The Value of Maxillary Central Incisors and Canines in Gender Determination as an Aid in Forensic Dentistry

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ABSTRACT

Background: This study aimed to determine the gender of a sample of Iraqi adults utilizing the mesio-distal width of maxillary central incisors and canines and to determine the percentage of dimorphism as an aid in forensic dentistry.

Materials and methods: The sample included 230 subjects (115 males and 115 females) with an age ranged between 17- 25 years and Class I dental and skeletal relations. Study casts were taken for each subject and the mesio-distal crown dimension was measured manually from the contact points for the maxillary central incisors and canines (both sides) using digital vernier caliper gauge. Descriptive statistics were obtained for the measurements for both genders; independent samples t-test was performed to evaluate the gender difference, percentage of dimorphism and stepwise discriminant function statistics were performed to determine the teeth that can be used for gender identification in addition to the percentage of gender identification accuracy.

Results and Conclusions: Generally, the mesio-distal dimensions of the maxillary central incisor and canine were larger in males than females with a high significant difference ($P \leq 0.001$). Stepwise discriminant function statistics indicated that the right central incisor and canine were the most predominant teeth in gender identification and the accuracy of identification reached up to 69.6%.

Keywords: Mesio-distal tooth dimension, forensic dentistry, gender determination.

INTRODUCTION

Genderual dimorphism refers to the systemic difference in the form (either in shape or size) between individuals of different genders in the same species. Teeth of various species are known to exhibit genderual dimorphism [(1)].

Gender determination is one of the important parameters in forensic identification. Teeth being the central component of the masticatory apparatus of the skull are good sources of material for civil and medico-legal identification. Teeth provide resistance to damage in terms of bacterial decomposition and fire when the rest of body is damaged beyond recognition which makes them valuable tool in forensic investigation [(2)].

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 non-metric dental traits like Carabelli's trait of upper molars, deflecting wrinkle of the lower first molars, distal accessory ridge of the upper and lower canines or shovelling of the upper central incisors [(3)]. This is based on the fact that although the morphology of the tooth structure is similar in males and females, the size of the tooth does not necessarily remain the same, as the tooth size is determined by cultural, environmental, racial and genetic factors [(4)].

Many researches were done to identify the genders using the maxillary and mandibular canines. They depended on the mesio-distal dimension of these teeth [(5,6)] and in many articles on the inter-canine width in addition to the mesio-distal width to get the canine index and standard canine index [(2,7-17)]. Other researches studied the bucco-lingual dimension of teeth [(18,19)], height of tooth [(3)] and permanent maxillary first molar [(20)] as a base for gender identification.

This study aimed to determine the gender of a sample of Iraqi adults utilizing the mesio-distal crown dimensions of the maxillary central incisors and canines with the aid of stepwise discriminant function statistics and to determine the percentage of dimorphism.

MATERIALS AND METHODS

SAMPLE

The sample comprised 230 Iraqi Arab subjects (115 males and 115 females) with an age ranges between 17 and 25 years. They had normal skeletal and dental pattern [(21)] i.e. had class I skeletal relation and class I dental relation with a full set of permanent well-aligned caries free teeth (regardless the wisdom teeth) and normal overjet and overbite with no history of orthodontic treatment, maxillo-facial trauma, surgery or defect.

METHODS

1. History and clinical examination

Each subject was asked to sit comfortably on the dental chair and asked information about the name, age, origin, medical history, the history of facial trauma and orthodontic treatment. Then they were asked to look forward horizontally (Frankfort plane parallel to the floor) for clinical examination (extra-orally and intra-orally) to check their fulfillment of the required sample selection.

2. Dental cast analysis

Dental cast production

Impressions were taken for every subject using Alginate impression material then poured with a prepared amount of stone. After setting of the dental stone, Plaster of Paris was prepared and put in the rubber base mold, and the poured cast was inverted over it. After the final setting of the gypsum, the cast was opened from the mold and made ready for the measuring procedure.

Mesio-distal crown dimensions measurements

The procedure of determining the mesio-distal crown width of the right and left maxillary central incisors and canines was done by measuring the greatest mesio-distal crown width of these teeth from the anatomic mesial contact point to the distal one [22]. The measurements were made to the nearest 0.1 mm by using the digital sliding caliper gauge with pointed beak inserted in a plane parallel to the long axis of the tooth.

