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Dentistry Section

Linear Odontometric Analysis of Permanent Dentition as A Forensic Aid: A Retrospective Study

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ABSTRACT

Introduction: Sex determination in forensic anthropology is an essential step for medico-legal purposes and crucial for identification as the number of possible matches is reduced to 50%.Teeth are an excellent material for anthropological, genetic, odontological and forensic investigations as they are known to resist a variety of ante-mortem and post-mortem insults. Sexual dimorphism in tooth size and the accuracy of odontometric sex prediction is found to vary in different population and therefore it is necessary to determine specific population values in order to make identification possible. Hence, the present study was undertaken to evaluate the existence of sexual dimorphism in South Kerala population.

Aim: To evaluate and estimate the degree of odontometric sexual dimorphism in all permanent teeth except third molars and the variations in odontometric dimensions between the left and right side teeth of the maxillary and mandibular arches in male and female groups.

Materials and Methods: The MesioDistal (MD) and BuccoLingual (BL) measurements of 28 teeth were estimated from the preorthodontic casts of 132 subjects; male group (66 males) and female group (66 females) of age range 15-25 years using digital Verniers' Caliper. The data obtained were analysed using SPSS version 17 and the Students' t-test for two independent samples.

Results: The MesioDistal (MD) and BuccoLingual (BL) parameters of all permanent teeth in the study group showed sexual dimorphism. Over 39% of the tooth variables showed reverse dimorphism. The comparison of mean values of MD and BL diameters of the maxillary and mandibular, right and left side teeth in male and female groups showed statistical significance in males whereas females show non-significant values in both MD and BL diameters.

Conclusion: The study showed a varied percentage of sexual dimorphism and variation in the mean values of MD and BL dimensions in males, but not in females between right and left side teeth of the maxillary and mandibular arches of the study population.

Keywords: Buccolingual, Forensic, Mesiodistal, Odontometry, Sexual dimorphism

INTRODUCTION

Forensic odontology or forensic dentistry, defined by Keiser-Nelson in 1970, as 'that branch of forensic medicine, which in the interest of justice deals with the proper handling and examination of dental evidence, with proper evaluation and presentation of the dental findings" [1,2]. The gender identification from human remains should be the initial step taken by the forensic odontologist [3]. In the human skeleton, the pelvis is shown to produce 100% or near 100% accuracy for gender identification [4-6]. In addition, craniofacial and mandibular features are also recommended to differentiate males and females [7-9]. The teeth take prominence when other skeletal parameters are unavailable, owing to the latter being missing or fragmented due to various destructive effects caused by trauma and incineration. The major advantage with the teeth is that, they are the strongest structures in the human body and at least a few out of the full complement are recovered from skeletonised remains [10]. Sexual dimorphism refers to the differences in size, stature and appearance between males and females. This can be applied to dental identification also, because no two mouths are alike and there are differences seen between the genders [11]. Studies have confirmed the existence of sexual dimorphism in specific populations and also within same populations [12]. Odontometric data in South Kerala population is still largely unexplored. Therefore, the present study was ventured to evaluate the existence of sexual dimorphism and variations in odontometric dimensions between the left and right side of the dental arches in South Kerala population.

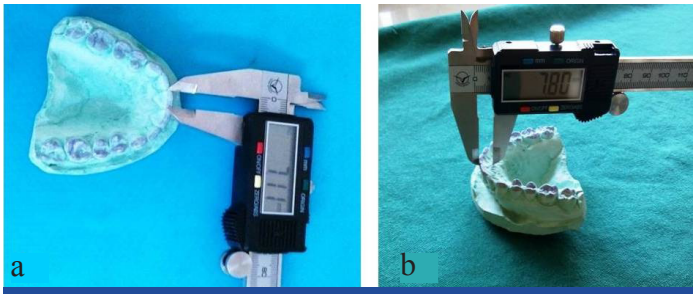
MATERIALS AND METHODS

The present retrospective study was done at Pushpagiri College of Dental Sciences, Kerala, India, on the maxillary and mandibular study models collected from the outpatient department and various dental clinics of South Kerala. The base sample comprised of 132 subjects (66 males & 66 females) of age group of 15-25 years from South Kerala. This age group was selected as minimum attrition and abrasion has been attributed to it. Inclusion criteria included healthy, periodontal disease free, caries free teeth & presence of full complement of teeth upto the permanent second molars. Armamentarium used were digital Verniers' Caliper, maxillary and mandibular models. Mesiodistal & buccolingual measurements of all the teeth were measured by two dental surgeons independently to avoid bias using digital Verniers' Caliper with an accuracy of 0.01mm [Table/Fig-1]. The average of the values was taken. Mean, standard deviation, and p values were obtained.

