Int J
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ORIGINAL ARTICLE

Journal Section

Analysis of the gender-identifying abilities of different odontometry methods - A Retrospective cross-sectional Study

Manoj Mahadeo Ramugade, MDS[1*] | **Mansi Mulay, BDS**[1*] | **Kishor D. Sapkale, MDS**[1*] | **Sayed Abrar Bashir Ahmed, MDS**[1*] |

Suryakant Powar, MDS[2*] | **Sapna Sonkurla, MDS**[1*]

[1]Department of Conservative Dentistry and Endodontics, Government Dental College and Hospital, Mumbai-400001, India

[2]Department of Orthodontics and Dentofacial Orthopaedics, Government Dental College and Hospital, Mumbai-400001, India

Correspondence

Dr. Manoj Ramugade, Department of Conservative Dentistry and Endodontics Government Dental College and Hospital, Mumbai-400001, India
Email: manojphd05@gmail.com

Abstract

Introduction: It is critical to identify the person in a criminal investigation process. Forensic odontology helps in the identification of the person using dentofacial structures as a differentiating tool in the criminal justice system. Several oro-dental anatomical landmarks like the palate, lips-bite marks, teeth such as maxillary central incisors, canines and molars have been used in the identification of the gender of an individual based on the principle of individuality. **Aims and objectives**: Studying different odontometric methods such as palatal depth, mandibular canine index and maxillary inter-canine width for sex determination and comparing it with the actual gender of an individual. **Settings and Design:** Retrospective cross-sectional study **Methodology:** For this study, 72 pairs of orthodontic study models were analysed for gender determination based on three odontometric parameters viz. palatal depth, mandibular canine index and maxillary inter-canine width. The patient's sex was not disclosed to the investigators until the completion of the model analysis. The measurements were taken using brass wire, a divider, stainless steel scale and a digital vernier calliper. The data was calculated and tabulated in a master chart and statistical analysis was done. **Result:** The results of odontometric measurement methods used for the gender determination study are in actual agreement with 32.6% male and 63.04% female population of Mumbai and the sub-urban region. **Conclusion:** The palatal depth, maxillary inter-canine width and mandibular canine index are simple, convenient, reproducible and reliable odontometric methods in the gender determination of individuals.

K E Y W O R D S

Forensic evidence; Odontometric method; Sex determination; Tooth

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*All authors have contributed equally.

1 | INTRODUCTION

Every individual is unique and possesses special body characteristics in accord with their species and gender. Sexual dimorphism is a term that generally denotes differentiating features between two sexes other than their reproductive organs. The gender of an individual may be identified from the reproductive system, sexual characteristics, or the soft tissues and skeletal differences between males and females.

In case of a crime scene, bomb explosion, mass disaster, natural calamity and to study ethnic patterns or any situation demanding the identity of the individual, it becomes necessary to have some physical evidence of the body remains for forensic evaluation. In some cases, the body parts recovered during the investigation process do not provide much information about the sex of the deceased. But, the DNA information obtained from tissue or body secretions is used in the identification of their parenthood. In these cases, teeth being non-destructive even after burning or burying; provide a clue and may act as admissible forensic evidence in a Court of law.

Though in many aspects, teeth or the arch pattern of the male and female are similar; they still possess some differences which help to determine their gender. Literature showed numerous studies for gender identification of the individuals by using several hard and soft oral tissues and methods such as; rugoscopy [1,2], cheiloscopy[3,4], palatal depth[5,6], inter-canine width[7,8], inter-molar width[9,10], and mandibular canine index[11-13] etc.

Among various forensic methods using dental hard tissues; palatal depth, mandibular canine index, and inter-canine width are more commonly employed methods. The canine is one of the non-missing, stable, and longest single-rooted teeth in the oral cavity due to their long root with wide labio-lingual dimensions embedded in jaw bones. Thus, they are frequently used for gender determination in cases of severe accidents, natural calamity or even murder cases where only jawbones or their parts are available for forensic investigations.