STATISTICAL ANALYSES

The data of this study were analyzed with SPSS version 15 program. The statistical analyses included:

a) Descriptive statistics: means, standard deviations and statistical tables.

b) Inferential statistics:

1. Independent sample t-test to evaluate the genders difference.
2. Percentage of dimorphism which is the percentage by which the tooth size of males exceeds that of females {it equals to = $[(X_m/X_f)\text{-}1x100]$ where X_m is the mean tooth dimension of males and X_f is the mean tooth dimension of females} [23].
3. Stepwise discriminant function statistics to determine the teeth that can be used in gender identification in addition to the percentage of gender identification accuracy.

RESULTS AND DISCUSSION

Crowns of permanent teeth are formed at an early stage and their dimensions remain unchanged during further growth and development, except in cases when specific changes and disorders in terms of functionality, pathology and nutrition can have effect on the normal dimensions of a tooth. Because of that odontometric features of teeth can be used in determining sex after the tooth has erupted even in children whose osseous features of the sex are not yet defined [24].

Human sexual dimorphism is said to be an outcome of a survival strategy, a balancing of the need for high degree of biological variation within the species with the need for a narrow range of variation in the female, who is physically structured for the support of an infant prenatally and postnatally [25]. Thus, the differences are a reflection of the ongoing processes of evolution. The genetic basis for variation has been explained by a polygenic model of inheritance. This is the basis of the sexual dimorphism in the morphological and metric attributes of males and females [26].

In Iraq, this is the third study that tries to identify the gender. Rashid and Ali [27] used the linear measurements related to the mental and mandibular foramina vertical positions on digital panoramic images in sex determination. They found statistically significant differences in all of the linear measurements between genders where males almost have higher measurements than females. Linear measurements related to the mandibular foramen vertical position can be used as best parameters to predict genders, while the measurements that related to the mental foramen vertical position ranked after in their discriminating abilities. Ali and Al-Nakib [28] evaluated the accuracy of digital cephalometric system in sex determination in Iraqi samples with different age range using certain linear and angular craniofacial measurements. They found that all the cranio-cephalometric measurements gave 86.7% overall predictive accuracy of sex determination by discriminant analysis while the stepwise selection method gave 85.8% overall predictive accuracy. These methods are X-ray dependant which is hazardous and not cheap. In the present study, measuring the tooth width is easy, fast and can be done intra- or extra-orally.

The results indicated that the mesio-distal crown dimensions of the right maxillary central incisor and canines were higher in males than females (Table 1) with a high significant difference ($p \leq 0.001$). This comes in agreement with many researches [5-8, 11,12].

Table 1. Descriptive statistics of the mesio-distal dimension of the measured teeth and genders difference

Teeth	Genders	Descriptive Statistics		Genders difference (d.f.=228)	
		Mean	S.D.	t-test	p-value
RCI	Males	8.83	0.54	5.09	0.000 ***
	Females	8.50	0.42		
LCI	Males	8.84	0.51	4.89	0.000 ***
	Females	8.54	0.44		
RC	Males	8	0.49	6.23	0.000 ***
	Females	7.63	0.42		
LC	Males	7.95	0.50	5.47	0.000 ***
	Females	7.61	0.45		

RCI= Right Central Incisor, LCI= Left Central Incisor, RC= Right Canine, LC= Left Canine , *** **Highly significant ($p \leq 0.001$)**

Discriminant analysis involves the determination of a linear equation like regression that will predict which group the case belongs to. The aim of the statistical analysis in discriminate analysis is to combine (weight) the variable scores in some way so that a single new composite variable, the discriminant score, is produced.

Discriminant analysis creates an equation which will minimize the possibility of misclassifying cases into their respective groups or categories. The form of the equation or function is:

$$D = a + b1x1 + b2x2 + \ldots + bnxn$$

D is predicted score (discriminant score: this is a weighted linear combination (sum) of the discriminating variables.)

a is constant

x is predictor and

b is discriminant coefficient.

Stepwise discriminate analysis, like its parallel in multiple regressions, is an attempt to find the best set of predictors. It is often used in an exploratory situation to identify those variables from among a larger number that might be used later in a more rigorous theoretically driven study

In stepwise discriminate analysis, the most correlated independent is entered first by the stepwise programme then the second until an additional dependent adds no significant amount to the canonical R squared [29].

Using the stepwise discriminant function statistics, gender identification can be determined and the percentage of identification accuracy can be obtained.

In this study, only the right maxillary central incisor (RCI) and canine (RC) showed high correlation and the left side of these teeth was excluded, so the formula was:

D= -21.53 + 1.033(RCI) +1.609(RC)

A further way of interpreting discriminant analysis results is to describe each group in terms of its profile, using the group means of the predictor variables. These group means are called centroids. In this study, males had a mean of 0.468 while females produce a mean of –0.468. The cut-off point for discrimination between the gender is ½ (0.468 + (-0.468)) = 0. If the calculated discriminant score is less than zero the case is classified as "Female" and if the score is greater than or equal zero, the case is classified as "Male"

As shown in table 2, the percentage of accuracy of gender identification were 67, 72.2 and 69.6% for males, females and total sample respectively using the right central and canine as predictors.

