Original Article

Root Length: As a determinant tool of sexual dimorphism in an ethnic Tamil population

Divyalakshmi Govindaram,
R. Bharanidharan,
R. Ramya,
A. Rameshkumar,
N. Priyadharsini,
K. Rajkumar
Department of Oral and Maxillofacial Pathology and Microbiology, SRM Dental College, Chennai, Tamil Nadu, India

Address for correspondence:
Dr. Divyalakshmi Govindaram, Department of Oral and Maxillofacial Pathology and Microbiology, SRM Dental College, Ramapuram, Chennai, Tamil Nadu, India.
E-mail: divyalakshmi7194@gmail.com

Abstract

Background: Sexual dimorphism in teeth has been an area of research for forensic anthropologists. The function of root in transmitting the forces of occlusion to the alveolar bone varies as the force in males tends to be larger than in females. This shows the significance of the root length as indicators of sexual dimorphism. **Aim:** The aim of this study was to determine the presence of sexual dimorphism in the root lengths of permanent teeth and to evaluate if root length could be instrumental in defining sexual dimorphism among an ethnic Tamil population. **Materials and Methods:** Orthopantomograms of 1000 individuals (500 males and 500 females) were utilized, and the measurement of root length of permanent maxillary and mandibular teeth from canine to first molar on all four quadrants using the Digital software SCANORA 5.2.6. was carried out. Statistical analysis including descriptive statistics and independent Student *t*-test were performed. **Results:** In this study, the sexual dimorphism in root length is observed in 13, 14, 15, 16, 23, 26, 33, 36, 43, and 46 (mesial), and there is a statistically significant difference between the root measurements of males and females ($P < 0.05$). Most dimorphic teeth were maxillary canines and mandibular canines. **Conclusion:** The data generated from this study suggest that the root length measurements present with a substantial evidence of sexual dimorphism emphasizing its importance on identifying sex and are therefore useful in determining the biological profile.

Key words: Forensic anthropology, forensic dentistry, odontometry, panoramic, radiography, sex determination analysis

Introduction

The human intelligence and perception have conquered great heights from the primitivism of the caveman but in contrary have also led to a surge in crime rate, terrorism, and mass disasters. All humans have an identity in life which is recognized even after the demise. Forensic identifications involve multidisciplinary team efforts with the coordination and cooperation of law enforcement officials, forensic pathologists, forensic odontologists, forensic anthropologists, serologists, and other specialists. Forensic odontology is an elemental, and integral part of forensic science still in the stage of infancy has emerged as a glimmer of hope in facilitating victim identification in forensic medicine.

Access this article online	
Website: www.jfds.org	Quick Response Code
DOI: 10.4103/jfo.jfds_10_18	

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Govindaram D, Bharanidharan R, Ramya R, Rameshkumar A, Priyadharsini N, Rajkumar K. Root Length: As a determinant tool of sexual dimorphism in an ethnic Tamil population. J Forensic Dent Sci 2018;10:96-100.

© 2019 Journal of Forensic Dental Sciences | Published by Wolters Kluwer - Medknow

Sex determination is one among the imperative facets of biological profiling. In the field of osteoarchaeology, sexual dimorphism is an area of supreme interest in the research realm. Mass disasters result in a striking number of fatalities, and henceforth, person identification is the prime target for the forensic personnel. The omnifarious techniques ranging from the visual assessments to metric analysis of sexually dimorphic traits could be used as prospective tools to estimate the sex of human remains, and these gamut methods have been documented in the stupendous literature of forensics.

Numerous odontometric studies have been done considering only the dimensions of the crown, i.e., the mesiodistal and the buccolingual measurements, whereas the root dimensions remain neglected.[1-3] Only few studies have concerted on sexual dimorphism of root length. The evidence of its efficacy in sex determination is almost nonexistent. The function of the roots is to transmit the forces of occlusion to the underlying supporting alveolar bone. This presents toward their significance as indicators of sexual dimorphism given that forces of mastication in males tend to be larger than in females.[4]

The current study scrutinizes the presence of sexual dimorphism utilizing the root length of the permanent teeth in an ethnic Tamil population and evaluates the most dimorphic teeth.

Materials and Methods

Ethical clearance was obtained from the institutional review board to conduct the study. The study included the collection of orthopantomograms (OPGs) of 1000 individuals inclusive of 500 males and 500 females from the department of oral medicine and radiology, and the measurement of root length of permanent maxillary and mandibular teeth from canine to first molar on all the four quadrants using the Digital software SCANORA 5.2.6.(Soredex, Tuusula, Finland) was carried out.

