Original Research Article

Comparative assessment of odontometric parameters for gender determination: A hospital based cross-sectional study

Mosmi Lomi[1],*, Jonathan Daniel M[1]

[1]*Dept. of Oral Medicine and Radiology, Mahatma Gandhi Postgraduate Institute of Dental Sciences Pondicherry, Pondicherry, India*

A B S T R A C T

Introduction: Determining gender is one of the most important procedure in forensics. Teeth are made of the most enduring mineralized tissues in the body, as such, they have an extraordinary resistance to putrefaction and the effects of external agents (physical, thermal, mechanical, chemical or biological) which makes them invaluable material for anthropological, genetic, odontologic and forensic examinations.

Aim and Objective: i) To assess the degree of sexual dimorphism in maxillary canine using maxillary canine index, maxillary first molar and central incisor using mesiodistal (MD) and buccolingual/buccopalatal (BL) dimensions of the crown. ii) To determine the accuracy of maxillary canine index, first molar and central incisor dimensions (mesiodistal and buccolingual/buccopalatal) in determining sex.

Materials and Methods: This study consisted of total 30 participants (males=15, females=15) of age group ranging from 20 to 35 yrs. Measurement of dimensions of selected teeth were performed on maxillary cast using digital Vernier caliper, resolution 0.01mm. Data thus obtained were analyzed statistically.

Results: The mean values of all the measurements in males were greater than females. There was statistical significant difference in mean value of bucco-lingual width of molar, mesiodistal width of canine (on left side, right side and average) and the inter-canine distance between males and females. The buccolingual width of molar showed the highest % of sexual dimorphism (5.33%) and the mesiodistal width of molar showed the least % of dimorphism (0.7%). Bucco-lingual width of molar posed the highest prediction accuracy for gender determination.

Conclusion: We conclude that buccolingual width of maxillary first molar can be used to predict the gender when only teeth of maxillary arch are available for forensic examination.

1. Introduction

Identification of an individual is a pre-requisite for certification of death and for personal, social and legal purposes. This establishment of identity is accomplished by several parameters including age, sex, dactylography, footprint, stature, tattoo marks, scars etc.[1] The initial step in the process of forensic human identification is gender determination.[2] Correct gender identification excludes the

pool of missing persons to just one half of the population. In forensic contexts, however, it is common to recover partial remains, with fragmentary skull and pelvic bones. Teeth being the central component of the masticatory apparatus of the skull are good sources of material for civil and medico-legal identification purposes. Additionally, the degree to which they provide resistance to destructive force in terms of bacterial decomposition, fire, and fracture, make them valuable for forensic examination and research.[1] Sexual dimorphism, it refers to those differences in size,

* *Corresponding author.*
E-mail address: nanulomi@gmail.com (M. Lomi).

stature, and appearance between male and female that can be applied to dental identification since no two mouths are alike.[3] Tooth size standards based on odontometric investigations can be used in age and sex determination because human teeth exhibit gender dimorphism.[4]

The aim and objective of this study: i) To assess the degree of sexual dimorphism in maxillary canine using maxillary canine index, maxillary first molar and central incisor using mesiodistal (MD) and buccolingual/buccopalatal (BL) dimensions of the crown. ii) To determine the accuracy of maxillary canine index, first molar and central incisor dimensions (mesiodistal and buccolingual/buccopalatal) in determining sex.

2. Materials and Methods

This study included 15 male and 15 female participants with age ranging from 20 to 35 yrs, who came to our department. The following criteria were considered for the selection of participants.

2.1. Inclusion criteria

1. Subjects willing to participate in the study.
2. Complete set of fully erupted permanent teeth atleast upto second molars.
3. Periodontally healthy, non carious, non restored, intact, satisfactorily aligned maxillary teeth.

2.2. Exclusion criteria

1. Subjects with evidence of developmental anomalies, history of maxillofacial trauma or surgery, orthognathic surgeries, orthodontic treatment, malocclusions.
2. Teeth with abrasion and erosion, severe attrition.