When the right canine was taken into consideration only, the percentages were 65.2, 67.8 and 66.5% respectively. These percentages were higher than of Khangura *et al.* [5]. While for right central incisor, the percenatges were 56.5, 67 and 61.7% respectively.

Table 2. Percentage of accuracy of correctly classified and misclassified cases

Genders	Accuracy of gender determination using RC and RCI				Accuracy of gender determination using RCI				Accuracy of gender determination using RC			
	Correctly Classified		Misclassified		Correctly Classified		Misclassified		Correctly Classified		Misclassified	
	No.	%*	No.	%*	No.	%*	No.	%*	No.	%*	No.	%*
Males	77	67	38	33	65	56.5	50	43.5	75	65.2	40	34.8
Females	83	72.2	32	27.8	77	67	38	33	78	67.8	37	32.2
Total	160	69.6	70	30.4	142	61.7	88	38.3	153	66.5	77	33.5

***The percentage of accuracy was obtained by dividing the number of cases by the total number multiplied by 100.**

The percentages of dimorphism were higher in right central and canine than the left side confirming the results of discriminant analysis (Table 3), i.e. the right central and canine are more dimorphic than left central and canine, with higher percentage for the canine.

Table 3. Descriptive statistics of the mesio-distal dimension of the measured teeth and percentage of dimorphism

Teeth	Genders	Descriptive Statistics		Percentage of dimorphism
		Mean	S.D.	
RCI	Males	8.83	0.54	3.83
	Females	8.50	0.42	
LCI	Males	8.84	0.51	3.60
	Females	8.54	0.44	
RC	Males	8	0.49	4.88
	Females	7.63	0.42	
LC	Males	7.95	0.50	4.48
	Females	7.61	0.45	

It is suggested that the way of influence of the Y chromosome on the amelogenesis is regulatory, and that the difference in tooth size between males and females is explained by a differential growth-promoting effect of the Y chromosome compared to the X chromosome. The general finding that tooth crown sizes in males exceeded, on average, those in females resulted from a greater thickness of dentin in male teeth. The difference is explained by the promoting effect of the Y chromosome on dentin growth, probably through cell proliferation. It is conceivable that due to the Y chromosome, mitotic potential is increased, which at different stages of development leads to the increase in cell division and may also account for other differences in the dentition [30,31].

Generally, canine gives accuracy more than the central incisor in gender determination in both tests (Table 2 and 3); this is because of the greater thickness of enamel in males due to the long period of amelogenesis compared to females [32].

CONCLUSION

This study is the first of its type in Iraq to determine the genders using the mesio-distal dimensions of maxillary central incisors and canines with the stepwise discriminant function statistics. The method in this study is simple and inexpensive to conduct, so it can be applied in forensic dentistry for establishing gender identity of an individual and gives accuracy of genders identification reached up to 69.6% for the total sample in addition to that right central incisor and canine were the most important teeth in this study to develop the formula that determine the discriminant score.

