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ORIGINAL ARTICLE

SEXUAL DIMORPHISM IN PERMANENT MANDIBULAR AND MAXILLARY CANINES OF SRI LANKAN SINHALESE POPULATION

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ABSTRACT

Introduction: Sexual dimorphism is one of the most important implications in forensic investigations and anthropological studies. Teeth are becoming a good source of material for gender determination. The canine is the most preferred tooth for gender determination because the canine is the strongest tooth in the oral cavity.

Objectives: To investigate sexual dimorphism in permanent mandibular and maxillary canines of a Sri Lankan Sinhalese population, and to ascertain the most suitable dimension (labiolingual, mesiodistal and crown height) to determine the sex of an individual.

Materials & Methods : The study was conducted using 384 dental casts (Males 192, Females 192) aged between 18 and 25 years in a sample of the Sri Lankan population. According to a selection criterion, casts were selected using a convenient random sampling technique. Mesio-distal, Bucco-lingual and Crown height of all the canines in the casts were measured using a digital vernier caliper accurate to 0.01 mm.

Results : Statistical analysis was performed using Minitab 17 and SPSS (Version 21). Unpaired sample t-test, paired sample t-test and point-biserial correlation were used for data analysis. The present study revealed that males show larger mean dimensions of canine teeth than females. Out of all four canines, mandibular canines show highly consistent results for sexual dimorphism. Further, crown height is the best measurement to evaluate sexual dimorphism.

Conclusion : It can be concluded that out of all the four canines, mandibular canines show highly consistent results for sexual dimorphism. Moreover, crown height is the best measurement to evaluate sexual dimorphism, in identifying an unknown individual.

Keywords: sexual dimorphism, mandibular canines, Sri Lankan, crown dimensions, forensic odontology

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INTRODUCTION

Forensic medicine is the application of medical knowledge for the investigation of crime, particularly in establishing the causes of injury or death of civilians and criminals. Identification of highly damaged dead bodies such as burnt human remains, in explosions, in aviation accidents, immersed human remains in train crash, suicidal attacks, wars, massacre and hidden decomposed bodies in mass graves, cannot be verified using typical methods, as these bodies are beyond recognition in most of the time after these incidents.[1,2] Therefore, identification of these dead bodies is paramount important especially in medico-legal death investigations such as criminals and other relevant lawsuits that do not have any direct evidence for an unbiased judgment [1].

Various methods are being used to confirm the identity of an unknown individual at death. Although the reliability of these methods is varying, and the DNA technique is the most accurate one among those methods. [1] However, the DNA technique cannot be used for each and every case, as it is an expensive method for countries like Sri Lanka.

Forensic odontology is an area of specialization in the field of dentistry that provides essential support in situations like criminal investigations, disasters, accidents, and genetic research in a forensic context. [3] The craniofacial skeleton and teeth have been identified as indispensable in the identification of individuals, especially in mass disasters for the estimation of age of an individual.

Being the most indestructible bodily structures, the teeth are becoming more and more useful in forensic odontology because of their resistance to dissolution and destruction by chemical and physical agents. Further, teeth are known as the most durable bodily components that can withstand at high temperatures, aviation disasters and hurricanes and they are preserved even when most of the bones have been destroyed, mutilated, or affected by other taphonomic agents. [4,5,6]

Determination of sex is the most initial step in medico-legal investigations in forensic medicine as well as in anthropological studies [7] as establishment of sex helps in narrowing down the pool of potential identities. In certain instances, it is extremely difficult to identify and determine the gender of some dead bodies which are less complete, decomposed, burned, or dismembered. In those instances, forensic medicine as well as forensic odontology is useful to determine the gender of the individuals. [1] Identification from skeletal remains, DNA analysis from biological evidence and fingerprint analysis are some of the methods that are being used in forensic medicine to identify the individuals and determine the gender.[7] Bite mark comparison and measurements of teeth dimension are also being used in forensic odontology to determine the gender of the individuals. [8,9,10]

Further, number of studies have shown that morphometrics of teeth such as crown height, mesiodistal width, buccolingual dimensions play an important role in the identification of the individuals including the sex.[9] Moreover, the different patterns of tooth size, shade and shape are reported between different populations groups and are thought to reflect differences in the relative contributions of genetic, and environmental influences to dental development between the different populations. [11]

It is well known fact, that the canines are very often the only teeth which remain in the oral cavity when all other teeth are missing or extracted due to caries or periodontal diseases because it is the most stable strongest tooth in the oral cavity.[4] The Strength and stability of the canine depend on its great anchorage to the alveolar process of the jaw by consisting of longest root compared to the other roots of the teeth. As well as the labiolingual thickness helps to keep the strength of the tooth. Besides, the morphology of the crown promotes self-cleanliness and hence low incidence of caries and also periodontal disease. Therefore, canine is considered

to be the preferred tooth for the determination of sex of an individual. The number of studies has investigated the degree of sexual dimorphism using canine dimensions in an attempt to determine the sex and have demonstrated that the canine dimensions in males are greater than in females and that gender can be determined with the considerable accuracy from these measurements and vary between different ethnic and population groups. [1,2, 4,8,9, 10,12,13, 14,15,16]