The study samples (OPGs) were selected through simple random sampling that was achieved over a period of 1 year (July 2016–November 2017). The sample population included patients who had reported to the institution during the above-mentioned time period.

Sample size calculation

A sample size of 1000 was decided on the basis of review of data of the department of oral medicine and radiology which revealed that at least 16,000 participants had reported to the department for the past 3 years; out of which, the approximately 3000 OPGs are recorded. Hence, assuming a population of 16,000, there would be 3000 OPGs during the study period. Of the 3000 newly recorded OPGs, at least 30% were selected for this study. The calculated minimum sample size was 1000 after application of the inclusion and exclusion criteria.

Inclusion criteria

Patients who had reported to the institution and OPGs recorded, patients with past three generations living in Tamil Nadu and with mother tongue as Tamil language, patients within the age group of 21–60 years, and patients with a complete dentition were included in the study.

Exclusion criteria

Patients with cross ethnicity are excluded from the study. The maxillary and mandibular central and lateral incisors were excluded considering the radiographic discrepancies seen due to placement of the object in the focal trough area. Patients with complete edentulism, bone pathologies, periapical pathologies, root resorption, root caries, and ankylosis were also excluded from the study.

The OPGs were taken using standardized techniques, and the measurements of the root length were taken into account by considering the landmarks [Figure 1]. Thus, these measurements were taken from the canine to the first molar [Figure 2]. The readings of 100 randomly selected OPGs were repeated by the same observer at a different time to test for intra-observer error and randomly selected OPGs were measured by another observer to test inter-observer error, and the obtained values were tabulated and analyzed using Student's *t*-test to measure the reliability.

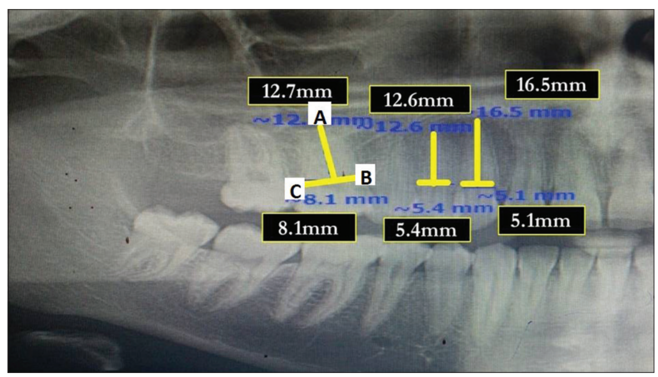

Figure 1: (A) Apical – most limit of the root, approximating the center of the apical foramen. (B) Coronal – most limit of the crestal bone adjacent to the mesial aspect of the tooth. (C) Coronal – most limit of the crestal bone adjacent to the distal aspect of the tooth

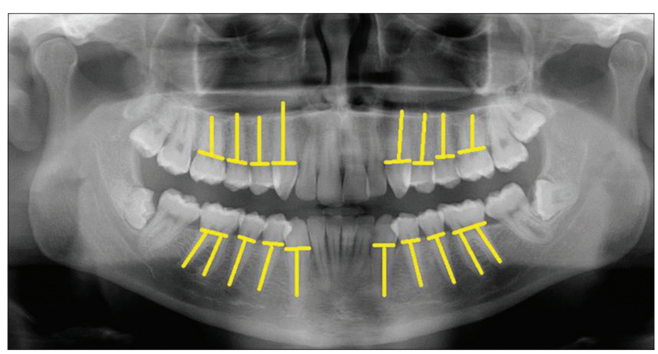

Figure 2: Measurement of root length with the reference points from canine to first molar in all the quadrants

In this study, the percentage of sexual dimorphism was used as an indicator to describe the degree of difference between males and females and was calculated using the formula given by Garn *et al*. (1967).

The percentage of sexual dimorphism represents the difference between male mean values and female mean values. A positive value indicates larger male tooth dimensions, whereas a negative value indicates larger female tooth dimensions. If the value is close to zero, the magnitude of sex dimorphism will be lower.

$$\frac{\text{Male mean - Female mean}}{\text{Female mean}} \times 100$$

The values were subjected to statistical analysis using the software – the Statistical Package for the Social Sciences version 17.0 (IBM, Armonk, NY, United States of America), and the descriptive statistics and independent Student's *t*-test were performed. Descriptive statistics generated included the mean, standard deviation (SD), standard error (SE), and the percentage of sexual dimorphism. In addition, independent samples *t*-test for the comparison between male and female mean values were performed, and *t* values with $P < 0.05$ were considered to be statistically significant.