Other advanced methods of sex determination are DNA analysis, Barr bodies identification, Polymerase chain reaction (PCR), amelogenin protein study, etc. Das et al. in their study have shown that by studying X and Y chromosomes, the sex of the person in question may be determined till after 4th week of their death.[14] Using the PCR technique, a small amount of pulp tissue obtained from the tooth of a dead body, the sex of the individual can be identified.[15] Similarly, a study by Sivagami et al. has shown that DNA prepared from teeth by ultrasonication method followed by PCR is 100% accurate in determining the sex of the person.[16] These advanced techniques are considered as best methods but usually are used in cases of dead victims. Also, in medico-legal cases their utility and reliability are unparallel. Unfortunately, their cost, need for expertise and infrastructure, and time; may limit their use where a very small amount of tissue available for examination and the other simple methods can not be utilized. Thus, this study was planned to analyse the reliability of three simple ododntometric methods i.e. palatal depth measurement, maxillary inter-canine width, and mandibular canine index in the estimation of the actual gender of an individual.

2 | METHOD

For study purpose, orthodontic primary casts (diagnostic models) of patients visited during the period of January 2021 to June 2022, for correction of their malaligned teeth in the Department of Orthodontics and Dentofacial Orthopaedics of the Govt. Dental College and Hospital, Mumbai were randomly selected. The prior permission was obtained from Dept. Orthodontics and Dentofacial Orthopaedics for the study. Ethical clearance was not required for this retrospective study conducted on models. The study models were comprised of a set of 72 casts (maxillary and mandibular for each) i.e. 144 models of patients from Mumbai, the Mumbai suburban, and Navi Mumbai region of India. The information about the patient's gender was kept blind and unrevealed to the investigators until the completion of the model analysis of all casts. Inclusion and exclusion criteria were applied while selecting the study casts as follows.

Inclusion criteria:

1. Casts of patients visiting the Department of Orthodontics and Dentofacial Orthopaedics during the period of January 2021 to June 2022.
2. Those patients living in Mumbai, Mumbai suburban

or, Navi Mumbai region

3. Cast models having a complete set of dentition till the second permanent molars in both the arches

Exclusion criteria:

Cast models having visible,

1. Extensive restorations in any tooth
2. Fractured anterior tooth
3. Teeth with severe crowding
4. Any missing permanent tooth
5. Wearing of teeth i.e. attrition or erosion
6. Bi-maxillary proclination
7. Cleft lip or palate cases

3 | SAMPLE SELECTION AND PREPARATION

The pair of models was selected according to inclusion and exclusion criteria. The assigned case numbers of the patient (already marked on the cast) were masked temporarily with opaque surgical tape. Then these pair of models were randomly re-numbered from No. 1 to No.72 to avoid any bias. All models were analyzed by two different investigators i.e. an experienced restorative dentist and an orthodontist. For analysis, points of references and methods of measurement were fixed. To avoid an intra and inter-examiner bias, a pilot study comprised of 15 random samples other than the study groups were analyzed by both investigators and their results were compared. In case of difference in opinion, the average was calculated and then the gender of an individual was determined and compared with actual gender.

4 | METHODS OF MEASUREMENT

For gender determination in the study, three methods of measurement were used:

1. Palatal depth (PD)
2. Inter-canine width (ICW)
3. Mandibular canine index (MCI)

Dental arch dimensions, palatal width, and inter-canine width were measured by using brass wire, a stainless steel scale and a digital vernier calliper.

a PD measurement: Palatal depth was measured using a straight brass wire and scale from the reference taken as maxillary first molar's mesio-palatal cusp tips to the deepest point on the mid-palatine raphe (Fig. 1).

b ICW measurement: The distance between two maxillary canine tips was measured using a digital vernier caliper (Fig. 2).

c MCI measurement: It is a ratio of mesiodistal (MD) width of the mandibular canine to mandibular intercanine width using the digital vernier calliper (Fig. 3). These measurements were taken for both the right and left sides.

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

Standard MCI was calculated as follows Standard MCI = (Mean Male MIC+ SD)-Mean Female MIC+SD)/2 Statistical analysis was done using XLstat software with excel spread sheets on Microsoft excel 2010

5 | STATISTICAL ANALYSIS

In this study, both descriptive as well as inferential statistical analyses were applied. Results in both categorical and continuous measurements were showed in numbers (%) and Mean and SD respectively. P value of statistical significance was kept at p=0.05 and values equal or less to it were considered as statistically significant. A Chi-square test was applied to evaluate the parameters on a categorical scale. Also, Student t-tests were (two-tailed, unpaired) used to comparatively evaluate the significance of parameters between the two groups. Data analysis was done using software, IBM SPSS statistics 20.0 (IBM Corporation, Armonk, NY, USA).