Sri Lankan population belonged to Caucasian and composed of having different ethnic groups. Despite the need for such studies, sexual dimorphism in tooth dimension has scarcely been discussed for the Sri Lankan population except the study that has been reported on sexual dimorphism, and tooth size variation in the permanent dentition of the Uva Bintenna Veddas of Sri Lanka. [17] Therefore, although it is evident that studies have been conducted to determine sex using tooth dimensions in various populations, similar studies establishing population specific standards have not yet been attempted in the Sri Lankan population.

In the past in Sri Lanka, when the need arose to determine the age of an individual, the norms established for western populations were used, since the lack of normative database established for Sri Lankan population. It has been shown that the sizes of the permanent and deciduous teeth (the length and the crown diameters) of Sri Lankans are significantly different from those of Caucasians. [18,19]

Therefore, the present study was undertaken to establish normative data for the MD, LL & Crown height dimensions of maxillary and mandibular canines teeth and to ascertain the correlation of sexual dimorphism of canine measurements, and to seek population specific models to determine of unidentified males and females in a sample of Sri Lankan population.

METHODOLOGY WITH STATISTICAL ANALYSIS

The present study was a quantitative descriptive surveillance survey to estimate the sexual dimorphism of canines in a sample of the Sri Lankan population belonging to the age group of 18-25 years. A total of 384 casts (Males 192, Females 192), aged between 18 and 25 years, have been selected for the study. Presence of all permanent teeth up to the second molars, non-carious, non-attrited and intact teeth together with, satisfactorily aligned teeth without spacing, rotation, crowding or any malocclusion included in the present study. History or clinical evidence of crown restorations, cleft palate and trauma was excluded from the study group. And also, the casts with air bubbles and broken teeth were excluded. The data collected from the casts available in the Comparative Human Biology lab in the Department of Basic Sciences, Faculty of Dental Sciences, University of Peradeniya according to random sample technique. (Brief record of the socio demographic background to ascertain the age, sex, date of birth, period of residence in the district, written consent etc. had already been obtained and documented). The Cochrane formula was used to determine the sample size.

Ethical clearance was taken from the Ethics Review Committee, Faculty of Dental Sciences, University of Peradeniya. (ERC/FDS/UOP/UGR/2021/08).

The study casts which were made using irreversible hydrocolloid impression material (alginate, Aroma Fine, China) and dental stone (New Plastone, G-C. Co., Japan) available in the Comparative Human Biology Lab of the Department of Basic Sciences were used. Measurements were taken by a digital vernier caliper (Mitutoyo Digital Caliper, Japan), accurate to 0.01 mm [Figure 1] as described by. [8,9,20,21]

The greatest mesiodistal (MD), labiolingual (LL) diameter and crown height (CH) of the maxillary and mandibular canines were measured as shown in Figure 2.

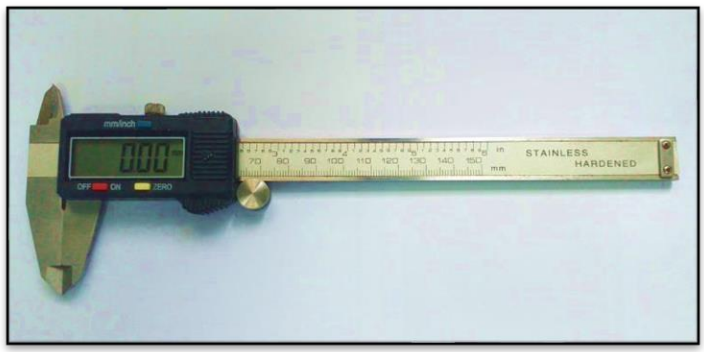

FIGURE 1: MITUTOYO DIGITAL VERNIER

- MD- Greatest distance between the contact points on the proximal surface of the crown, measured with the calipers aligned along the mesio-distal axis of the tooth.
- LL- Greatest distance between the labial surface and the lingual surface of the crown measured with the calipers held at 90-degree angles to the mesio-distal axis.
- CH- Distance between the most apical point of the cervical line (gingival margin) to the cusp tip of the canine. [Figure 2]

A measurement was taken in three times in three days interval to minimize intra-observer error

