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Sex Determination by Evaluating Inter-Canine Distance and Mesio-Distal Width of Mandibular Canine

ROHINI SINGH¹, KRITI GARG², SHIV KUMAR SINGH³

INTRODUCTION: Establishing one's identity is necessary for legal as well as humanitarian purpose. Sex determining is considered to be one of the major factors employed to assist for the identification of a person. Individual identification heavily relies on the quality of the dental records in the office.

AIM: The purpose of this study was to assess the usefulness of the Mandibular Canine Index(MCI) as an aid in sexual dimorphism in Kanpur population using mesiodistal with intercanine distance of mandibular canines.

MATERIALS AND METHOD: This was an experimental study involving the preparation of plaster casts of 200 males and females each residing in Kanpur, UP, India. Both the genders were in the age group of 17-30 years. The casts for study were prepared and measurements of mandibular canine along with intercanine distance were taken. The MCI calculations were done using standard equations. Statistical analysis used students't-test. All values were considered statistically significant for value of $p < 0.05$.

RESULTS: The present study demonstrated that left MCI predictability for males is more whereas in case of females, right MCI predictability is more, with no significant variation in the intercanine distance.

CONCLUSION: It was found out that mandibular canines exhibit maximum sexual dimorphism, hence, they can be considered as the key teeth for one's identification.

KEYWORDS: Canine, Forensic dentistry, Sexual dimorphism

INTRODUCTION

Identification through uncharacteristic features is the basis of individuality of a person. The question of personal identity arises in courts of law not only in the identification of criminals but also in the identification of the dead bodies. In the case of mass disasters, the problems of identity of the dead arises in the cases of mutilated bodies.¹ There are numerous methods of identifying such cases using various body parts. Usually all of these methods have their own merits and demerits. The tooth is considered to be the hardest and most stable tissue in the human body, so it can be considered as a helpful adjunct in the identification of humans whereas other body parts cannot be used because of their microbial disintegration or mutilation.²

Teeth are considered as an excellent material in case of living as well as nonliving populations for anthropological, forensic, odontologic and genetic investigations. The word forensic is derived from the latin word "forensis" meaning forum which means a market place where, in earlier days, the Romans held their court of justice. Keiser- Neilson stated that "Forensic dentistry is the proper handling and examination of dental evidence in

the interest of justice, so that the dental findings may be properly presented and evaluated". Forensic odontology is the study of dental applications in legal proceedings.¹ Some authors prefer to use the term "forensic odontostomatology" as its purview includes the whole of orofacial region".³

More appropriately it can be said that the overlap between the dental and legal professions represents the forensic dentistry. The science of forensic dentistry deals with relation of teeth and jaws as an evidence to law and justice and one of the principal objectives in the field is personal identification and sex determination. Identification is simplified, if it can possibly predict the sex because then, only missing persons of one sex are to be considered. In this sense, identification of sex succeeds over age. In general the sex of any unidentified body can be identified on the basis of anatomical features such as the external genitals. However, only bones and teeth are available material for the sex determination in remarkably mutilated/decayed or skeletonized bodies. Enamel, the outermost layer of the tooth is the hardest tissue of the human body and it

remains intact even long after death.⁴

Sexual dimorphism defines to differentiate between males and females on the basis of morphological characteristics. Among all the dimorphic traits, size of the tooth evaluation in various populations has its applicability in anthropologic and forensic investigations. The crowns of tooth of the males are seen to be invariably broader than those of females. Canines are also better likely to survive severe trauma, such as disasters, hurricanes or conflagrations. In cases when postcranial bones are fragmentally damaged or unavailable, measurements of the mandibular canine tooth and inter-canine distance can provide a means to determine the sex. Thus to identify the gender by using odontometric techniques is one of the real interest in cases of major catastrophes.⁵