6 | RESULTS

After calculating all measurements, it was revealed to the investigators that out of 72 pair of models, there were 26 pairs of male patient casts and 46 pairs of female patient cast for the study analysis. These values were compared with previous studies to identify the gender of the person and then compared with the actual gender.

In the present study, the mean palatal depth (MPD) for males was 22.13 mm (range 20.1-26.6 mm) and 20.59 mm for females (range 16.22 - 22.58 mm). The mean

inter-canine width (MICW) in males was 34.30 mm (range 24.85 - 40.46 mm) whereas; in females, it was 33.38 mm (range 28.04 - 36.58 mm). Also, considering both sides MCI; no significant difference exhibited and they were measured to be 0.16 and 0.28 for males. On the right side, MCI was in the range of 0.16 - 0.28 for males and 0.15 - 0.22 form females and on the left side, MCI for males and females was 0.16 - 0.28 and 0.17 - 0.22 respectively. These measurements were compared with previous studies values to determine whether the cast belongs to a male patient or a female patient (Table 1).

It was observed that the sex determination was accurate in 73.1% of males and 58.7 using a combination of all examined methods of the study (Table 2). The overall accuracy of the combination of the methods in males was 52.8% and 42.7% for females. The statistical data showed that using these three methods in 63.9% (64%) of cases actual gender can be determined (Table 3).

7 | DISCUSSION

Gender determination is a crucial task in medicolegal cases and cases of suspected death, mass disasters etc. Forensic odontology i.e. study of teeth and facial structures in relation to law and justice is an important field in forensic medical science. Information regarding age, gender, height or facial profile etc. could be guessed and identified using teeth and surrounding bony structures.

Survival of teeth even after burial or destruction by fire, help the forensic expert to identify the individual by studying the teeth and jaw pattern. Usually, teeth are similar in both genders except in their size and prominent shape in males. Females usually have smaller teeth, less palatal depth, low prominence of canine ridges with rounding etc. Thus, three methods i.e. PD, ICW and MCI were used in the sex determination of this study.

Literature showed that numerous studies were conducted in the Indian population and the results of the present study are compared with them.[17-21] In a study by Patel et al.[22] compared the accuracy of tooth measurements of teeth done on the model cast and clinically in the oral cavity and found no statistically significant difference but exhibit a high degree of accuracy with cast measurements. Advantages of using patient's casts being it simple, able to reproduce measurements, minimising in-

fection transmission and convenient method. In our study as this was a blind procedure for the investigators, the examination of the cast to identify the gender from the casts was recommended. In the present study, measurements were done using digital vernier calliper as it is a convenient, simple, accurate and reproducible method.[23]

In the study, the mean palatal depth (MPD) for males was 22.13 mm (range 20.1-26.6 mm) and 20.59 mm for females (range 16.22 - 22.58 mm) which was comparable with values reported in a study by Mankapure P. K. et. al.[6] In their study, the measured mean palatal depth (MPD) values reported in males and females were 18.17 ± 1.85 mm (range 13.2 - 22.0 mm) and 17.99 ± 1.58 mm (range 14.0 - 22.5 mm) respectively.[6] In the presented study, though MPD values were statistically insignificant among males and females. Similar observations were noted in this study where males showed greater PD values as compared to females.[24,25] Conversely, significant gender difference in PD values were shown in some studies.[25,26]

The present study showed mean inter-canine width (MICW) values in males and females as 34.30 mm (range 24.85 - 40.46 mm) and 33.38 mm (range 28.04 - 36.58 mm) respectively and exhibited higher values for both the genders when compared with studies by Bano et al.[10] and Singh et. al.[7] In a study, it was observed that the ICW in maxillary teeth was in the range of 34.22 ± 1.50 mm for males and 34.49 ± 1.40 mm for the females.[10] In another study carried out in the Indian population by Singh et al. reported that the mean ICW for males was 26 ± 0.91 mm (23.66-27.62 mm) and 25.30 ± 0.85 mm (23.15- 27.25 mm) for females.[7] Also, when the results obtained from the present study for mean ICW values compared with the actual gender of an individual, discrepancies were exhibited and thus, it may not be used reliably to estimate the gender of a person.