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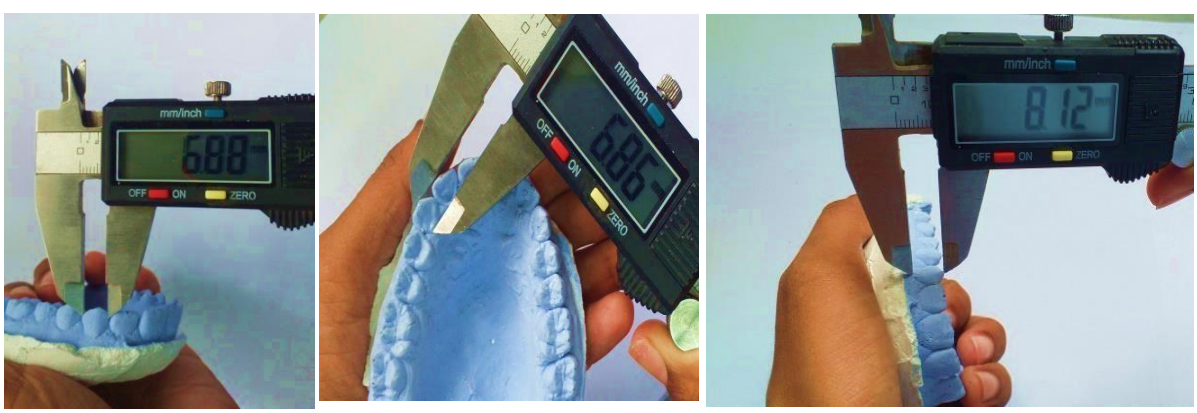

FIGURE 2: MEASURING MESIODISTAL, LABIOLINGUAL WIDTH AND CROWN HEIGHT.

Statistical analysis was performed using Minitab 17 and SPSS (Version 21). The data were assessed for normality using the Anderson-Darling test. Descriptive statistics, including the means and standard deviation, were obtained for each dimension for each sex. The two-sample t-tests (Unpaired sample t-tests) were performed to ascertain whether significant differences exist between the mean values of each measurement of males and females. The paired sample t-tests were applied to compare the measurements on the left and right sides of males and females separately. Also point-biserial correlation is used to measure the relationship between maxillary and mandibular canines. p- value <0.05 was considered statistically significant in all the test results. The formula given in the following research articles was used to calculate the sexual dimorphism ratio for each measurement.[22] Sexual dimorphism ratio= (Male mean/ Female mean)

OBSERVATION & RESULTS

The results of the Anderson-Darling test confirmed that sample data of this study was carried from a normal distribution (p>0.05). [Table 1]

Table 1. Results of Anderson Darling test

FEMALE VS MALES

Gender	**Jaw**	**Side**	**Mesiodistal**		**Labiolingual**		**Crown Height**	
			AD Test Statistic	p-value	AD Test Statistic	p-value	AD Test Statistic	p-value
Male	Maxillary	Right	0.613	0.110	0.233	0.795	0.244	0.760
		Left	0.262	0.702	0.602	0.116	0.613	0.110
	Mandibular	Right	0.321	0.529	0.441	0.288	0.477	0.235
		Left	0.476	0.237	0.718	0.066	0.628	0.101
Female	Maxillary	Right	0.396	0.363	0.192	0.896	0.315	0.541
		Left	0.287	0.617	0.731	0.059	0.210	0.859
	Mandibular	Right	0.474	0.239	0.439	0.290	0.284	0.627
		Left	0.439	0.290	0.707	0.064	0.505	0.200

Descriptive statistical analysis including mean and standard deviation, was performed for all variables separately for males and females (Table 2). The mean values of the measurements in males are higher than in females. The unpaired student t test is exhibited a statistically significant difference between males and females in all three dimensions [Table 2 (p<0.05)]. Furthermore, results are illustrated in Figure 3 and 4 based on the mean values and standard deviations of all the measurements, respectively.

Table 2. Descriptive statistical analysis in the mesiodistal, labiolingual, crown height of maxillary and mandibular canines for males and females

Tooth	Parameter	Male mean	Male SD	Female mean	Female SD	95% CI Upper Limit	95% CI Lower Limit	t-test	p-value
Maxillary Right Canine (13)	MD	7.642	0.557	7.346	0.529	0.4042	0.1862	5.32	<0.001
	LL	7.453	0.702	7.195	0.728	0.4013	0.1144	3.53	<0.001
	CH	10.29	1.190	9.61	1.070	0.913	0.459	5.94	<0.001
Maxillary Left canine (23)	MD	7.683	0.505	7.357	0.538	0.4315	0.2222	6.14	<0.001
	LL	7.421	0.727	7.274	0.680	0.2886	0.0061	2.05	0.041
	CH	10.39	1.160	9.64	1.060	0.977	0.532	6.66	<0.001
Mandibular Left Canine (33)	MD	6.844	0.496	6.471	0.468	0.4690	0.2755	7.56	<0.001
	LL	6.807	0.840	6.531	0.696	0.4303	0.1207	3.5	0.001
	CH	10.26	1.220	9.54	1.020	0.948	0.495	6.27	<0.001
Mandibular Right Canine (43)	MD	6.863	0.479	6.485	0.444	0.4699	0.2845	8	<0.001
	LL	6.721	0.780	6.539	0.657	0.3264	0.0370	2.47	0.014
	CH	10.41	1.190	9.59	1.100	1.051	0.591	7.02	<0.001

[MD- mesiodistal width, LL- labiolingual width, CH- crown height, SD- standard deviation ($p<0.05$)]

RIGHT VS LEFT

The present study has found that there is no significant difference between right and left maxillary canines in males as well as females. ($p>0.05$). But the labiolingual width in the left maxillary canine is greater than the right maxillary canine in females, as demonstrated in Table 3 and Figure 5 & 6.