Results

The root length dimension was compared between the two genders. Independent Student's *t*-test was done to assess the relationship of the root lengths with gender. The alpha error was set at 5%, and $P < 0.05$ was considered as statistically significant.

Tables 1 and 2 present the descriptive statistics (mean, SD, and SE) and the percentages of sexual dimorphism.

The maxillary teeth (maxillary mean = 12.603) have higher average root length than mandibular teeth (mandibular mean = 11.798) with a difference of 0.805.The maximum root length in both male and female: maxillary right canine [Table 1].

Comparing the average of the maxillary teeth in males versus maxillary teeth in females, the mean difference is 0.987 mm, inferring that the root length in males is greater than in females; similarly, the root length of the mandibular teeth shows minimal average difference of 0.195 between males and females. This infers that maxillary teeth are more dimorphic than mandibular teeth [Table 2].

The percentages of sexual dimorphism for maxillary teeth ranged from 9.2% to 14.15%, and the percentages of sexual dimorphism for mandibular teeth ranged from 10.8% to 11.6%.

Degree of sexual dimorphism is given by the percentage of the male and female mean which is 4.97%, which is a positive value, indicating that the male root measurements are greater than that of females. The comparison between maxillary and mandibular teeth in terms of degree of sexual dimorphism shows that maxillary teeth (8.1%) are more dimorphic than mandibular teeth (1.6%).

Table 1: Descriptive statistics

Tooth number	*n*	Minimum	Maximum	Mean	SD
13	1000	9.6	19.1	14.400	1.7998
14	1000	8.4	14.5	12.025	1.2593
15	1000	8.7	15.3	11.721	1.1944
16_P	1000	8.1	14.7	11.845	1.3107
23	1000	8.5	19.1	14.076	1.8234
24	1000	7.4	12.1	12.743	10.9887
25	1000	8.0	10.3	12.461	9.2204
26_P	1000	7.6	15.6	11.556	1.1878
33	1000	6.1	17.4	12.054	1.7841
34	1000	8.4	9.4	12.231	8.3680
35	1000	8.5	14.8	11.658	1.2647
36_M	1000	8.9	14.8	11.823	1.1111
36_D	1000	3.1	14.8	11.642	1.2945
43	1000	8.4	16.9	12.091	1.6211
44	1000	8.4	15.5	11.292	1.3037
45	1000	8.5	15.5	11.475	1.3333
46_M	1000	8.3	13.9	11.470	1.1082
46_D	1000	8.4	9.4	12.253	8.3257
Valid *n* (list wise)	1000				

SD: Standard deviation

Table 3 presents with the results of independent *t*-test which shows that 13, 14, 15, 16, 23, 26, 33, 36, 43, and 46 (mesial root) are sexually dimorphic, and there is a statistically significant difference between the root measurements of males and females ($P < 0.05$).

The most dimorphic teeth are the maxillary right and left canines ($P = 0.000$), mandibular right ($P = 0.001$), and left canines ($P = 0.000$), followed by the right maxillary first premolar ($P = 0.001$) and second premolar ($P = 0.005$).

Table 4 represents the results of the intra- and inter-observer reliability using Student's *t*-test with significance level $P < 0.05$. The results show that none of the *t* values are significant at $P < 0.05$.

Discussion

In forensic anthropology, the accuracy of determining the correct sex by morphological and metric assessment of different skeletal bones is between 80% and 90% for the scapula, sternum, humerus, and femur.[5] Other methods such as fingerprinting[6] and DNA analysis[7] have a high accuracy between 96.8% and 100%.

During mass disasters, identification of the victims portrays as a colossal challenge as soft-tissue destruction and in such a scenario hard tissues, that is, bones and teeth abet as tools for victim identification. Bones pose as the prime source of evidence in victim identification. The recuperation of the bones in an intact figure is unprecedented and henceforth