REFERENCES

1. Dahberg AA. Dental traits as identification tools. Dent Prog 1963; 3: 155–60.

2. Rao NG, Rao NN, Pai ML, Kotian MS. Mandibular canine index - a clue for establishing gender identity. Forensic Sci Int 1989; 42(3): 249–54.
3. Vodanović M, Demo Ž, Njemirovskij V, Keros J, Brkić H. Odontometrics: A useful method for gender determination in an archaeological skeletal population? J Archaeol Sci 2007; 34(6): 905–13.
4. Dempsey PJ, Townsend GC. Genetic and environmental contributions to variation in human tooth size. Heredity 2001; 86(6): 685-93.
5. Khangura RK, Sircar K, Singh S, Rastogi V. Gender determination using mesio-distal dimension of permanent maxillary incisors and canines. J Forensic Dent Sci 2011; 3(2): 81–5. (IVSL).
6. Bakkannavar SM, Monteiro FNP, Arun M, Kumar GP. Mesio-distal width of canines: a tool for gender determination. Med Sci Law 2012; 52(1): 22–6.
7. Al-Rifaiy MQ, Abdullah MA, Ashraf I, Khan N. Dimorphism of mandibular and maxillary canine teeth in establishing gender identity. Saudi Dent J 1997; 9(1): 17-20.
8. Kalia S. A study of permanent maxillary and mandibular canines and inter-canine arch widths among males and females. A master thesis. Department of Oral Medicine and Radiology, Rajiv Gandhi University of Health Sciences, Karnataka, Bangalore, 2006.
9. Vishwakarma N, Guha R. A study of genderual dimorphism in permanent mandibular canines and its implications in forensic investigations. Nepal Med Coll J 2011; 13(2): 96-9.
10. Kaushal S, Patnaik VVG, Agnihotri G. Mandibular canines in gender determination. J Anat Soc India 2003; 52(2): 119-24.
11. Parekh DH, Patel SV, Zalawadia AZ, Patel SM. Odontometric study of maxillary canine teeth to establish genderual dimorphism in Gujarat population. Int J Biol Med Res 2012; 3(3): 1935-7.
12. Boaz K, Gupta C. Dimorphism in human maxillary and mandibular canines in establishment of gender. J Forensic Dent Sci 2009; 1(1): 42-4. (IVSL).
13. Hosmani JV, Nayak RS, Kotrashetti VS, Pradeep S, Babji D. Reliability of mandibular canines as indicators for genderual dichotomy. J Int Oral Health 2013; 5(1):1-7.
14. Kaushal S, Patnaik VVG, Sood V, Agnihotri G. Gender determination in north Indians using mandibular canine index. JIAFM 2004; 26(2): 45-9.
15. Ibeachu PC, Didia BC, Orish CN. Genderual dimorphism in mandibular canine width and intercanine distance of university of Port-Harcourt students, Nigeria. Asian J Medical Sci 2012; 2(5): 166-9.
16. Reddy VM, Saxena S, Bansal P. Mandibular canine index as a gender determinant: A study on the population of western Uttar Pradesh. J Oral Maxillofac Pathol 2008; 12(2): 56-9.
17. Mughal IA, Saqib AS, Manzur F. Mandibular canine index (MCI); its role in determining gender. Professional Med J Sep 2010; 17(3): 459-63.
18. Işcan MY, Kedici PS. Genderual variation in bucco-lingual dimensions in Turkish dentition. Forensic Sci Int 2003; 137(2-3): 160–4.
19. Prathibha Rani RM, Mahima VG, Patil K. Bucco-lingual dimension of teeth- An aid in gender determination. J Forensic Dent Sci 2009; 1(2): 88-92. (IVSL).
20. Sonika V, Harshaminder K, Madhushankari GS, Sri Kennath JAA. Genderual dimorphism in the permanent maxillary first molar: a study of the Haryana population (India). J Forensic Odontostomatol 2011; 29(1): 37-43.
21. Mitchell L. An introduction to orthodontics. 4th ed. Oxford: Oxford University Press; 2013.
22. Hunter WS, Priest WR. Errors and discrepancies in measurement of tooth size. J Dent Res 1960; 39(2): 405-14.
23. Garn SM, Lewis AB, Kerewsky RS. Bucco-lingual size asymmetry and its developmental meaning. Angle Orthod 1967; 37(3): 186-93. (IVSL).
24. Teschler-Nicola M, Prossinger H. Sex determination using tooth dimensions. In: Alt KW, Ro¨sing FW, Teschler-Nicola M (eds). Dental Anthropology, fundamentals, limits and prospects. 1st ed. Wienna: Springer-Verlag; 1998. pp. 479-501.
25. Vito CD, Sauders SR. A discriminant function analysis of deciduous teeth to determine sex. J Forensic Sci 1990; 35(4): 845–58.
26. Acharya AB, Mainali S. Univariate sex dimorphism in the Nepalese dentition and use of discriminant functions in gender assessment. Forensic Sci Int 2007; 173(1): 47–56.
27. Rashid SA, Ali J. Sex determination using linear measurements related to the mental and mandibular foramina vertical positions on digital panoramic images. J Bagh Coll Dentistry 2011; 23(Special Issue): 59-64.
28. Ali AR, Al-Nakib LH. The value of lateral cephalometric image in sex identification. J Bagh Coll Dentistry 2013; 25(2): 54-8.
29. Extension chapters on advanced techniques. Chapter 25 Discriminant Analysis. pp. 589-608. www.uk.sagepub.com.
30. Alvesalo L, Tammisalo E, Hakola P. Enamel thickness in 47, XYY males' permanent teeth. Ann Hum Biol 1985; 12(5): 421-7.
31. Alvesalo L, Tammisalo E, Therman E. 47 XXX females, sex chromosomes and tooth crown structure. Hum Genet 1987; 77(4): 345-8.
32. Moss ML, Moss-Salentijn L. Analysis of developmental processes possibly related to human dental sexual dimorphism in permanent and deciduous canines. Am J Phys Anthropol 1977; 46(3): 407-13.