Table 04 exhibits that the labiolingual width the of left mandibular canine is greater than the right mandibular canine, whereas the crown height of the right mandibular canine is greater than the left mandibular canine, in males, according to the results of paired student's t-test. Therefore, it is conveyed a significant difference in labiolingual width and crown height between right and left mandibular canines in males. However, the mesiodistal width of the right and left mandibular canines in males, do not show any statistical difference. (Table 4, Figure 7).

In females, there is no significant difference between all 03 dimensions of right and left mandibular canines. (p>0.05) (Table 4, Figure 8)

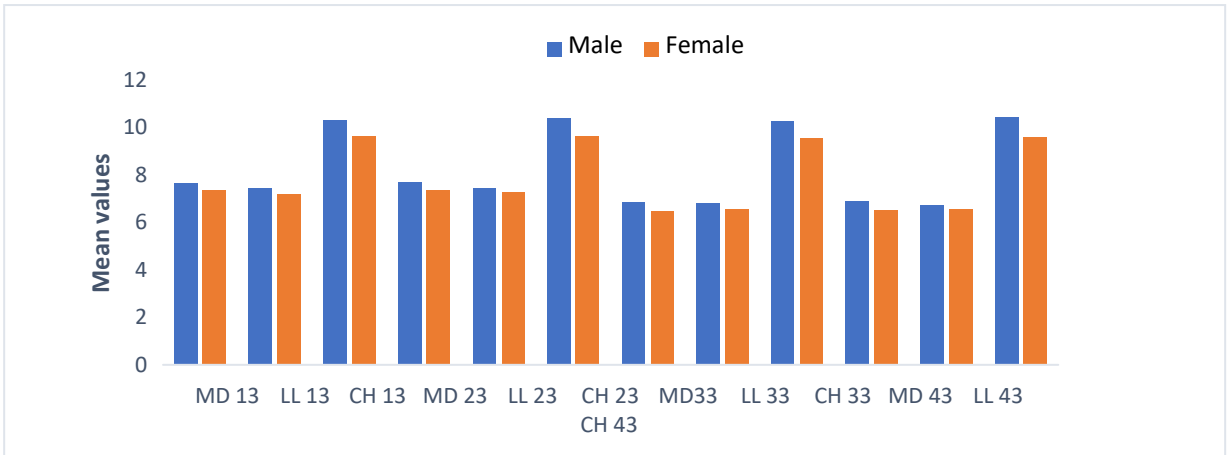

FIGURE 3. COMPARATIVE CHART BASED ON MEAN VALUES

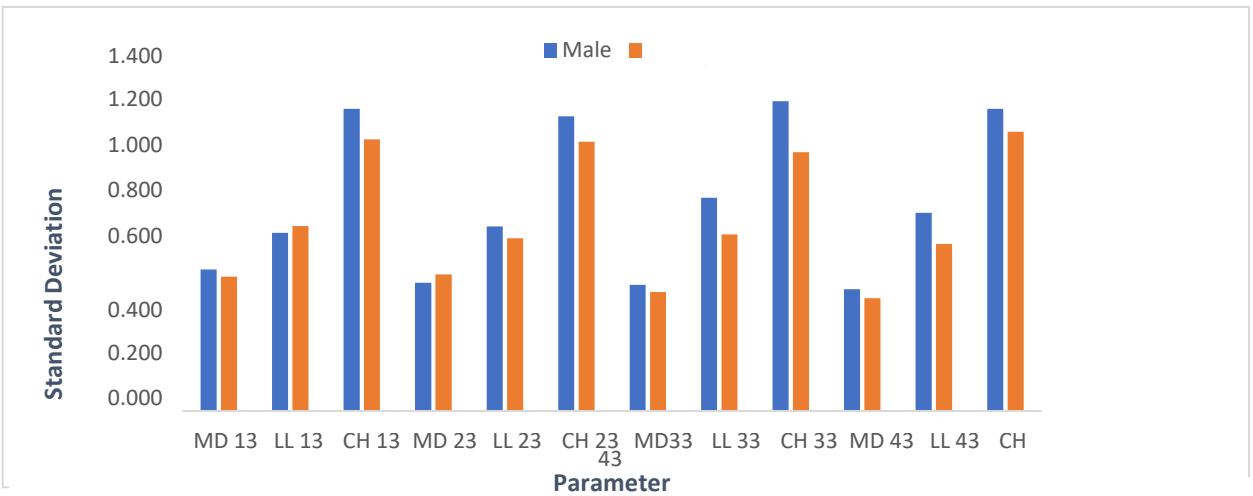

FIGURE 4. COMPARATIVE CHART BASED ON STANDARD

MAXILLARY VS MANDIBULAR

As shown in Tables 5 and 6, all dimensions in both arches indicate significant difference except the crown height of both arches in both males and females. (p>0.05).