Patel et al. in their study reported that in Indian individuals the mean inter-canine distance (MID) in males was 26.361 (±2.09) mm and 25.654 (±1.98) mm in females. The mean of the standard MCI was found to be 0.254. It was observed that MCI correctly predicted the gender of an individual in 80% of males and 77.5% of the female population. The overall accuracy of MCI method in the study population was 78.8%.[22] In the present study, con-

sidering MCI on right and left sides was similar i.e. 0.16 -0.28 for males and for females, it was in the range of 0.15 - 0.22 and 0.17 - 0.22 respectively. There are several studies that used MCI for gender estimation.[17-21] Yadav et al.[19], Rao et al.[20], and Kaushal et al.[21] in their extensive studies shown that the MCI in males was 0.310 ± 0.016, 0.296 ± 0.016 and 0.28 ± 0.01 whereas; in females, it was 0.288 ± 0.014, 0.254 ± 0.014 and 0.26 ± 0.01 respectively. This study also showed that left side MCI value was same as for the right side in males but for females, it was in the range of 0.17 - 0.22. Also, the values of left side MCI were observed to be more predictive in determining the gender of an individual.

The studies conducted in the Indian population found that MCI was accurate in 75% to identify gender.[21,27] Similar studies were conducted to identify gender sex prediction in subjects of Punjabi–Pakistani population[28] and South Indian population[19,20] and found the sex determination accuracy in 76%, 85.9% and 82.2% subjects respectively. Whereas; Muller et al. studied the French population and showed that in only 59.57% of cases MCI is predictable.[29]

The observations of the study revealed that sex identification using inter canine width showed poor statistical significance. Within the limitations of a small sample size of this retrospective study, to assess the reliability and for their universal application; larger sample size is recommended which may cover a wide geographic area for future studies.

8 | CONCLUSION

Odontometric methods such as palatal depth and mandibular canine index are simple, convenient and reproducible forensic methods that can be reliably used for sex determination. However, a combination of two or more methods is highly conclusive for achieving accurate results than using a single method for sex determination. For a larger sample size, these odontometric methods are preferable due to their simplicity and cost-effectiveness.

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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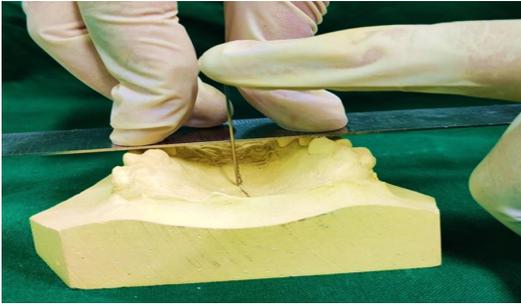
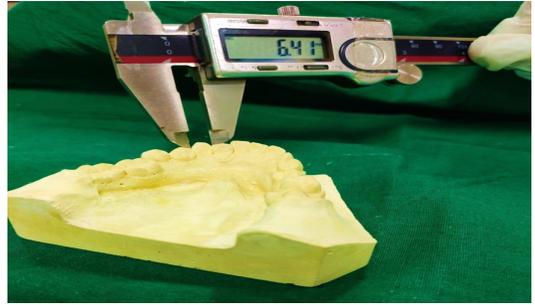**FIGURE 1** Measurement of palatal depth (PD).
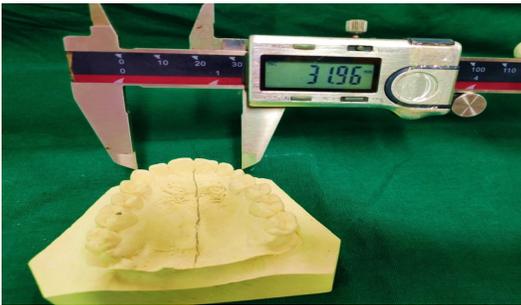

FIGURE 3 Measurement of mandibular canine width.

FIGURE 2 Measurement of maxillary inter-canine width (ICW)