Monali C et al. in their work described various methods to differentiate between sexes on the behalf of visual, microscopic and advanced methods. Clinical or visual method comprises of tooth size, length of root and diameter of crown, canine dimorphism, tooth morphology and odontometric differences. Microscopic method for differentiating between the sexes is barr bodies whereas, advanced methods are polymerase chain reaction and enamel protein evaluation.⁶

They stated that the measurements of the dimensions of the tooth and assessing the certain crown traits present readily applicable, non-invasive technique useful in the process of sex determination. The benefits of determining sex by using these odontometry methods are simple, inexpensive and less time consuming. Sex determination using dental features is mainly based upon the comparison of tooth dimensions. Teeth are best material in populations whether living or non-living for anthropological, genetic, odontogenic and forensic investigations. Forensic dentists are responsible for six main areas of practice: 1) In identifying human remains, 2) To identify mass fatalities, 3) To assess the bite mark injuries, 4) To assess the cases of abuse (child, spousal, elder), 5) Civil cases involving malpractice and 6) To evaluate the age estimation.

Studies concerning sex determination showed variation in sexual dimorphism of mandibular permanent canine teeth among the different

ethnic-populations. Garn et al.⁷ studied sexual dimorphism by measuring the mesio-distal width of the canine teeth in different ethnic groups and found that the magnitude of canine sexual dimorphism and the patterning of dimorphism have a genetic basis. Comparisons have been made between tooth size of various other populations, both of earlier date and modern era. Very few studies have been done to establish the degree of sexual dimorphism of the mandibular canine and inter-canine distance.

This study was undertaken to evaluate the effectiveness of sex identification by using intercanine distance and mesiodistal width of the mandibular canines of Kanpur population. This is of definite significance as tooth morphology is known to be influenced by cultural, environmental and racial factors.

MATERIALS AND METHODS

The mentioned study was conducted in Rama Dental College, Hospital and Research Centre, Kanpur, Uttar Pradesh, India with 400 subjects, 50% males and 50% females contributing to the population respectively.

The study was conducted using stratified random sampling in which the study population was divided into two groups (males and females) and then random sample were selected from each group. The age of each subject was recorded followed by parameter measured.

Inclusion Criteria

- Age range 17-30 years.
- Healthy state of periodontium
- Absence of spacing in anterior teeth
- Angle's molar and canine relationship

Exclusion Criteria

- Caries
- Attrition
- Increased Overjet And Overbite
- Impacted Canine
- Retained Deciduous Canine
- Morphologically Altered Teeth
- Developmental Abnormalities Of Jaws
- Abnormal teeth alignment/Malocclusion.
- Subjects with missing anterior teeth.
- Crowded or excessive spacing in the anterior teeth.

- Subjects with poor oral hygiene
- Subjects with orthodontic treatment.
- Any trauma to canine teeth.

Armamentarium

- Digital vernier caliper with resolution of 0.01 mm
- Curved Spatula
- Disposable Mouth Mask
- Dentulous impression trays
- Alginate
- Bowl
- Dental stone
- Dental plaster
- Base former
- Divider
- Mouth mirror
- Straight probe
- Hypo(disinfectant)
- Tweezer
- Head Cap
- Kidney Tray(Stainless Steel)
- Gloves

Materials

The oral examination of the subjects was carried out using mouth mirror and probe and a brief case history proforma was filled. Impressions of the mandibular arch were taken using alginate (Zelgan 2002) impression paste and casts were prepared using dental stone (Type III). Later the bases of the casts were prepared using base former with dental plaster (Type II).

Methodology

The present study was conducted in Rama dental college, hospital and research centre, Kanpur, Uttar Pradesh, India. The study comprised of 400 subjects, of which 191 were males and 209 females, in the age group of 17-30 years, who were randomly selected after obtaining their informed consent. A detailed case history was recorded to ensure the selection of ideal subjects. Alginate impressions of the mandibular arches were taken using metallic perforated impression trays and the resultant impressions were thoroughly cleaned and disinfected. Type III dental stone was used to make study models from alginate impressions, which were used for conducting the measurements after complete setting. The following measurements were taken from all the casts. Width of the mandibular canines was taken

as the greatest mesio-distal width between the contact points of teeth on either side of the jaw.