Table 3. Comparison between the dimensions of right and left maxillary canines in males and females.

	Parameter	Right Maxillary Canine (13)		Left Maxillary Canine (23)		t value	p- value
		Mean	SD	Mean	SD		
Male	MD	7.6415	0.5573	7.6834	0.5046	1.46	0.145
	LL	7.4529	0.7018	7.4211	0.7268	0.9	0.371
	CH	10.2938	1.1866	10.3919	1.1613	1.8	0.073
Female	MD	7.3463	0.5287	7.3566	0.5379	0.33	0.738
	LL	7.195	0.7279	7.2737	0.6802	2.11	0.036
	CH	9.6075	1.0731	9.6376	1.056	0.55	0.585

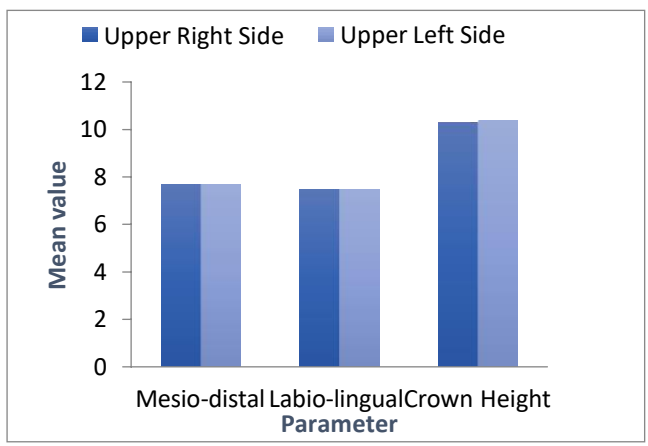

Figure 5. Comparison of mesio-distal, labio-lingual dimensions and crown heights between right and left side of maxillary canines among males

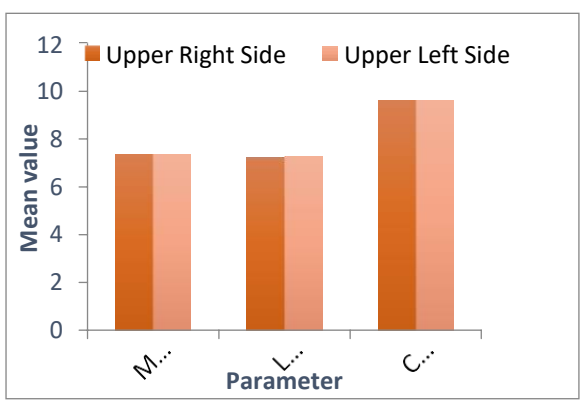

Figure 6. Comparison of mesio-distal, labio-lingual dimensions and crown heights between right and left side of maxillary canines in females

Table 4. Comparison between the three dimensions of right and left mandibular canines in males and females.

	Parameter	Right Mandibular Canine (43)		Left Mandibular Canine(33)		t value	p-value
		Mean	SD	Mean	SD		
Male	MD	6.8626	0.4786	6.8437	0.4964	0.73	0.467
	LL	6.7208	0.78	6.8067	0.84	2.21	0.029
	CH	10.4121	1.193	10.2619	1.2239	2.83	0.005
Female	MD	6.4853	0.4444	6.4714	0.4676	0.52	0.602
	LL	6.5391	0.6569	6.5313	0.696	0.22	0.826
	CH	9.5913	1.0969	9.5405	1.0203	1.13	0.261

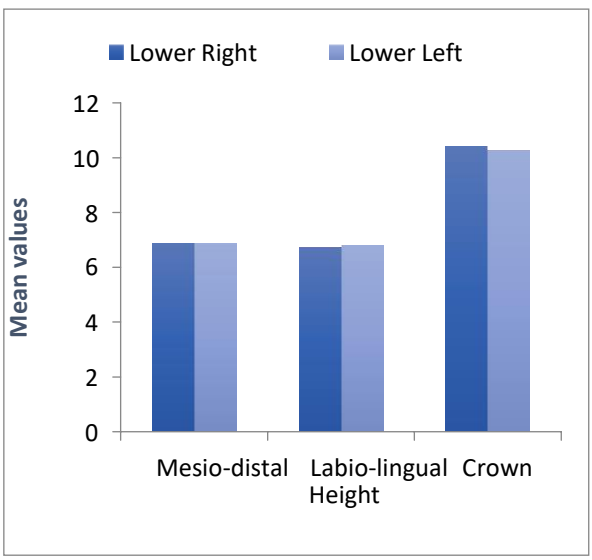

Figure 7. Comparison of mesio-distal, labiolingual dimensions and crown heights in right and left side of mandibular canines in males