Following informed consent from each of the selected participant, full upper arch impression was made using alginate impression material which was poured immediately with dental stone to avoid dimensional alteration. Then, measurement of all the required dimensions were taken from teeth from both left and right on the maxillary cast using digitals calipers, resolution 0.01mm (Figure 1). All measurements (mm) were carried out by a single examiner to avoid inter-observer error.

2.3. Mesiodistal (MD) dimension of crown

It was measured as the greatest distance between mesial and distal surfaces of crown[5] (figure:1). Both left and right MD dimensions of each tooth was measured, average value was taken for calculation for each tooth.

2.4. Buccolingual (BL) dimension of crown

It was measured as the greatest distance between buccal and lingual surfaces of crown parallel to the long axis of the tooth[5] (Figure 2). Both left and right BL dimension of each tooth was measured.

Fig. 1:

Fig. 2:

2.5. Intercanine distance

It was measured by placing the beaks of digital vernier caliper at the cusp tips, and the linear distance between the left and right canine was measured.[6] (Figure 3)

Maxillary canine index (CI)[6] =
$$\frac{MD\ of\ maxillary\ canine}{Intercanine\ distance\ in\ maxillary\ arch}$$

Fig. 3:

Data obtained was analyzed statistically using descriptive analysis, t test and linear discriminant analysis using IBM SPSS version 20.0 (IBM Corp. Released 2011.IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp). P<0.05 was considered significant.

The percentage of sexual dimorphism was calculated using the following formula: [1]

% Sexual dimorphism = [(Xm / Xf) – 1] × 100

Where Xm = mean male tooth dimension, Xf = mean female tooth dimension.

To assess the gender using tooth dimensions, discriminant formula was used i.e.

y = a + b (p)

Where "a" is the canonical discriminant constant, "b" is the unstandardized coefficient, and P is the parameter. The "y" value thus obtained from calculation after applying the discriminant formula for various parameters was compared with group centroids as given in Table 3. The approximate of the "y" value to a particular group centroid value helps us determine the gender of the person.

3. Results

Table 1 shows descriptive statistics. The mean values of all the measurements in males were greater than females. There was a statistically significant difference in mean value of bucco-lingual width of molars (on left side, right side and average) between males and females. Mesiodistal width of canine (on left side, right side and average) and the inter-canine distance were also showed significant difference between males and females (P<0.001). Other variables/parameters did not differ significantly with gender. This indifference could have arisen partly due to the smaller sample size.

Table 2 shows dimorphism of various parameters. As seen from the Table 2, the buccolingual width of molar showed the maximum sexual dimorphism (5.33%) and the mesiodistal width of the molar showed the least % of dimorphism (0.7%).

Table 3 shows constants used in the formulae and centroid value for male and female.

Figure 4 shows graphical representation of accuracy of all the parameters of this study. Except for the mesiodistal width of molar, which is close to 50% (53.8), all other parameters are fairly likely to predict the gender. Buccolingual width of molar posed the highest prediction accuracy for gender determination.
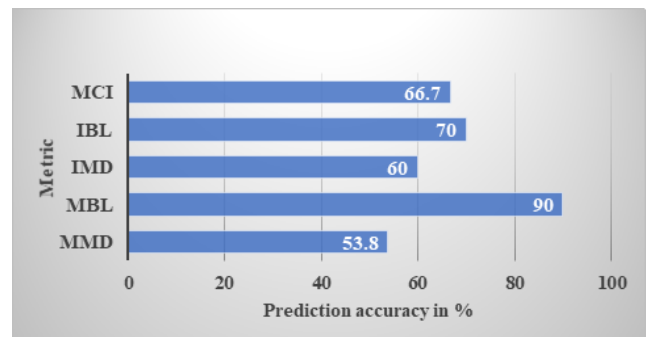
Fig. 4: Graphical representation of accuracy of all the parameters of this study MCI – Maxillary Canine Index
IBL – Buccolingual width of Incisors
IMD – Mesiodistal width of Incisors
MBL – Buccolingual width of Molars
MMD - Mesiodistal width of Molars