Inter-canine distance was measured between the tips of both the canines in lower jaws. All the measurements were taken using a digital vernier caliper with a resolution of 0.01 mm and a divider with a fixing device. Vernier caliper was used as it gives readings with an accuracy of 0.01 mm. Each parameter was measured and later the values were compared and the mean mesiodistal width and the inter-canine distance were taken for calculation.

The mandibular canine index (MCI) was calculated based on the formula used by Rao et al (1999).⁸ It is derived as a ratio between two parameters of permanent mandibular canine teeth, namely the maximum crown width and the canine arch width (measured in mm) and is calculated as follows.

MCI= Mesiodistal Crown Width Of Mandibular Canine/ Mandibular Canine Arch Width

The MCI for each subject was calculated as per the formula given above and the mean male MCI and mean female MCI was determined (annexure-III). Using the mean male and the mean female MCI, standard MCI was calculated which is the sum of the mean male MCI minus standard deviation and the mean female MCI plus standard deviation divided by two. If the calculated MCI for an individual was higher than the standard mandibular canine index the individual will be considered male and if it was lesser than the standard MCI the subject will be considered as female.

STANDARD MCI= (Mean Male MCI-SD) + (Mean Female MCI+SD)/2

The readings obtained were subjected to statistical analysis and sexual dimorphism in the right and left mandibular canines was calculated. Sexual Dimorphism in the right and left canines was calculated using the formula given by Garn and Lewis (1967).⁹

SEXUAL DIMORPHISM= $X_m^{-1} * 100 / X_f$

The statistical analysis of data was entered in Microsoft Excel 2010 and analysed statistically

using SPSS (Statistical Package for Social Sciences, Version 21). Descriptive statistics included calculation of means, standard deviation (S.D), and frequencies (percentage). Significance of differences for the tooth measurements between the genders was tested using Student's t- test. All values were considered statistically significant for a value of $p < 0.05$.

In the present study, a total of 400 subjects were taken as a study group, among which 191 were males and 209 were females covering the range of 17 to 30 years. Casts were prepared for each subject and the mesio-distal widths of the mandibular canines were measured for left and right side. The distance between the two canines i.e. the inter-canine distance was also measured. To rule out the measuring error, the measurements were performed thrice by three different individuals and the mean of the measurements was taken into consideration.

RESULTS

Table 1 shows the mean age (in years) of the study subjects according to gender in the present study which ranges from 17 to 30 years. Out of the four hundred samples, 191 were males with mean age 23.78 ± 4.56 years and the remaining 209 females with mean age 23.49 ± 4.01 years. The mean age of the subjects was 23.63 ± 4.28 years.

Table 2 shows the mesio-distal width (MDW) of right mandibular canine (RMNC) according to gender with the age range 17-30 years. The mean value of mesio-distal width of right mandibular canine of 191 males was 7.68 ± 0.30 mm and that of 209 females was 6.83 ± 0.36 mm.

Table 3 shows the mesio-distal width of left mandibular canine according to the gender with the age range 17- 30 years. The mean value was estimated as 7.70 ± 0.29 mm for 191 males with that of 6.88 ± 0.38 (SD) mm for 209 females.

Table 4 shows Distribution of inter-canine distance (ICD) according to gender of the age range 17- 30 years. The mean value of inter-canine distance for males was 26 ± 0.91 (SD) mm with the range 23.66-27.62 mm and for females, the mean value of inter-canine distance was 25.30 ± 0.85 (SD) mm with range of 23.15-27.25 mm.

Table 5 shows right mandibular canine index according to gender with age of 17-30 years in mm. The canine index of right mandibular canine in females was 0.270 ± 0.015 (SD) mm with average range 0.234-0.303 mm, the right mandibular canine index for males was 0.295 ± 0.010 (SD) mm ranging 0.272-0.308 mm.