Table 2: Group statistics

Tooth number	Gender	*n*	Mean	SD	SEM	Percentage
13	Male	500	15.352	1.5715	0.2222	14.15
	Female	500	13.448	1.4919	0.2110	
14	Male	500	12.444	1.1594	0.1640	7.2
	Female	500	11.606	1.2253	0.1733	
15	Male	500	12.052	1.1668	0.1650	5.8
	Female	500	11.390	1.1390	0.1611	
16	Male	500	12.118	1.2449	0.1760	4.7
	Female	500	11.572	1.3302	0.1881	
23	Male	500	15.006	1.5908	0.2250	14.1
	Female	500	13.146	1.5562	0.2201	
24	Male	500	13.980	15.4754	2.1885	4.5
	Female	500	11.506	1.1656	0.1648	
25	Male	500	11.860	1.1544	0.1633	−9.2
	Female	500	13.062	13.0267	1.8423	
26	Male	500	12.074	1.0583	0.1497	9.3
	Female	500	11.038	1.0876	0.1538	
33	Male	500	12.718	1.6733	0.2366	11.6
	Female	500	11.390	1.6527	0.2337	
34	Male	500	11.586	1.3668	0.1933	−10.0
	Female	500	12.876	11.7796	1.6659	
35	Male	500	11.810	1.2321	0.1742	2.6
	Female	500	11.506	1.2908	0.1826	
36_Mesial	Male	500	12.048	1.0068	0.1424	3
	Female	500	11.598	1.1736	0.1660	
36_Distal	Male	500	11.888	0.9663	0.1367	4.3
	Female	500	11.396	1.5260	0.2158	
43	Male	500	12.610	1.6026	0.2266	8.9
	Female	500	11.572	1.4805	0.2094	
44	Male	500	11.416	1.3866	0.1961	2.2
	Female	500	11.168	1.2165	0.1720	
45	Male	500	11.650	1.2992	0.1837	3.0
	Female	500	11.300	1.3569	0.1919	
46_Mesial	Male	500	11.694	1.0643	0.1505	3.9
	Female	500	11.246	1.1163	0.1579	
46_Distal	Male	500	11.544	1.0891	0.1540	−10.8
	Female	500	12.962	11.7403	1.6603	

SD: Standard deviation, SEM: Standard error of mean

the other hard structure of the human body that is the teeth presents as an integral tool in the field of forensic sciences. Teeth are inimitable organs and are the strongest hard tissues that could resist postmortem annihilation and disintegration to an extent. Odontometrics has been acknowledged as a reliable biologic feature which is subjected to being comparatively easy, objective, and easily repeatable. Henceforth, it has been used as a device for determining the sex of the individual.[1,8-10] Based on this, we have chosen metric method that is the metrics of root length in our study.

Many researchers have established that permanent teeth present with a high degree of sexual dimorphism, the greatest being in the canines.[9,10] Therefore, permanent teeth were only included in the study.

Collection of all the data from direct measures on extracted teeth is not feasible as it would be difficult to sample 1000 corpses with all the teeth present. Therefore, as an alternative method, the measurements of teeth were taken from panoramic radiograph for the current study. Preceding literature presents with odontometric data that is obtained intraorally, dental casts and panoramic radiographs which allow registering measurements of the whole tooth, including the root. Furthermore, panoramic radiograph allows us to take all the teeth present into account in a single frame compared to the periapical radiograph during postmortem data collection. Roots are said to be more sheltered in the alveolar socket and are comparatively less exposed to pathological phenomenon and also they are faster and easier to measure than crowns and are not affected by wear.

Hence, the current study was done to determine if root metrics could be used to determine sex and is one of the few studies done for sex estimation using root length in Tamil population. All the variables analyzed were statistically significant. This result is in agreement with the previous studies. The greatest percentage of sexual dimorphism is shown by the maxillary right canine. Thus, the most dimorphic teeth include the canines followed by the right maxillary first premolar and second premolar.

The finding that root length presents a high degree of sexual dimorphism deriving from the present study is of great importance as it suggests that root length measurements can be employed to assess sex. This was also concluded by Garn *et al*.[10]

According to Garn *et al*., the teeth located adjacent to the canines (e.g., first premolar) are more dimorphic than the others.[10] In this study, the upper right premolars show a statistically significant difference between males and females.

The results of this study may be population specific, as the degree of sexual dimorphism in tooth size differs among populations. This is influenced by genetic, epigenetic, and environmental factors, affecting dental development in each population.[11] The environmental factors that influence the variation in size are nutrition, disease, and climate. In humans, the masticatory apparatus is very much a function of the subsistence pattern.[12] Hence, eating habits can influence the size of teeth. It is known that the magnitude of sexual dimorphism in tooth size is inheritable.[10] Hence, genetic differences between and within population contribute to the diversity in odontometrics. More studies on sexual dimorphism related to root length are in the need of hour that is to be carried out on other skeletal samples, as these would permit comparisons and also provide a more unswerving picture of the utility of root length measurements as a tool of sexual dimorphism. This study also suggests that researchers using age estimation methods based on root length should develop separate mathematical formulae for each sex.