4. Discussion

The initial step in the process of human bodies identification in forensic is gender or sex determination. Gender determination, even performed before age and stature [2] as subsequent methods for age and stature estimation are often gender dependent. [3] Various methods are used to establish the identity of unidentified remains. The only method with totally accurate result is the DNA technique, however in many cases and for various reasons, it cannot be used. [7] Teeth are the hardest organ in the body and crucial in post-mortem identification procedure. Although Pelvic and cranial bones can be more accurate in identifying gender, they are rarely in optimal condition in extreme case, such as natural disasters or mass graves, which may prevent their accurate estimation for gender differentiation. In such circumstances, teeth are considered quite useful as they are often recovered intact. [8] Identification of gender with the help of dental features can be categorized into metric and non metric methods. Non metric features methods are based on presence or absence of particular morphological dental features such as cusp of carabelli, upper incisor shovelling, hypocone and protostylid whereas metric features are based on tooth measurements. Identification of particular population or ethnicity can be done using non metric

Table 1: Descriptive statistics

Parameters	Gender	N	Mean	SD	SEM	P Value (t test)
Molar Mesiodistal width-Right	Male	15	10.0133	.25598	.06609	0.18
	Female	15	9.9133	.13020	.03362	
Molar Mesiodistal width-Left	Male	15	9.9667	.18387	.04748	0.461
	Female	15	9.9267	.09612	.02482	
Molar Buccolingual width -Right	Male	15	11.2400	.15946	.04117	0.000
	Female	15	10.6533	.26421	.06822	
Molar Buccolingual width -Left	Male	15	11.2467	.19591	.05058	0.000
	Female	15	10.6933	.27377	.07069	
Incisor Mesiodistal width -Right	Male	15	8.0867	.50124	.12942	0.198
	Female	15	7.8600	.43720	.11288	
Incisor Mesiodistal width-Left	Male	15	8.0667	.48058	.12408	0.188
	Female	15	7.8467	.40860	.10550	
Incisor Buccolingual width- Right	Male	15	6.2267	.41998	.10844	0.123
	Female	15	5.9867	.40685	.10505	
Incisor Buccolingual width -Left	Male	15	6.2067	.45429	.11730	0.155
	Female	15	5.9867	.364230	.09404	
Maxillary Canine Index - Right	Male	15	.22258	.008880	.002293	0.153
	Female	15	.21764	.009498	.002452	
Maxillary Canine Index – Left	Male	15	.22220	.009078	.002344	0.213
	Female	15	.21784	.009638	.002489	
Canine Mesiodistal Width-Right	Male	15	7.6000	.15119	.03904	0.000
	Female	15	7.0067	.23745	.06131	
Canine Mesiodistal Width-Left	Male	15	7.5867	.15055	.03887	0.000
	Female	15	7.0133	.25317	.06537	
Inter-Canine Arch Width	Male	15	34.1933	1.45968	.37689	0.000
	Female	15	32.2133	.76799	.19829	
Canine Mesiodistal Width - Average	Male	15	7.593	.14622	.03775	0.000
	Female	15	7.010	.2429	.06272	
Maxillary Canine Index - Average	Male	15	.2224	.00891	.00230	0.178
	Female	15	.2177	.00951	.00245	
Molar Mesiodistal Width- Average	Male	15	9.9900	.21314	.05503	0.256
	Female	15	9.9200	.10823	.02795	
Molar Buccolingual Width- Average	Male	15	11.2433	.16889	.04361	0.000
	Female	15	10.6733	.25765	.06652	
Incisor Buccolingual Width- Average	Male	15	6.2167	.43122	.11134	0.133
	Female	15	5.9867	.38194	.09862	
Incisor Mesiodistal Width- Average	Male	15	8.0767	.48619	.12553	0.187
	Female	15	7.8533	.41510	.10718	