Table 6 shows the left mandibular canine index according to the gender with the age ranging 17-30 years in millimeters. The canine index of left mandibular canine in males was 0.296 ± 0.010 (SD) mm with average range 0.271- 0.334 mm, and 0.272 ± 0.015 (SD) mm ranging 0.238-0.327 mm for females.

Table 7 shows the standard canine index according to the gender with the age ranging 17-30 years with right mandibular canine index as 0.285 and left mandibular canine index as 0.2865.

Table 8 shows sex predictability using mandibular canine index with left mandibular canine index predictability is found to be 85.8% for males and 82.5% for females and right mandibular canine index predictability is to be 79.5% for males and 87.0% for females.

DISCUSSION

Identification of an unknown body or living person can be defined as a statement based on certain characteristics which correspond to that of a specific person. Proper identification of dead is required both for legal and humanitarian reasons. Forensic experts have been using finger printing, serologic and DNA comparison, radiographic methods etc. for recognition of the deceased.¹⁰

Forensic odontologists are an important part of the forensic team as dental evidence plays a crucial role in identification of human in a number of situations where other methods are of no help. Dental identifications have always played a key role in natural and manmade disaster situations and in particular the mass casualties normally associated with aviation and fire disasters.¹¹

In the past, sex determination of a victim as an essential stage in identification, has been relied on visual methods, shape of the mandible, pelvic bone etc. in determining the sex of the deceased.

Teeth are known for being the most resistant mineralized tissue against different agents of destruction. They are particularly useful in determination of gender by using different odontometrical techniques, which are of real interest in case of major catastrophes when bodies are damaged beyond recognition.

Human dentition is a morphologically well organized system and responds to genetic changes in an orderly manner. Some genetic variations are general in the dentition, whereas others are specific and affect particular teeth. Among the thirty two permanent teeth, mandibular canines are known to show maximum sexual dimorphism. The mandibular canines consistently exhibit greater sex difference in mesio-distal crown size and canine arch width. Other advantages of using canine teeth in sex determination emanate from the fact that they are least frequently extracted teeth and are rarely affected by periodontal diseases.¹¹

Biological variation is a characteristic of life, whether it is between different species or between different individuals of the same species. Pronounced differences in the tooth dimensions between various populations have been observed in various studies conducted in the past. In the present study, the subjects who have been taken into consideration were from Kanpur population, Uttar Pradesh. Similar study was conducted by Rao et al.⁸ on South Indian population, and Al Rifaiy et al.¹¹ in Saudi population.

The sample size in the present study was 400 subjects comprising of 200 females and 200 males. Al-Rifaiy et al. conducted a study on 503 school students (252 females and 251 males)¹¹ and Rao et al.⁸ considered 766 individuals (384 females and 382) as study subjects in their study. Garn et al.⁷ explored the magnitude of sexual dimorphism in 243 subjects which is almost similar to our sample size.

In the present study an age range of 17 to 30 years was considered, which was comparable to the age range of 15 to 18 years by Al-Rifaiy et al.¹¹ and 15 to 21 years in a study conducted by Rao et al.⁸ Compared to other studies, greater age range was taken into consideration in the present study. This age group was selected as periodontal problems

and attrition is minimum in this age group.

In the present study based on the measurements and statistical analysis, the mesio-distal width of left and right mandibular canine were measured and analysed to be 6.824 ± 0.358 mm for left mandibular canine in females and 7.691 ± 0.313 mm in males whereas 6.794 ± 0.360 mm for right mandibular canine in females and 7.657 ± 0.313 mm in males. These values are in accordance to the values obtained from the study conducted by Al-Rifaiy et al.,¹¹ who calculated the mesio-distal width of left mandibular canine in females to be 6.8310 ± 0.9345 mm. Thus, the range of mesiodistal width of mandibular canine may be helpful in establishing the sex for unidentified bodies in forensics and also in criminal scenes.

