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Accuracy of canine, premolar and molar indices in sex determination

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Abstract

Introduction: Sex determination is a subdivision of forensic odontology and it is very important especially when information relating to the deceased is unavailable.

Aim and Objective: To determine canine, premolar and molar indices in upper and lower arch and to evaluate the accuracy of canine, premolar and molar indices in determining sex.

Materials and Method: This study includes 28 patients of both sexes, age range between 18-45 years. Upper and lower impressions were made using alginate and the obtained casts were subjected to determine the canine, premolar and molar indices.

Results: In lower arch, there is a high significant gender difference at 1% level for mesio-distal width of canine and premolar index and 5% significance for molar index and premolar arch-width.

Conclusion: This study shows >70% of accuracy in sex determination using mandibular premolar index, premolar arch width and mandibular mesio-distal width of canine.

Keywords: Tooth index, Odontometric analysis, Sexual dimorphism

Introduction

The four leading features of biological identity are sex, age, stature, and ancestry background. The forensic anthropologists wish to authenticate these traits for an individual from their skeletal remains. Assessment of sex has significant contribution in construction of a physical profile of the decedent along with other parameters like race, stature and age.(1)

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.(2) During the last few years DNA techniques have been developed providing accurate sex determination, but usually some skeleton measurements are enough for sex identification. Determination of sex is not a problem when a complete skeleton is available, primarily with measurements from the pelvis and the skull.(3) An alternative option is to use teeth size. Dental sexual dimorphism has been extensively studied by means of odontometric analysis, and most studies have shown statistically significant differences in the permanent dentitions.

First step in human identification is gender determination. Determination of sex using skeletal remains presents a great problem to forensic experts especially when only fragments of the body are recovered. Forensic dentistry can help to determine the sex of the remains by using teeth and skull. Various features of teeth like morphology, crown size, root length etc., are characteristics for male and female sexes. There are also differences in skull patterns. These will help the forensic odontologists to identify the sexes. New developments like PCR amplication etc. will assist in accurately determining the sex of the remains. Forensic odontology plays an important role in establishing the sex of victims with bodies mutilated beyond recognition due to major mass disaster.(4)

Sex can be assessed with high precision using pelvic and cranial bones. But the demerit of using these bones is that they easily get fragmented which may be major hindrance for assessment of sex. The dentition is considered as an useful adjunct in skeletal sex estimation, particularly since teeth are resistant to post-mortem destruction and fragmentation.(1)

Schrantz and Bartha proposed seven dental morphological types used for sex determination—the BL diameters of teeth are smaller in females than males; the upper central incisor is larger than the upper canine in females, while the MD diameters are equal in males; the difference of MD diameter of the upper central incisor and the upper lateral incisor is about 2.1 mm in females and 1.8 mm in males; the difference of the MD diameter of the lower canine and the lower lateral incisor is smaller in females (0.7 mm versus 1.8 mm in males); the fusion of second molar roots is more frequent in females; the frequency of hypoplasia and agenesia of the third molar is higher in females; the phenomenon of hyperdontia is more frequent in males.(5)

Sex determination using dental features is primarily based upon the comparison of tooth dimensions in males and females, or upon the comparison of frequencies of nonmetric dental traits, like Carabelli's trait of upper molars. Mesiodistal and buccolingual diameters of the permanent tooth crown are the two most commonly used and studied features in determining sex on the basis of dental measurements.(5) With this background we intend

to compare the accuracy of canine, premolar and molar indices both in upper and lower arch in determining sex. Our aim is to determine the mesio-distal width of canines, inter-canine arch width, premolar arch width, molar arch width, incisor arch width, canine, premolar and molar indices in upper and lower arch and to evaluate the accuracy of canine index, premolar index and molar index in maxillary and mandibular arch.