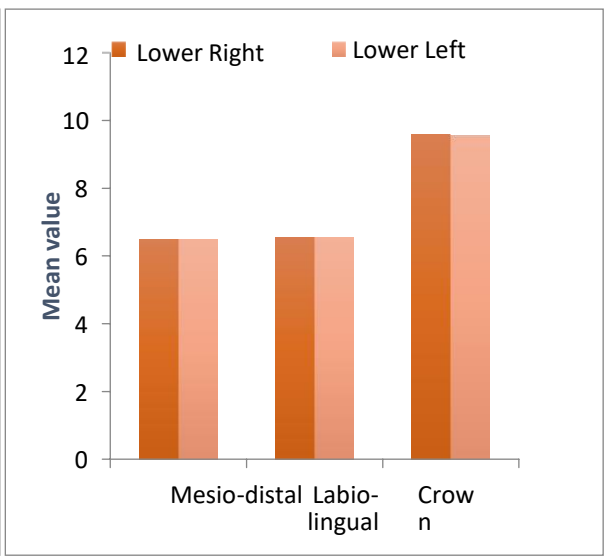

Figure 8. Comparison of mesio-distal, labiolingual dimensions and crown heights in right and left side of mandibular canines in females

Table 5. Comparison between the three dimensions of right and left sides maxillary vs mandibular canines of males

	Parameter	Maxillary canine		Mandibular canine		t value	p-value
		Mean	SD	Mean	SD		
Right Side	MD	7.6425	0.5574	6.8628	0.47879	23.499	<0.001
	LL	7.4541	0.7018	6.7220	0.78023	14.591	<0.001
	CH	10.2950	1.1865	10.4133	1.19296	-1.666	0.097
Left Side	MD	7.6844	0.50469	6.8440	0.49652	25.726	<0.001
	LL	7.4223	0.72687	6.8078	0.84044	12.773	<0.001
	CH	10.3929	1.1612	10.2629	1.22357	1.845	0.067

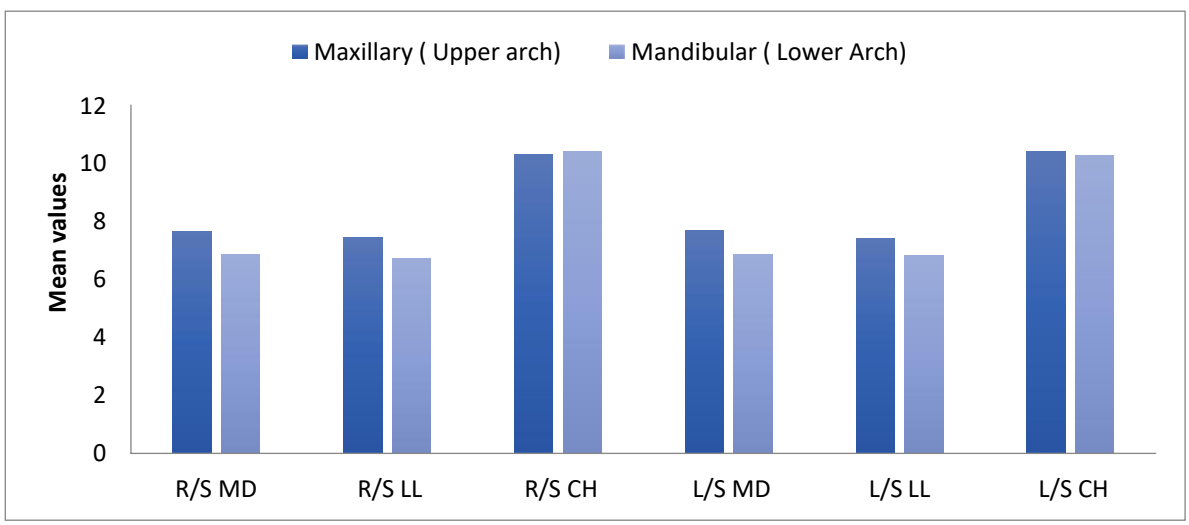

FIGURE 9. COMPARISON OF MAXILLARY AND MANDIBULAR CANINES IN MALES (R/S MD-RIGHT SIDE MESIO-DISTAL, R/S LL-RIGHT SIDE LABIO-LINGUAL, R/S CH-RIGHT SIDE CROWN HEIGHT, L/S MD-LEFT SIDE MESIO-DISTAL, L/S LL

Table 6. Comparison between the three dimensions of right and left sides maxillary vs mandibular canines of females