CONCLUSION

Identification of gender by odontometric techniques is of real interest in case of major catastrophes when bodies are mutilated beyond recognition. Mandibular canines can be considered as the “key teeth” for the person’s identification as they are known to exhibit maximum sexual dimorphism among all the teeth. In the present study, following conclusions were made:

1. Mesio-distal width of the mandibular canines and inter-canine distance of 400 subjects from Kanpur population were measured successfully and a statically significant difference in mandibular canine mesio-distal width was seen between the two genders, thus implying that sex determination is possible on the basis of the mesiodistal width of the mandibular canine and the mandibular canine index.
2. Left mandibular canine index shows more efficacy in determining the sex of an individual compared to right mandibular canine index.
3. The left MCI was successful in identifying the sex in 90% of females and in 94% of males and the right MCI was successful in identifying the sex in 92% of females and 91% of males.
4. The values of the standard MCI calculated for Kanpur population in the present study varied from those for other populations calculated by different investigators which implies that there are variations in the tooth size of different populations.
5. MCI is a quick, simple and reliable method utilized to determine the sex of an individual in

forensic investigations can help in providing justice to deceased.

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LEGENDS

Gender	No. of subjects (n)	Age in years Mean ± SD
Males	191	23.78 ± 4.56
Females	209	23.49 ± 4.01
Total	400	23.63 ± 4.28

Table 1. Mean age (in years) of the study subjects according to gender

Gender	No. of subjects (n)	MDW Right Mandibular Canine (mm)		t(df)= t-statistic	p-value [†]
		Mean ± SD			
Males	191	7.68 ± 0.30		t(398)=25.333	<0.001*
Females	209	6.83 ± 0.36			

Table 2. Mesio-Distal Width (MDW) of Right Mandibular Canine (RMnC) according to gender

Gender	No. of subjects (n)	MDW Left Mandibular Canine (mm)		t(df)= t-statistic	p-value [†]
		Mean ± SD			
Males	191	7.70 ± 0.29		t(398)=24.099	<0.001
Females	209	6.88 ± 0.38			

Table 3. Mesio-Distal Width (MDW) of Left Mandibular Canine (LMnC) according to gender

Gender	No. of subjects (n)	Inter Canine Distance (mm)		t(df)= t-statistic	p-value [†]
		Mean ± S.D.	Range		
Males	191	26.00 ± 0.91	23.66 - 27.62	t(398)=7.814	<0.001
Females	209	25.30 ± 0.85	23.15 - 27.39		

Table 4. Distribution of Inter-Canine Distance (ICD) according to gender

Gender	No. of subjects (n)	RMCI		t(df)= t-statistic	p-value [†]
		Mean ± S.D.	Range		
Males	191	0.295 ± 0.010	0.272-0.328	t(359.689)=19.480	<0.001
Females	209	0.270 ± 0.015	0.234-0.323		
Total	400	0.282 ± 0.018			

Table 5. Right Mandibular Canine Index according to gender

Gender	No. of subjects (n)	LMCI		t(df)= t-statistic	p-value
		Mean ± S.D.	Range		
Males	191	0.296 ± 0.010	0.271-0.334	t(356.027)= 18.343	<0.001
Females	209	0.272 ± 0.015	0.238-0.327		
Total	400	0.283 ± 0.018			

Table 6. Left Mandibular Canine Index according to gender

Standard CI	Value
RHCI	0.285
LMCI	0.2865

Table 7. Standard Canine Indices

MnCI	Sex	Cases	Percentage
Right MnCI	Males	152 (n= 191)	79.5
	Females	182 (n=209)	87.0
Total		334 (n=400)	83.5
Left MnCI	Males	164 (n=191)	85.8
	Females	173 (n=209)	82.7
Total		337 (n=400)	84.2

Table 8. Sex predictability using Mandibular Canine Index