Materials and Methods

The present study includes 28 individuals of both sexes, age range between 18-45 years (14 males and 14 females). The volunteers were selected from the individuals who attended the dental treatment at our institute. We included the individuals with complete dentulous arches without any missing teeth and caries free teeth, normal over jet and overbite and absence of spacing in the anterior teeth. We excluded the individuals with carious, restored and missing teeth, teeth with gross attrition and who had history of maxilla-facial trauma.

Informed consent was obtained from the individuals. Upper and lower impressions were made using alginate and the cast was poured using type 3 dental stone. The obtained casts, when dried, were subjected to determine the canine, premolar and molar indices. To attain the above mentioned indices, the following measurements were done in the dried casts using a digital vernier caliper.

- Mesial-distal width of canine (upper and lower).
- Inter-canine distance (upper and lower).
- Premolar arch width (upper and lower).
- Molar arch width (upper and lower).
- Combined width of incisors (upper and lower).

Mesio-distal canine width: Mesio-distal canine width or the maximum width of canine teeth will be taken as mesio-distal width on right side of the jaw (Fig. 1).

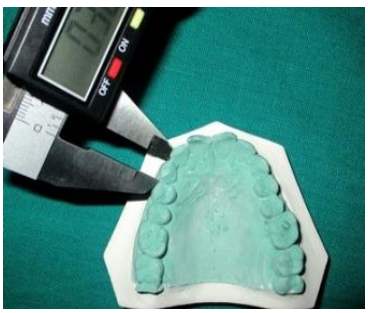

Fig. 1: Mesio-distal canine width

Fig. 2: Inter-canine distance

Inter-canine distance: The inter-canine distance will be measured as the straight line distance between the 2 canines at the most pointed tip of both the canines (Fig. 2).

Premolar arch width: The premolar arch width will be taken as the straight line distance between the left first premolar and right first premolar at the distal end of the occlusal groove (Fig. 3).

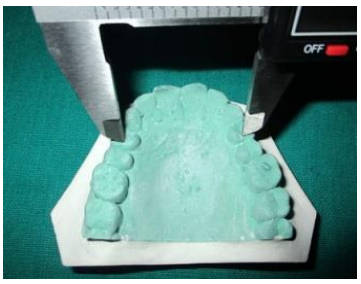

Fig. 3: Premolar arch width

Molar arch width: The molar arch width will be taken as the straight line distance between the left first molar to the right first molar at its mesial pit on the occlusal surface (Fig. 4).

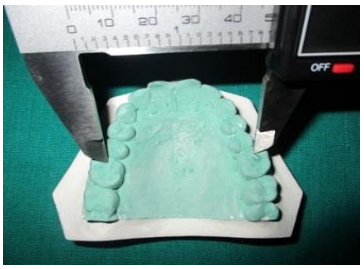

Fig. 4: Molar arch width

Combined width of the incisors: The combined width of the incisors (central and lateral) will be taken at the distal contact points with the canines on either side (Fig. 5).

Fig. 5: Combined width of the incisors

Canine index:

Canine index = Mesio-distal crown width of canine / Canine arch width

Premolar index:

Premolar index = Sum of incisal width x 100 / Premolar arch width

Molar index:

Molar index = Sum of incisal width x 100 / Molar arch width

Statistical analysis: All the measurements were noted and the statistical analysis was done using SPSS version 16 to evaluate the data using, Student's unpaired 't' test, and Regression analysis was attained.

Results

There is a significant gender difference with p-value<0.05 on values of canine arch width, premolar arch width and molar arch width (Table 1). There is a high significant gender difference at 1% level for mesio-distal width of canine and premolar index and 5% significance for molar index and premolar arch-width (Table 2). The mean values of almost all parameters are higher for males when compared with females (Table 1 and 2).