The students t-test for two independent samples (Male v/s Female, Right v/s Left) was applied to compare the dimensions measured for males and females. A $p < 0.05$ was considered statistically significant.

MD dimension: It is the greatest mesiodistal dimension between the contact points of teeth [13].

BL dimension: It is the greatest dimension between buccal and lingual surfaces of crown, taken at right angles to the plane in which mesiodistal diameter is taken [13]. The mean values of BL and MD dimensions of males and females were subjected to the given formula to calculate sexual dimorphism [14].



[Table/Fig-1]: Armamentarium (a) MD dimension (b) BL dimension.

Sexual dimorphism= (Xm/Xf)- 1 x100,

Where,

Xm=mean values of males

Xf=mean values of females.

A reference point was obtained to differentiate males from females by using the following formula [15].

Reference point= (Xm-SD)+(Xf+SD) where SD is the standard deviation.

If the linear values of BL and MD dimensions were higher than their respective reference points, the individual was considered to be a male otherwise a female [15]. The data obtained were subjected to statistical analysis (SPSS version 17).

RESULTS

The mean values and standard deviation of MD & BL dimension of maxillary and mandibular teeth in male and female groups are shown in [Table/Fig-2,3].

Tooth No:	MESIODISTAL				BUCCOLINGUAI		
	Sex	Mean	SD	p-value*	Mean	SD	p-value*
17	M	9.94	0.551	0.715	11.86	0.224	0.001
	F	9.98	0.635		11.05	0.224	
16	M	9.36	0.939	0.001	11.73	0.449	0.009
	F	10.82	0.469		11.47	0.656	
15	M	6.75	0.281	0.001	9.23	0.869	0.001
	F	6.95	0.393		9.93	0.581	
14	M	6.93	0.554	0.001	9.67	0.468	0.001
	F	7.39	0.554		10.12	0.657	
13	M	8.35	0.48	0.001	8.89	0.587	0.001
	F	7.77	0.4.04		8.32	0.651	
12	M	6.73	0.851	0.001	7.49	0.551	0.001
	F	7.26	0.59		6.82	0.768	
11	M	8.92	0.272	0.587	7.64	0.939	0.261
	F	8.97	0.744		7.8	0.656	
21	M	8.47	0.503	0.001	7.64	0.939	0.191
	F	8.92	0.824		7.82	0.618	
22	M	6.45	0.821	0.001	6.72	0.448	0.262
	F	7.12	0.576		6.84	0.75	
23	M	7.82	0.893	0.798	8.89	0.587	0.001
	F	7.85	0.35		8.45	0.643	
24	M	6.9	0.528	0.001	9.68	0.469	0.002
	F	7.3	0.518		10.02	0.701	
25	M	6.75	0.267	0.017	9.21	0.864	0.001
	F	6.94	0.579		9.9	0.634	
26	M	9.3	0.96	0.001	11.59	0.673	0.147
	F	10.71	0.483		11.43	0.574	
27	M	9.68	0.747	0.081	11.45	0.898	0.009
	F	9.93	0.87		11.1	0.622	

[Table/Fig-2]: Mean, standard deviation, p values of mesiodistal and buccolingual dimensions of maxillary teeth. (*The students t-test).

