APPLICABILITY OF THE DIMODENT EQUATION OF SEX PREDICTION IN A LEBANESE POPULATION SAMPLE

F.Ayoub[1], A.Cassia[1], S.Chartouni[1], F.Atiyeh[1], A.Rizk[1], M.Yehya[2], Z.Majzoub[1], A.Abi-Farah[3]

1. School of Dentistry, Lebanese University, Beirut, Lebanon
2. Orthodontist, Beirut, Lebanon
3. Faculty of Sciences, Lebanese University, Beirut, Lebanon

ABSTRACT

Background: Sexual dimorphism represents a group of morphologic characteristics that differentiate a male from a female. Among these dimorphic traits, tooth size has been evaluated in various populations for its interest in anthropologic and forensic applications. Recent studies have shown that dental dimorphism is population-specific and that the most dimorphic tooth is the mandibular canine. In addition to the dimension of single teeth in dimorphic dental assessment, dimorphism has been evaluated, using equation of prediction, applying various dimensions of one or more teeth or indices. **Purpose:** The objective of this preliminary study was to evaluate the applicability of the Dimodent predictive equation in sex determination in a sample of Lebanese young individuals. **Materials and Methods:** Mesiodistal widths of the mandibular canine and lateral incisor were measured from dental casts of the permanent teeth of 60 Lebanese University dental students (30 males and 30 females), aged 18-25 years. The sex-predictive equation of Fronty was applied to calculate the percentage of accurately-diagnosed sexes. **Results:** Accuracy of sex prediction ranged from 63.3% for males and 90% for females. Overall, the Dimodent equation enabled a correct sex determination in 76.7% of the cases. When compared to the accuracy obtained with this equation in a French population sample, the accuracy was significantly different (Z=3.1225). **Conclusions:** This research supports earlier studies that sexual dimorphism is population specific. The difficulty or lack of dimorphism seems to originate from male subjects. Further investigations should include the preparation of population-specific prediction tables and testing their accuracy in a larger sample with a strongly-established Lebanese background.

(J Forensic Odontostomatol 2007;25:36-9)

Keywords: Dimodent equation, sexual dimorphism, Lebanese population sample

INTRODUCTION

Sexual dimorphism represents a group of morphologic characteristics that differentiate a male from a female.[1,2] Sex-related morphologic differences in the human skeleton have been extensively evaluated in several living and prehistoric populations.[3] However, tooth-associated odontometric differences have been less investigated[4] and mostly derive from the dentition of extinct populations.[5-8] Several studies have demonstrated that male teeth are generally larger than those of females in various populations.[9-11] According to a study evaluating the odontometric sexual variations of various species of living and fossil mammals, as well as of human beings, Fronty[2] reported that dental sexual dimorphism is always present in living humans although in process of regression in hominoids. Stroud *et al.*[12] evaluated sexual dimorphism in mesiodistal diameter, enamel thickness and dentin thickness of the permanent posterior mandibular dentition in a sample of 59 males and 39 females aged between 20 and 35 years using digitized bitewing radiographs. The authors concluded that significant sex differences exist in mesiodistal diameter favoring males over females. This discrepancy was attributed to differences in dentin thickness and not to enamel thickness. Alvesalo *et al.*[13] indicated that amelogenesis is promoted by both X and Y chromosome genes, and sexual dimorphism in average tooth size is determined by a promoting effect of the Y chromosome on dentin growth, probably through cell proliferation.