Table 1: Descriptive Analysis and Comparison of Means between Males and Females – Upper Arch

Variable	Sex	Min	Max	Mean	SD	t-value	p Value
MDWC	Male	7.28	8.38	7.76	0.32	2.21*	0.0365
	Female	6.91	8.39	7.46	0.39		
ICD	Male	31.45	37.10	34.74	2.11	1.84	0.0777
	Female	31.03	36.22	33.43	1.65		
PRW	Male	33.59	39.91	37.09	1.99	2.42*	0.0228
	Female	32.96	37.86	35.54	1.33		
MRW	Male	43.86	49.52	46.13	1.83	2.47*	0.0206
	Female	41.95	47.18	44.58	1.47		
CIW	Male	27.19	32.43	29.58	1.48	1.86	0.0744
	Female	26.99	30.36	28.69	1.04		
CANIDX	Male	0.20	0.24	0.22	0.013	0.13	0.8982
	Female	0.21	0.24	0.22	0.011		
PRMOIDX	Male	73.05	86.99	79.89	4.18	-0.65	0.5218
	Female	74.10	84.17	80.76	2.85		
MOLIDX	Male	57.08	68.56	64.17	3.01	-0.20	0.8457
	Female	58.70	68.75	64.37	2.28		

*p < 0.05: Significant at 5% level

Table 2: Descriptive Analysis and Comparison of Means between Males and Females – Lower Arch

Variable	Sex	Min	Max	Mean	SD	t-value	p Value
MDWC	Male	6.13	7.47	6.84	0.37	2.82**	0.0091
	Female	5.76	7.03	6.43	0.39		
ICD	Male	23.39	28.60	25.75	1.89	1.06	0.2972
	Female	22.26	27.67	25.02	1.72		
PRW	Male	26.78	34.42	31.22	2.08	2.64*	0.0140
	Female	27.72	32.89	29.42	1.48		
MRW	Male	36.65	43.74	39.49	2.10	1.99	0.0568
	Female	35.97	42.22	38.02	1.78		
CIW	Male	19.19	22.89	20.84	1.08	-0.85	0.4029
	Female	19.59	24.12	21.21	1.24		
CANIDX	Male	0.23	0.30	0.27	0.021	1.08	0.2896
	Female	0.23	0.31	0.26	0.022		
PRMOIDX	Male	59.70	75.09	66.92	4.01	-3.48**	0.0018
	Female	64.97	81.51	72.17	3.97		
MOLIDX	Male	48.62	58.70	52.84	2.69	-2.70*	0.0121

	Female	51.81	61.72	55.85	3.20		

**p < 0.01: Significant at 1% level; *p < 0.05: Significant at 5% level

The maximum standard error of estimate is shown by canine index (0.5187) and least by molar arch width (0.4672) in upper arch. Maximum correlation is shown by molar arch width (0.4353) and least by canine index (0.0385) (Table 3).

Table 3: Linear and multiple regression equations-Upper

Linear Regression Equation – Upper			
Equation	**SE of Estimate**	**R**	**R^2**
Sex = 5.525 - 0.529 MDWC	0.4762	0.3970	0.1576
Sex = 4.483 - 0.088 ICD	0.4882	0.3390	0.1149
Sex = 5.807 - 0.119 PRW	0.4688	0.4288	0.1838
Sex = 7.061 - 0.123 MRW	0.4672	0.4353	0.1894
Sex = 5.300 - 0.130 CIW	0.4875	0.3425	0.1173
Sex = 1.768 – 1.2 CANIDX	0.5187	0.0253	0.0006
Sex = 0.040 + 0.018 PRMOIDX	0.5147	0.1263	0.0160
Sex = 1.020 + 0.007 MOLIDX	0.5185	0.0385	0.0015

Multiple Regression Equation – Upper			
Equation	**SE of Estimate**	**R**	**R^2**
Sex = 114.829 + 12.354 MDWC - 2.788 ICD - 0.966 PRW+ 0.505 MRW + 0.249 CIW – 444.3 CANIDX - 0.381 PRMOIDX + 0.350 MOLIDX	0.4517	0.6680	0.4462

The maximum standard error of estimate is shown by inter-canine arch width (0.5079) and least by premolar index (0.4285) in lower arch. Maximum correlation is shown by premolar index (0.5638) and least by inter-canine arch width (0.1645) (Table 4).