Average= average of right and left

Table 2: Dimorphism of various parameters

Parameter	Dimorphism
Canine Index	2.15%
Molar mesiodistal width	0.7%
Molar buccolingual width	5.33%
Incisor buccolingual width	3.84%
Incisor mesiodistal width	2.84%

Table 3: Constants used in the formulae and centroid value for male and female

Parameters	Constant-a (Canonical Discriminant constant)	Constant-b (Unstandardized coefficient)	Centroid value	
			Male	Female
Canine Index	-23.882	108.523	0.295	-0.295
Molar mesiodistal width	-58.895	5.916	0.290	-0.290
Molar buccolingual width	-50.306	4.591	1.384	-1.384
Incisor mesiodistal width	-17.62	2.212	0.248	-0.248
Incisor buccolingual width	-14.98	2.455	0.291	-0.291

features. However, the use of the metric approach in gender estimation is more structured, less subjective and additionally, it can be repeated to validate the obtained results.[9] Hence, our study was carried out based on metric approach.

According to our results, all the measurements of every tooth included in the study were higher in males than females. The statistical significant difference was observed in buccolingual width of molars, mesiodistal width of canines, inter-canine distance.

In the present study, the mesiodistal and buccolingual width of central incisors showed no significant difference between genders which is inconsistent to various other earlier studies.[2,9–11] Dash, et al.[2] Gloria et al.[10] S.K. Padmakumar et al.[11] found significant gender difference in both mesiodistal and buccolingual dimension of maxillary central incisors whereas Srivastava R et al.[9] carried out investigation where they studied gender dimorphism in mesiodistal dimensions and observed highly significant difference in both left and right upper central incisors between males and females (P < 0.001).

As observed in the current study, the p value of maxillary canine index (right, left and average) were 0.153, 0.213 and 0.178 respectively indicating no significant difference in maxillary canine index between sexes. Our results for maxillary canine index were in agreement with studies undertaken by Yuvenya et al.[12] in the Malaysian population of Selangor, S.M. Bakkannavar et al.[13] in South Indian population but inconsistent to that of Peter et al.[14]

Although, there was no significant difference in canine index between genders in our study, significant differences were observed in canine mesio-distal crown width and inter-canine arch width between genders with males being higher mean values than females. Results in our study were in agreement with Abhishek Banerjee et al.,[4] Rahul Srivastava et al.[9] for mesiodistal crown dimension, Prakash Chandra et al.[15] for mesio-distal dimension and inter-canine arch width. This sexual dimorphism in teeth has been explained by various theories: 1) According to Moss, because of the longer period of amelogenesis there is a greater thickness of enamel in males compared to females, leading to a difference in dimensions. 2) Sex chromosomes are also responsible for the different effects on the tooth size. Compared to the 'X' chromosome, the 'Y' chromosome influences the timing and rate of body development, thus producing slower male maturation.[9]

Amongst the selected parameters included in our study, buccolingual width of maxillary first molar exhibited the highest degree of sexual dimorphism with highest accuracy in determining gender. The sexual dimorphism observed in molar was found to be 0.7% for mesiodistal width and 5.33% for buccolingual width. Phulari et al.[6] assessed the probability of determining sex using maxillary canine index, buccolingual and mesiodistal dimensions of maxillary first molar in their study. Buccolingual dimension of maxillary first molar was found to be the most dimorphic parameter (11.66%) with higher gender prediction accuracy of 82% among the selected parameters in their study. They concluded that BL dimension of maxillary first molar is a more reliable indicator for gender determination than other molar and canine dimensions in maxilla. In the current study we also observed similar finding that buccolingual (BL) dimension of first molar is more reliable indicator giving an accuracy of 90% in predicting gender membership.

5. Limitation of the Study

Sample size was limited as this was a hospital based study on patients visiting a teaching hospital.