Table 3: Results of independent *t*-test

Tooth number	Eqaulity of variance	Significance
13	Equal variances assumed	0.000
	Equal variances not assumed	0.000
14	Equal variances assumed	0.001
	Equal variances not assumed	0.001
15	Equal variances assumed	0.005
	Equal variances not assumed	0.005
16_P	Equal variances assumed	0.037
	Equal variances not assumed	0.037
23	Equal variances assumed	0.000
	Equal variances not assumed	0.000
24	Equal variances assumed	0.262
	Equal variances not assumed	0.265
25	Equal variances assumed	0.517
	Equal variances not assumed	0.519
26_P	Equal variances assumed	0.000
	Equal variances not assumed	0.000
33	Equal variances assumed	0.000
	Equal variances not assumed	0.000
34	Equal variances assumed	0.444
	Equal variances not assumed	0.445
35	Equal variances assumed	0.231
	Equal variances not assumed	0.231
36_M	Equal variances assumed	0.042
	Equal variances not assumed	0.042
36_D	Equal variances assumed	0.057
	Equal variances not assumed	0.058
43	Equal variances assumed	0.001
	Equal variances not assumed	0.001
44	Equal variances assumed	0.344
	Equal variances not assumed	0.344
45	Equal variances assumed	0.191
	Equal variances not assumed	0.191
46_M	Equal variances assumed	0.043
	Equal variances not assumed	0.043
46_D	Equal variances assumed	0.397
	Equal variances not assumed	0.399

In the current study, the maxillary canines showed the superlative degree of sexual dimorphism. Forensic odontology focuses on the uniqueness of teeth and its associated structures. Odontometrics is an adjunct tool that could be utilized in victim identification during massacres and mass disasters. Due to the strength of teeth and the resistance to postmortem destruction and fragmentation, odontometric studies have played an important role in human biological investigations. The crux of forensic odontology is the maintenance of a central database, and this could serve as a purposeful tool of identification following the maintenance of antemortem and postmortem records. Although this approach inclines as a quick and easy method, auxiliary studies are required to evaluate the prospects fusing root length in diverse populations.

Table 4: *t* values of intra- and inter-observer error tests

Tooth number	Intra-observers	Inter-observers
13	0.31	−0.11
14	0.41	−0.55
15	0.13	0.67
16	0.17	1.26
23	0.26	0.42
24	0.34	0.09
25	0.28	0.26
26	0.34	0.57
33	0.62	0.67
34	0.61	0.19
35	−0.22	0.97
36 (mesial)	0.66	−0.64
36 (distal)	0.58	0.96
43	−0.50	−1.07
44	−1.05	−0.89
45	0.98	1.15
46 (mesial)	0.49	0.55
46 (distal)	0.44	0.70

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Acharya AB, Mainali S. Univariate sex dimorphism in the Nepalese dentition and the use of discriminant functions in gender assessment. Forensic Sci Int 2007;173:47-56.
2. Khamis MF, Taylor JA, Malik SN, Townsend GC. Odontometric sex variation in Malaysians with application to sex prediction. Forensic Sci Int 2014;234:183.e1-7.
3. Angadi PV, Hemani S, Prabhu S, Acharya AB. Analyses of Odontometric sexual dimorphism and sex assessment accuracy on a large sample. J Forensic Leg Med 2013;20:673-7.
4. Harris EF, Couch WM. The relative sexual dimorphism of human incisor crown and root dimensions. Dent Anthropol 2006;19:87-94.
5. Capitaneanu C, Willems G, Jacobs R, Fieuws S, Thevissen P. Sex estimation based on tooth measurements using panoramic radiographs. Int J Legal Med 2017;131:813-21.
6. Dhall JK, Kapoor AK. Fingerprint ridge density as a potential forensic anthropological tool for sex identification. J Forensic Sci 2016;61:424-9.
7. Álvarez-Sandoval BA, Manzanilla LR, Montiel R. Sex determination in highly fragmented human DNA by high-resolution melting (HRM) analysis. PLoS One 2014;9:e104629.
8. Prabhu S, Acharya AB. Odontometric sex assessment in Indians. Forensic Sci Int 2009;192:129.e1-5.
9. Zorba E, Moraitis K, Eliopoulos C, Spiliopoulou C. Sex determination in modern Greeks using diagonal measurements of molar teeth. Forensic Sci Int 2012;217:19-26.
10. Garn SM, Lewis AB, Swindler DR, Kerewsky RS. Genetic control of sexual dimorphism in tooth size. J Dent Res 1967;46:963-72.
11. Brook AH, Griffin RC, Townsend G, Levisianos Y, Russell J, Smith RN, *et al*. Variability and patterning in permanent tooth size of four human ethnic groups. Arch Oral Biol 2009;54 Suppl 1:S79-85.
12. Ateş M, Karaman F, Işcan MY, Erdem TL. Sexual differences in Turkish dentition. Leg Med (Tokyo) 2006;8:288-92.