	Parameter	Maxillary canine		Mandibular canine		t value	p-value
		Mean	SD	Mean	SD		
Right side	MD	7.3474	0.5288	6.4860	0.44438	22.788	<0.001
	LL	7.1960	0.7277	6.5402	0.65657	13.318	<0.001
	CH	9.6086	1.0731	9.5925	1.09686	.212	0.832
Left side	MD	7.3577	0.5376	6.4720	0.46778	22.597	<0.001
	LL	7.2746	0.6798	6.5321	0.69596	16.026	<0.001
	CH	9.6385	1.0557	9.5417	1.02023	1.431	0.154

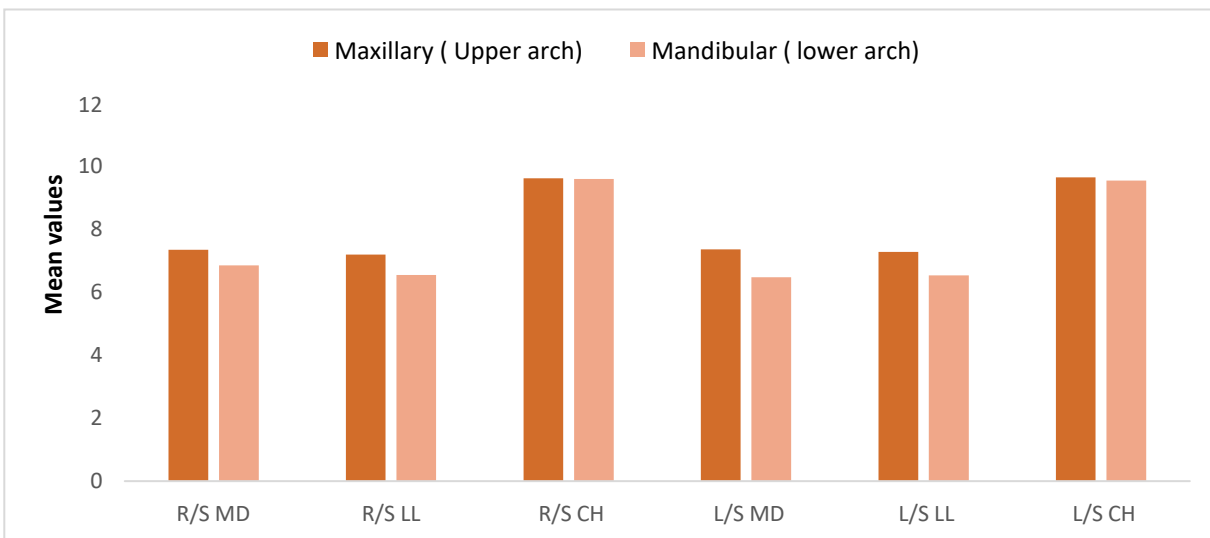

FIGURE 10. COMPARISON OF MAXILLARY AND MANDIBULAR CANINES IN FEMALES (R/S MD-RIGHT SIDE MESIO-DISTAL, R/S LL-RIGHT SIDE LABIO-LINGUAL, R/S CH-RIGHT SIDE CROWN HEIGHT, L/S MD-LEFT SIDE MESIO-DISTAL, L/S LL- LEFT SIDE LABIO-LINGUAL, L/S CH-LEFT SIDE CROWN HEIGHT)

Furthermore, point-biserial correlation in all variables of females and males exhibit positive values (Table 07). It is revealed that there is a perfectly positive correlation between the females and males dimensions of canines.

Table 7. Comparison between mesio-distal, labiolingual dimensions and crown heights of maxillary and mandibular canines in both males and females.

Variable	Jaw	Side	Correlation (ρ)	p-value
Mesiodistal	Maxillary	Right	0.2637	<0.0001
		Left	0.3005	<0.0001
	Mandibular	Right	0.3791	<0.0001
		Left	0.3611	<0.0001
Labiolingual	Maxillary	Right	0.1787	0.0004
		Left	0.1052	0.0394
	Mandibular	Right	0.1261	0.0134
		Left	0.1769	0.0005
Crown Height	Maxillary	Right	0.2914	<0.0001
		Left	0.3229	< 0.0001
	Mandibular	Right	0.3384	<0.0001
		Left	0.3061	<0.0001

CLASSIFICATION OF GENDER USING DISCRIMINANT ANALYSIS

Sexual dimorphism ratios were calculated to determine the level of differences between the sexes using the following formula: Sexual dimorphism ratio = Male mean/ Females mean ×100

The demarking points for the univariate discriminant analysis have been defined as the midpoints between the male and female means. When a single variable is used, a more straightforward way to determine sex would be to compare the value of the canine dimensions with the demarking point. If a measurement is above the respective demarking point, it has a high probability of being a male. In contrast, if any measurement is below the relevant demarking point, it is highly likely to be female. (Table 08)

The dimorphism index was always more than 100, indicating that males have greater teeth dimensions. Also, the percentage of difference was calculated the using following formula to determine the amount of difference between males and females using mean values of all dimensions. Percentage of difference = (Male mean - Female mean)/ Females mean× 100. Accordingly, the highest value of the index was seen in the crown height of the right mandibular canine, which showed a difference of 8.55%, while the lowest value was recorded for the labiolingual width of the left maxillary canine (2.02%).