Table 4: Linear and regression equation-Lower

Equation	**SE of Estimate**	**R**	**R^2**
Sex = 5.292 - 0.572 MDWC	0.4541	0.4838	0.2341
Sex = 2.956 - 0.057 ICD	0.5079	0.2042	0.0417
Sex = 5.057 - 0.117 PRW	0.4609	0.4592	0.2108
Sex = 4.996 - 0.090 MRW	0.4833	0.3640	0.1325
Sex = -0.017 + 0.072 CIW	0.5118	0.1645	0.0271
Sex = 2.789 - 0.049 CANIDX	0.5076	0.2074	0.0430
Sex = -2.710 + 0.061 PRMOIDX	0.4285	0.5638	0.3179
Sex = -2.447 + 0.073 MOLIDX	0.4587	0.4676	0.2187

Multiple Regression Equation – LOWER			
Equation	**SE of Estimate**	**R**	**R^2**
Sex = 17.169 +1.831 MDWC - 0.776 ICD - 1.146 PRW + 0.918 MRW + 0.263 CIW - 58.7 CANIDX - 0.446 PRMODIX + 0.588 MOLIDX	0.3982	0.7547	0.5696

Mesio-distal width of mandibular canine shows 71.4% accuracy and premolar index shows 78.6% and 71.4% accuracy in males and females respectively (Table 5).

Table 5: Accuracy of Sex Determination

Parameters	Upper		Lower	
	Male	**Female**	**Male**	**Female**
MDWC	57.1%	71.4%	71.4%	71.4%
ICD	50.0%	64.3%	42.9%	64.3%
PRW	57.1%	71.4%	64.3%	71.4%
MRW	50.0%	78.6%	50.0%	64.3%
CIW	64.3%	57.1%	57.1%	50.0%
CANIDX	57.1%	57.1%	57.1%	71.4%
PRMOIDX	64.3%	57.1%	78.6%	71.4%
MOLIDX	42.9%	64.3%	64.3%	71.4%
MDWC + ICD + PRW + MRW + CIW + CANIDX + PRMOIDX + MOLIDX	71.4%	92.9%	78.6%	85.7%

Discussion

Teeth are the hardest and chemically most stable tissues in the body and exhibit least turnover of natural structure. They are well preserved after death. Further, they show significant sexual dimorphism and are readily accessible for examination. Thus, they provide excellent materials for forensic studies involving identification of genders. Pont's established constant ratio's between tooth sizes and arch widths in French population which came to be known as premolar and molar indices.[6] This study focuses on the maxillary and mandibular measurements like canine width, inter-canine distance, premolar arch width, molar arch width, combined width of the incisors and the respective indices of canines, premolars and molars. This study is unique when compared with other similar studies to the best of our knowledge, wherein not all of these indices and parameters were compared in both upper and lower arches.

The obtained values were statistically analysed. There is a significant gender difference with p-value<0.05 on values of canine arch width, premolar arch width and molar arch width (Table 1). This is in accordance with study conducted by Agnihotri et al[6] for premolar and molar arch width and Dhara et al[2] for canine arch width. According to Dhara et al and Rajbir Kaur et al[7] the mean mesio-distal canine width is higher in males when compared with females. Our present study supports this, where a value of 7.76 mm and 7.46 mm for males and females respectively were found to be mean of mesio-distal canine width. The mean premolar arch width and molar arch width in males are 37.09 mm and 46.13 mm respectively and in females are 35.54 mm and 44.58 mm respectively. This implies that there is a greater value of maxillary premolar and molar arch width in males when compared with females. In this study, the p-value of maxillary canine index is 0.8 which reveals that there is no significant gender difference on maxillary canine index which is contradictory to studies conducted by Kalia.[8] Accuracy of maxillary canine index in our study is 57.1% in both males and females. This is very much lower when compared with study conducted by Kalia which was 77.38% in males and 74.21% in females. This is of definite significance as the tooth morphology is known to be influenced by cultural, environmental and racial factors. Variation in food resources exploited by different populations has been explained as one such environmental cause. According to Garn et al,[9] teeth have behaved in many ways through the course of evolution, ranging from reduction of the entire dentition to reduction of one group of teeth in relation to another.

