>Sex</th>
<th>Right mandibular canine index</th>
<th>Left mandibular canine index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percentage</td>
</tr>
<tr>
<td>Male</td>
<td>31</td>
<td>77.5%</td>
</tr>
<tr>
<td>Female</td>
<td>34</td>
<td>85%</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>81.2%</td>
</tr>
</tbody>
</table>
DISCUSSION:

Gender determination in damaged or mutilated dead bodies or from skeletal remains constitutes the foremost step for identification in medico-legal examination. Although DNA profile gives accurate results yet measurement of linear dimensions, such as inter-canine distance and width of canine teeth can be used for determination of sex in large population because it is simple, reliable, inexpensive and easy to perform.

In the present study the inter-canine distance both in males and females is found highly significant (p value <0.01). It is further observed that mean intercanine distance in males is 27.87±1.25 mm and the value in females is 25.07±1.19 mm, thus values in males being higher than those of females. Observations in males and females has been observed by Kaushal et al10 (male: 25.873±1.253, female: 25.070±1.197), Reddy et al11 (male: 26.860±1.48, female: 26.287±1.45), Kaushal et al12 (male: 25.87±1.25, female: 25.07±1.19), Abdullah13 (male: 26.9552±2.3129, female: 26.4575±2.7790), and Al-Rifaiy et al14 (males: 27.0171±2.3168 and females: 26.4615±2.7761 mm). The results of present study are higher than previous studies in case of male as well as female.

In the present study there exists a statistically significant sexual dimorphism in the morphometry of the mandibular canines as far as mandibular canine widths are concerned. We have noted the mean value of right canine width in males and females to be 7.11±0.20 mm and 6.06±0.16 mm respectively and that of left canine width in males and females 7.56±0.21 mm and 6.86±0.18 mm respectively. These values are found to be highly significant (p <0.01). It is also observed that mean values of canine widths to be higher in males compared to females. Our findings in males and females have been supported by Kaushal et al10 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 subjects (males: 30 and females: 30) of 17 – 21 years age group. In the present study comparison of right canine width with left canine width in males have showed 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 workers10-15.

Kaushal et al12 in their study on 30 males and 30 females of the North Indian population in the age group of 17 - 21 years on right and left mandibular canine have observed that the probability of sex determination using right MCI for males and females is 70% and 80% respectively and that with left MCI for males and females has been 66.67% and 83.33% respectively. This is in contrast to our findings wherein we have noted still lower values for sex prediction i.e. 50.5% in males and 49% in females using MCI of right side and 52.4% males and 50.8% females using MCI of left side. Further, the probability of correct prediction of sex using MCI is higher for males in our study. We have noted an overall higher percentage of accuracy for sex prediction from right side MCI as compared to left side MCI.

In the present study it is observed that whenever canine width is greater than 7.3 mm, the probability of sex being male is 100%. This is in contrast to Kaushal et al10 and Rai et al16 who have reported corresponding values as 7.0 mm and 7.2 mm respectively. This finding could be of immense medico-legal importance in identification of Gujarati subjects as the determination of sex makes identification easier.

The present study establishes the existence of a definite statistically significant sexual dimorphism in mandibular canines. It is consistent with Hashim and Murshid (1993) who 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. Similar findings were given by Lew and Keng (1991) in their study on ethnic Chinese population with normal occlusions. Kumar et al (1989) have demonstrated that intercanine distance and mandibular canine index are useful parameters in differentiating the sexes. In the present study both these parameters as measured in males and females were compared and the difference was found to be statistically significant.

Garn & Lewis (1967) and Lysell & Myrberg (1986) concluded that the mandibular canine with 6.4% and 5.7%, respectively demonstrates the greatest sexual dimorphism amongst all teeth. Nair et al (1999) in their study on South Indian subjects concluded that the left mandibular canine with 7.7% followed by the right mandibular canine with 6.2% shows the maximum sexual dimorphism. In the present study also, the left mandibular canine was found to exhibit greater sexual dimorphism (9.796% in casts, 8.891% intraorally).

Gabriel (1958) has stressed that any measurement of teeth unaccompanied by age, race and sex must be treated with great reserve. Amongst the significant findings that can be obtained from teeth are race, age, sex, habits and racial customs. Robinson (1972) has pointed out that in Burma buccally displaced canines are considered lucky. Molnar (1971) found the existence of a positive correlation between tooth wear and cultural factors. The incidence of dental caries is greater in civilized countries due to large intake of sugar in their diet while the Eskimos are known to show the least susceptibility to dental caries. Since the present study has been conducted on both sexes in a definite age group in the North Indian population, it establishes the morph metric criteria of canine size for the North Indian population.

The present study also indicates the probability of sex determination to an extent as high as 100% (when the width of either canine is greater than 7 mm, the sex is male). This finding in North Indian population is of definite significance as 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 the history of mankind 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 (Danielsen, 1973).

Table 3: Comparison of inter canine distance in different ages and populations

<table>
<thead>
<tr>
<th>Age</th>
<th>Population</th>
<th>Author</th>
<th>Inter canine distance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Male</td>
</tr>
<tr>
<td>0-20 Years</td>
<td>Canadian</td>
<td>Anderson and Thompson (1973)</td>
<td>25.080</td>
</tr>
<tr>
<td>17-21 Years</td>
<td>Indian</td>
<td>Kausch et al. (2003)</td>
<td>25.830</td>
</tr>
<tr>
<td>24-34 Years</td>
<td>Norwegian</td>
<td>Olav (1993)</td>
<td>19.060</td>
</tr>
<tr>
<td>17-21 Years</td>
<td>Indian</td>
<td>Bindu et al. (2008)</td>
<td>26.001</td>
</tr>
<tr>
<td>17-30 Years</td>
<td>Indian</td>
<td>Marwaha and Gurus (2010)</td>
<td>34.700</td>
</tr>
<tr>
<td>30-50 Years</td>
<td>Indian</td>
<td>Marwaha and Gurus (2010)</td>
<td>34.520</td>
</tr>
<tr>
<td>17-21 Years</td>
<td>Baramati, Uttar Pradesh</td>
<td>Sevastrika (2006)</td>
<td>25.760</td>
</tr>
<tr>
<td>18-23 Years</td>
<td>Present study</td>
<td>Thoma (2012)</td>
<td>27.87</td>
</tr>
</tbody>
</table>

It is a known fact that teeth provide excellent models for the study of relationship between ontogeny and phylogeny. Eimerl and De Vore (1965) postulated that in the evolution of primates, the canines are functionally not masticatory but are related to threat of aggression and actual aggression. A transfer of this aggressive function occurred from the teeth to the fingers in man and until this transfer was complete, survival was dependent on canines especially in males.

CONCLUSIONS:

Our study conclusively establishes the existence of a definite statistically significant sexual dimorphism in mandibular canines and that MCI
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is of limited value and can only be used as an adjunct with other parameters for the determination of sex in cases of highly mutilated and damaged bodies where jaws are at hand. It is concluded that a canine width greater than 7.3 mm is 100% suggestive of males. Incidence but can be expected to be based on functional activity. findings of this study and those of other populations, the mandibular canine width and intercanine distance have indeed proven beyond doubt high degree of sexual dimorphism, hence a useful material in forensic identification.

REFERENCES:

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