6. Conclusion

In the present study, buccolingual width of maxillary first molar exhibited statistically significant gender dimorphism. The percentage of sexual dimorphism was higher than other parameters included in the study with prediction accuracy of 90%. This result led us to conclude that buccolingual width of maxillary first molar can be used to predict the gender when only maxillary teeth are available for forensic examination.

7. Source of Funding

None.

8. Conflict of Interest

The author declares no conflict of interest.

References

1. Narang RS, Manchanda AS, Malhotra R, Bhatia HS. Sex determination by mandibular canine index and molar odontometrics:

A comparative study. *Indian J Oral Sci*. 2014;5(1):16–20.

2. Dash KC, Panda A, Behura SS, Ramachandra S, Bhuyan L, Bandopadhyay A. Employing dimensional disparity of teeth to establish the gender in Odisha population: A dimorphic study. *J Int Soc Prevent Communit Dent*. 2018;8(2):174–8.

3. Mehta S, Kaur S, Verma P, Khosa R, Sudan M, Kaur H. Evaluation of sexual dimorphism using permanent maxillary first molar in Sri Ganganagar population. *Indian J Dent Res*. 2017;28(5):482–6.

4. Banerjee A, Kamath VV, Satelur K, Rajkumar K, Sundaram L. Sexual dimorphism in tooth morphometrics: An evaluation of the parameters. *J Forensic Dent Sci*. 2016;8(1):22–7.

5. Metgud R, Surbhi, Naik S, Patel S. Odontometrics: A useful method for gender determination in Udaipur population. *J Forensic Investigation*. 2015;3(2):1.

6. Phulari RG, Rathore R, Talegaon T, Jariwala P. Comparative assessment of maxillary canine index and maxillary first molar dimensions for sex determination in forensic odontology. *J Forensic Dent Sci*. 2017;9:110.

7. Shireen A, Ara SA. Odontometric analysis of permanent maxillary first molar in gender determination. *J Forensic Dent Sci*. 2016;8(3):145–9.

8. Neves JA, Ferreira NA, Machado V, Botelho J, Proença L, Quintas A. Sex prediction based on mesiodistal width data in the Portuguese population. *Appl Sci*. 2020;10:1–7.

9. Srivastava R, Jyoti B, Jha P, Gupta M, Devi P, Jayaram R. Gender determination from the mesiodistal dimension of permanent maxillary incisors and canines:An odontometric study. *J Indian Acad Oral Med Radiol*. 2014;26(3):287–92.

10. Staka G, Asllani-Hoxha F, Bimbashi V. Sexual dimorphism in permanent maxillary central incisor in Kosovo- Albanian population.

Int J Morphol. 2016;34(3):1176–1180.

11. Padmakumar SK, Nair KN, Pragya. Assessment of sexual dimorphism using odontometric parameters. *IOSR JDMS*. 2019;18(2):50–52.

12. Kaeswaren Y, Weinheimer AZ. The use of mandibular and maxillary canine teeth in establishing sexual dimorphism in the Malaysian population of Selangor. *J Forensic Sci & Criminal Inves*. 2019;11(3):1–007.

13. Bakkannavar SM, Manjunath S, Nayak V, Kumar GP. Canine Index-A tool for sex determination. *Egypt J Forensic Sci*. 2014;doi:10.1016/j.ejfs.2014.08.008.

14. Otuaga PO, Chris-Ozoko LE, Sakpoba O, Oyem JC. A comparative study of the canine tooth as a tool in gender determination in Nigerian population. *Galician Med J*. 2019;26(2):1–7.

15. Jha PC, Sanghamesh NC, Alok A, Singh S, Bharti BB, Raj R. Dimorphism of Canine: A Diagnostic Value in Gender Identification - A Clinical Study. *Int J Sci Stud*. 2015;3(8):81–4.

Author biography

Mosmi Lomi, Postgraduate Resident

Jonathan Daniel M, Professor and Head