Tooth No:	MESIODISTAL				BUCCOLINGUA		
	Sex	Mean	SD#	p-value*	Mean	SD	p-value*
37	M	10.32	0.469	0.046	10.73	0.449	0.188
	F	10.11	0.715		10.83	0.535	
36	M	11.15	0.232	0.029	10.73	0.449	0.000
	F	10.99	0.537		11.21	0.393	
35	M	7.07	0.667	0.220	8.89	0.587	0.003
	F	7.20	0.601		9.18	0.538	
34	M	7.34	0.384	0.000	8	0.000	0.001
	F	6.91	0.827		8.32	0.773	
33	M	6.50	0.504	0.000	8.14	0.821	0.000
	F	7.05	0.369		7.68	0.516	
32	M	6.07	0.667	0.999	6.75	0.800	0.054
	F	6.07	0.463		6.52	0.515	
31	M	5.66	0.686	0.081	6.39	0.587	0.373
	F	5.68	0.417		6.30	0.582	
41	M	5.66	0.686	0.751	6.39	0.587	0.503
	F	5.69	0.359		6.32	0.579	
42	M	5.82	0.893	0.001	6.89	0.587	0.025
	F	6.23			6.64	0.637	
43	M	7	0.000	0.100	7.86	1.226	0.101
	F	6.91	0.446		7.59	0.540	
44	M	7.84	0.235	0.000	7.86	0.224	0.000
	F	7.03	0.540		8.28	0.770	
45	M	7.32	0.469	0.870	8.89	0.587	0.007
	F	7.30	0.588		9.16	0.556	
46	M	10.91	0.446	0.348	10.73	0.449	0.000
	F	11	0.645		11.23	0.498	
47	M	10.33	0.475	0.082	10.59	0.673	0.000
	F	10.17	0.565		10.89	0.567	

[Table/Fig-3]: # Mean, standard deviation, p values of mesiodistal and buccolingual dimensions of mandibular teeth.
Standard deviation ($S=\sqrt{(\Sigma(xi-x-)2)/n}$; i=1 to 66 Where xi are the observations, x- is the mean of observations and n is the sample size (66).
* The students t-test [($t= (X-1-X-2)/S\sqrt{[(1/n1)+(1/n2)]}$ where $S=\sqrt{[[(n1-1)S12 + (n2-1)S22]/(n1+n2-2)}$degrees of freedom = (n1+n2 -2)].

MD dimension showed highly significant values for maxillary right and left first molars(16,26), first and second premolars (14,15,24,25), lateral incisors(12,22), right canine(13), left central incisor(21) and mandibular right and left first premolars(34,44), left canine(33) and right lateral incisor(42), significant values for mandibular left first and second molars(36,37),nonsignificant values for maxillary right and left second molars(17,27), right central incisor(11), left canine(23), mandibular right and left second premolars(35,45), central incisors(31,41), left lateral incisor(32) and right canine(43), first and second molars(46,47) [Table/Fig-2,3].

BL dimension showed highly significant values for maxillary right and left second molars(17,27), first and second premolars(14,15,24,25), canines(13,23), right first molar(16), lateral incisor(12) and mandibular right and left first molars(36,46), first and second premolars(34,35,44,45), left canine(33) and right second molar(47), significant value for mandibular right lateral incisor(42), non-significant values for maxillary right and left central incisor(11,12), left lateral incisor(22), first molar(26) mandibuar right and left central incisor(31,41), left second molar(37), lateral incisor(32) and right canine(43).

The values of sexual dimorphism for both MD & BL dimension of maxillary and mandibular teeth are given in [Table/Fig-4]. The MD dimension of maxillary left first molar (26) exhibited the greatest sexual dimorphism followed by the MD dimension of the maxillary right first molar (16), BL of the maxillary right second premolar (25), MD of the mandibular left canine (33). The least

#SEXUAL DIMORPHISM – MAXILLARY		
TOOTH NO:	MD	BL
17	-0.400	7.330
16	-13.493	2.266
15	-2.877	-7.049
14	-6.224	-4.446
13	7.464	-6.594
12	-7.3	9.824
11	-0.557	-2.051
21	-5.044	-2.301
22	-9.410	-1.754
23	-0.382	5.207
24	-5.479	-3.393
25	-2.737	-6.969
26	-13.165	1.399
27	-2.517	3.153
SEXUAL DIMORPHISM - MANDIBULAR		
TOOTH NO:	MD	BL
37	2.077	-1.014
36	1.455	-4.281
35	-1.805	-3.159
34	6.222	-3.846
33	-7.801	5.989
32	0	3.527
31	-0.352	1.428
41	-0.527	1.107
42	-6.581	3.765
43	1.302	3.557
44	11.522	-5.072
45	0.273	-2.947
46	-0.818	-4.452
47	1.573	-2.754