Table 8: Demarking points, sex dimorphism and univariate statistics of dimensions

TOOTH	VARIABLE	DEMARKING POINT	SEX DIMORPHISM RATIO	WILKS' LAMBDA	F RATIO	P-VALUE
Right Maxillary Canine (13)	MD	F<7.49<M	104.20	0.931	28.314	<0.001
	LL	F<7.32<M	103.58	0.968	12.505	<0.001
	CH	F<9.95<M	107.07	0.915	35.344	<0.001
Left Maxillary Canine (23)	MD	F<7.52<M	104.43	0.910	37.687	<0.001
	LL	F<7.35<M	102.02	0.989	4.226	0.040
	CH	F<10.02<M	107.78	0.896	44.366	<0.001
Left Mandibular Canine (33)	MD	F<6.66<M	105.76	0.870	57.074	<0.001
	LL	F<6.67<M	104.23	0.969	12.259	0.001
	CH	F<9.90<M	107.55	0.907	39.348	<0.001
Right Mandibular Canine (43)	MD	F<6.67<M	105.82	0.857	63.890	<0.001
	LL	F<6.63<M	102.78	0.984	6.101	0.014
	CH	F<10.00<M	108.55	0.886	49.258	<0.001

DISCUSSION

Forensic odontology in Sri Lanka is an emerging field and depends a lot on low-cost and non-invasive means of identification of individuals from teeth and remains of dental hard tissues. There are many advantages in determining sex of an unknown individual based on odontometric data such as simplicity and low cost. Moreover, a database established for canine morphometric measurements for Sri Lankan may be beneficial for other disciplines such as anthropological, forensic genetic, and legal applications.

Determination of sex becomes a challenging task in a highly damaged dead bodies in forensic investigations as well as in anthropological studies. In such situations, canine dimensions are important parameters for sex determination as an adjunctive method.

The present study also noted significant differences of all the measurements (mesio-distal, Labio-lingual, crown height) of the sexes, which supports the literature on sexual dimorphism. [1,2,4,8,9, 10,12,13,14,15,16,23,24,25] although some studies reported no significant sex difference in tooth dimensions. [26,27]

Dimorphism was greater for mandibular teeth than for maxillary teeth as greatest percentage of sexual dimorphism demonstrated for mesiodistal width in right mandibular canine followed by mesiodistal width of left mandibular canine in the present study. This result also consistent with the findings of the studies conducted for other populations groups. [1,10,12,13,28,29,31]

Although it is reported that the complex interaction between various genetic and environmental factors may play a role in the variability of sexual dimorphism.[32] However, a degree of variation between sexes has been declined for contemporary populations as reported in literature.[33]

In the present study, there are no statistically significant bilateral asymmetry exhibit between right and left canines except of right and left canines of labiolingual dimension of female maxillary canine, labiolingual and crown height dimensions of male mandibular canines. Although other studies have also observed significant differences in tooth dimensions between the right and left sides of arches [34,35] some studies have not. [36]

Interestingly “crown height" is the best dimension of the permanent canines to determine the sex of an individual and the right mandibular canine was identified as the most suitable canine for the determination of sex in the present study, which is supported by the studies done for other population groups. [12,16]

It must be noted, however, that the method of sex determination via canine measurement has its limitations; The present study was conducted to establish normative data for the mesiodistal, labiolingual & crown height dimensions of maxillary and mandibular canines and to investigate sexual dimorphism in a Sri Lankan adolescent. Dental records of 384 young healthy patients (age, 13-25 years) were included in the study. The benefit of selecting healthy young age subjects was to minimize the extent of age-related changes as well as periodontal disease in teeth that could affects dental morphology, like gingival swellings and other periodontal conditions such as, recession, tooth fracture, occlusal and approximal tooth attrition, and erosion so that it would have been affected minimally when taking the measurement in the present study.

CONCLUSION

In conclusion, the present study observed significant sexual dimorphism in both maxillary and mandibular permanent canines of a Sri Lankan population. It indicates, larger mean dimensions in males than females. Accordingly, linear dimension of mandibular canine can be used for sexual dimorphism with accuracy along with other accepted procedure for sex determination.

However, the right mandibular canine shows highly consistent results for sexual dimorphism. Furthermore, it revealed that mesiodistal, labiolingual dimensions, and crown height are more sensitive indicators for sex determination. Furthermore, among these three dimensions, the crown height is the most sensitive indicator for sex determination.

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