There is a highly significant gender difference with p-value<0.01 on mesio-distal canine width (Table 2) which is in accordance with study conducted by Shankar Bakkannavar et al,[10] Prateek Rastogi et al[11] and Ramandeep Narang et al[12] which showed p-value<0.05. The studies conducted by Ghose and Baghdady,[13] on Iraqi population, Lysell and Myrberg[14] on Swedish population and by Bishara[15] on populations of Egypt, Mexico, and Iowa showed consistent findings that the mesio-distal width of the mandibular canines is more in the males than the females and the difference is statistically significant. The reason behind this sexual dimorphism of canine amongst various populations has been explained by various theories. A) According to Moss, it is because of the greater thickness of enamel in males due to the long period of amelogenesis compared to females. B) Because of Y chromosomes producing slower male maturation.[7] The mean value of mandibular premolar arch width and premolar index in males is 2.08 and 4.01 respectively and for females it is 1.48 and 3.97 respectively. This shows that the values of mandibular premolar arch width and premolar index are greater in males when compared with females. But the molar index is found to be greater in females than the males. This clearly reveals that not only mandibular canine shows sexual dimorphism, but also mandibular premolars may be included as one of the tooth exhibiting sexual dimorphism.

There is no significant gender difference on mandibular molar arch width and combined width of incisors. But premolar arch width shows significance at 5% level with p-value<0.05. The mandibular premolar index and molar index shows significance at 1% and 5% level respectively. These values are much lower when compared with the study conducted by Bindu Aggarwal

et al[16] on Punjabi population where they observed a very high significance of p-value<0.0001, 0.0006 and 0.0001 for premolar arch width, molar arch width and combined width of incisor respectively. The reason behind this low significance in our study may probably due to the age group they have included i.e. 17-21 years (young individuals) where the regressive changes of teeth may be very minimal when compared with our study where we have included adults.

The linear and multiple regression equations were attained. The coefficient of correlation for multiple regression equation in upper and lower arch is greater than 0.6, which is 0.67 and 0.75 respectively. This shows that there is a strong positive correlation when all the parameters and indices are taken into consideration at single point of time. Table 5 shows the accuracy of sex determination using all the six parameters and the indices. The mesio-distal width of lower canine in sex determination in our study showed 71.4% which is almost similar to the value obtained from study conducted by Ramandeep Narang et al[11] which was 67.5%. These values are much less when compared with study conducted by Prateek Rastogi et al which showed 85.4% and 82.7% in males and females respectively.[11] The accuracy of mandibular canine index in our study showed 71.4% in females and 57.1% in males which is much less when compared to study conducted by Prateek Rastogi et al 86.3% and 70.9% in males and females respectively.[11] The probable reason for this margin of difference may be due to the direct method involved in the measurement of various parameters where as we have adopted indirect method on tooth models.

The accuracy of combined measurements of mandibular canine width, inter –canine distance, premolar and molar arch width, combined incisor width, canine, premolar and molar index in our study was 85.7% and 78.6% in females and males respectively.

Conclusion

Forensic odontology is an emerging field in countries like India. Hence a comprehensive database must be established using all the possible morphometric measurements of tooth and their accuracy or variations in degree of sex determination must be analysed. In this study the usefulness of human teeth as an aid in gender determination by odontometric analysis is well supported. This study establishes the significance of morphometric criteria of sex determination using mandibular premolar index, premolar arch width and mandibular mesio-distal width of canine which shows >70% of accuracy in both sexes. In comparison with maxillary parameters and indices, mandibular parameters and indices show greater accuracy in sex determination. Apart from the population variation amongst the tooth morphology, the mandibular canine shows the maximum sexual dimorphism which enables immense medico-legal significance in identification of individual by determining gender.

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