[Table/Fig-4]: Sexual dimorphism in maxillary and mandibular teeth
Sexual dimorphism = Sexual dimorphism= (Xm/Xf)- 1 x100 ,
where, Xm= mean values of males and Xf = mean values of females.

dimorphic parameter being the MD dimension of mandibular right first premolar (44). Over one-third of the measured tooth variables showed reverse dimorphism. The MD dimensions of maxillary right canine(13), mandibular right and left second molars(37,47), first premolars(34,44), left first molar(36), right canine(43) and second premolar(45) and the BL dimensions of maxillary right and left canines(13,23), first molars(16,26), second molars(17,27), right lateral incisor(12) and mandibular right and left canines(33,43),lateral incisors(32,42), central incisors(31,41) showed reverse dimorphism (female group showed greater dimensions). [Table/Fig-5] shows the comparison of the MD and BL dimensions on the right and left maxillary and mandibular teeth in male and female groups. While evaluating the p value of the right and left side teeth of the same arch, the MD dimension in males show a highly significant values for maxillary second molars (17 &27), maxillary and mandibular canines (13 & 23, 33 & 43),mandibular first molars (36 & 46) & mandibular premolars (34 & 44,35 & 45). The BL dimension in males showed highly significant values for maxillary second molar (27 & 17), maxillary lateral incisor (12 & 22) and mandibular first premolar (34 & 44). In females, both MD and BL dimensions did not show any significant differences between the mean values on left side as compared to the right side. [Table/Fig-6] shows the MD & BL reference point values for both maxillary and mandibular teeth. The reference point is calculated separately for MD and BL dimension on all teeth except third molars, which showed 88% reliability.

TOOTH NO:	MESIODISTAL		BUCCOLINGUAL	
	MALE	FEMALE	MALE	FEMALE
17 27	0.024	0.706	0.000	0.730
16 26	0.717	0.817	0.160	0.710
15 25	0.990	0.910	0.895	0.780
14 24	0.750	0.330	0.900	0.399
13 23	0.000	0.226	0.999	0.860
12 22	0.056	0.170	0.000	0.880
11 21	0.000	0.720	0.999	0.860
37 47	0.900	0.590	0.160	0.603
36 46	0.000	0.920	0.999	0.798
35 45	0.014	0.330	0.999	0.830
34 44	0.000	0.325	0.000	0.766
33 43	0.000	0.051	0.126	0.329
32 42	0.070	0.052	0.254	0.236
31 41	0.999	0.880	0.999	0.843

[Table/Fig-5]: Table comparing mean odontometric values in right and left maxillary and mandibular teeth.

DISCUSSION

The biological profiling of unidentified human remains is an important step in gender determination, when an accurate result could exclude about half the population in search operations. Forensic odontologists utilize investigative measures such as DNA analysis, tooth dimensions and craniofacial morphology for gender differentiation [16]. DNA analysis is time consuming and technique sensitive even though it gives irrefutable evidence concerning the sex of the skeletal remains [4,9]. Odontometric analysis is utilized as a method of sex determination since long, as it can be used accurately both in skeletal remains which maybe in a poor or fragmented condition and in living individuals [17]. Sex determination by odontological features can be grouped into nonmetric and metric methods. Non metric methods are based on the presence or absence of certain morphological features of the tooth such as maxillary incisor shoveling, cusp of Carabelli, hypocone and protostylid [18]. Metric features are studied by measuring the tooth dimensions. Sex determination by metric approach is more structured, less subjective and can be repeated to validate the results [19].

The two most commonly used tooth dimensions for sex assessment in forensic investigations are the mesiodistal and the buccolingual diameters of the permanent tooth crown, as they are simple, easy to measure, cheap and reliable [20,21]. Tooth dimensions aids in gender determination of young individuals where the skeletal characters are not yet fully developed [22]. Permanent tooth crowns form early in the life and their dimensions remain stable except when there are functional, pathological or nutritional disorders which affect the morphology or structure of the teeth. Permanent dentition in young individuals provide the best sample for tooth dimensions because less attrition and mutilation are noticed in this age group when compared with older individuals [23]. Therefore subjects in the age group of 15-22 years were only included in the study sample.

TOOTH NO:	MD	BL
17	10.002	11.844
16	9.855	11.703
15	6.906	9.436
14	7.155	9.985
13	8.022	8.647
12	6.864	7.263
11	9.181	7.578
21	8.855	7.569
22	6.662	6.931
23	7.563	8.698
24	7.095	9.966
25	7.001	9.140
26	9.766	11.460
27	9.866	11.137
37	10.338	10.828
36	11.222	10.942
35	7.102	9.010
34	7.346	8.546
33	6.707	7.757
32	5.968	6.492
31	5.535	6.342
41	5.511	6.351
42	5.815	6.790
43	7.178	7.382
44	7.587	8.343
45	7.369	9.009
46	11.054	11.004
47	10.295	10.687

[Table/Fig-6]: Reference point in maxillary and mandibular teeth.
Reference point= (Xm-SD)+(Xf+SD) ÷2 where SD is the standard deviation.

In the present study, we analyzed the degree of sexual dimorphism in all teeth except third molars by measuring the mesiodistal and buccolingual diameters from preorthodontic study casts. The MD dimension of 26 (-13.165) exhibited the greatest sexual dimorphism followed by MD of 16 (-13.493), and the maxillary first molar was the most sexually dimorphic tooth. Traditionally canines have shown the greatest degree of sexual dimorphism across population [24]. However, first molar dimension have also been reported as the most sexually dimorphic variable in some studies [21,24-28] and among the most dimorphic in others population [21,24,29-33]. Some authors have used the percentage dimorphism defined as "the percent to which the tooth size of males exceeded that of females"- to express the magnitude of sex dimorphism [34]. Percentage dimorphism is calculated as "(Xm/Xf-1) x 100", where 'Xm' is the mean male tooth dimension and 'Xf' is the mean female tooth dimension. A positive value indicates that the male tooth dimension is larger whereas a negative value indicates larger female tooth dimension. There are evidences to suggest that the magnitude of sexual dimorphism is neither genetically independent nor region specific [35]. The variation in the magnitude of dimorphism can be the result of environmental and/ or cultural factors [30]. Over one-third of the measured tooth variables (22/56, 39%) were statistically larger in females. Fourteen of them were mandibular variables and eight pertained to the MD dimensions which indicate that mandibular teeth & MD dimension is relatively larger in females which is consistent with two studies [22, 25]. Reverse dimorphism has also been reported in Iraqi (Ghose et al.) and Ticuna Indians (Harris et al.) populations, all of which examined a relatively small sample that ranged from 57–161 subjects [33,35]. This may be due to evolution resulting in a reduction in sexual dimorphism, causing an overlap of tooth dimensions in modern males and females [36].

The present study revealed that the comparison of mean values of MD & BL diameters on the right and left side teeth of the dental arches showed significance in males whereas females did not show any significance in both MD and BL diameters. Studies done by Swati et al., [37] and Narang et al., [38] on first molars showed statistical insignifance whereas Rai et al., [39] and Sonika et al., [40], found that BL dimensions of maxillary left first molar(26) to be greater than maxillary right first molar(16).

Reference point calculated for both MD & BL dimension showed 88% reliability in our study. If the linear values of the bucco-lingual and mesio-distal dimensions are higher than their respective reference points, the individual is considered to be a male otherwise a female [15]. Sexual dimorphism in tooth size and the accuracy of odontometric sex prediction is found to vary in different populations and therefore it is necessary to acquire a population specific data. The linear odontometric analysis of all permanent teeth except third molars showed sexual dimorphism and a statistical significance in the MD & BL dimensions of right & left side teeth in males whereas the mean values in females were not significant. The literature review revealed few studies correlating odontometric analysis in the Kerala populations.

LIMITATION

The limitations of this study were small sample size and geographic range.

CONCLUSION

The present study revealed the existence of sexual dimorphism in South Kerala populations. In our study, out of all the class traits, the MD dimension of maxillary left first molar (26) exhibited the greatest sexual dimorphism. The least dimorphic parameter being the MD dimension of mandibular right first premolar (44). Sex determination using linear dimensions of all permanent teeth among South Kerala population was lacking in literature. Studies conducted by different researchers on various populations have shown a varied percentage of dimorphism, indicating that sexual dimorphism is population specific which is consistent with our study. Reference point calculated in this specific population can be used by a trained forensic odontologist for gender determination from the human teeth remains presented as the specimen. Further studies including larger populations of wider geographic range are expected to confirm our study results.

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