Dimorphism was reported to be more pronounced for the molars than for the premolars[12] but posterior teeth are generally less variable than anterior teeth.[11] Canines have been demonstrated to display greater sexual dimorphism in crown size than any other tooth

class in the permanent dentition in various populations.[4,9,11,14,15]

In contrast with differences in single tooth dimensions, various authors have selected to apply equations of prediction using multiple dimensions of one or more teeth or indices such as the mandibular canine index (MCI),[16] the quadratic discriminant analysis,[17] functions combining various crown indices and modules[18] and the Dimodent method.[1] The application of such equations in different populations has yielded different degrees of predictability in sex determination as sexual dimorphism in tooth dimensions has been reported to vary between populations.[4,9,19-24] Hattab et al.[9] showed that Jordanians have tooth sizes close to those of Iraqis, but significantly larger than those of Yemenite-Jews, Caucasians and Chinese. Iscan and Kedici[4] demonstrated that dental differences between sexes were not highly dimorphic in Turks. The application of the mandibular canine index for sex determination in India allowed the correct detection of males and females in 83.3% and 81% of the cases respectively. Tooth sizes of Southern Chinese were reported to be, in general, larger than those of the Caucasians, comparable with Northern Chinese, but smaller than those of Australian Aboriginals.[11] Sherfudhin et al.[17] concluded that in Indian subjects, the percentage of correct classifications of sex was higher when using quadratic discriminant analysis compared to the MCI. Currently, there are no published data related to sexual dimorphism in the Lebanese population. The purpose of the present preliminary investigation was, therefore, to evaluate the applicability of the Dimodent sex prediction equation in a sample of the Lebanese population.

MATERIALS AND METHODS
Study Sample
The sample studied included 60 students (30 males and 30 females) from the School of Dentistry of the Lebanese University, Beirut, aged between 18 and 25 years. The students recruited from different Lebanese regions were selected based on the following inclusion criteria:
1. Parents and grandparents of Lebanese origin;
2. Presence of the lower canines and lateral incisors;
3. Absence of morphological tooth abnormalities, crowding or malposition;
4. Absence of carious lesions or fillings involving the interproximal aspects of the studied teeth (mandibular lateral incisors and canines); and
5. Absence of severe abrasions, attrition or fractures on the involved teeth. Patients with ongoing orthodontic therapy were excluded from the study.

Mandibular dental casts were obtained using polysiloxane in a double mixture* base. Casts that did not allow accurate measurements of the teeth were excluded and the impressions repeated.

Measurement Method
Since the differences in crown diameters between the right and left sides of the same dental arch are not significant,[9,25] the left-side measurements were taken arbitrarily to represent the tooth size of the study population. The following measurements were carried out on the mandibular canine and lateral incisor directly on the dental casts according to the technique described by Seipel[26] and Moorrees.[27]
1. Maximum mesiodistal (MD) width defined as the greatest distance between the proximal surfaces of the crown;
2. Maximum bucco-lingual (BL) crown diameter measured as the greatest distance between the buccal and lingual surfaces of the crown at right angles to the mesio-distal crown diameter of the tooth.

All measurements were carried out by one operator using a digital caliper** that had been calibrated prior to measuring. All measurements were to a precision of 0.01 mm. Subsequently, the measurements were subjected to the Dimodent sex prediction equation of Fronty et al.[1] formulated as follows:

$$P = 1/(1 + e^{-y})$$

where P stands for the probability of being present in a male or female dentition, whereas the parameter **y** is obtained from the linear combination of selected variables multiplied by the coefficients specifying their importance. **y** is calculated as follows:

y = 24.2 + (1.54 ILI-MD) + (1.92 ILI-VL) – (2.84 CI-MD) – (3.38 CI-VL)

ILI-MD represents the mesio-distal diameter of the lateral mandibular incisor;

ILI-VL is the vestibulo-lingual diameter of the lateral mandibular incisor;

CI-MD is the mesio-distal diameter of the mandibular canine; and

CI-VL is the vestibulo-lingual diameter of the mandibular canine.

The four odontometric measures of all subjects are introduced in the equation. According to the values of P, three alternatives are possible:
1. If P tends to 100% (i.e. P>50%), the dentition with the calculated probability belongs very likely to a female;

---

* Zetaplus, Indurent Oranwash L, Zhermack, Italy
**Absolute Digimatic, Mitutoyo, United-Kingdom

2. If P tends to 0% (i.e. P<50%) , the dentition is very likely to be masculine;

3. If P = 50%, discrimination is null and sex can not be determined.

Statistical Analysis

The application of the sex predictive equation was considered to be successful if sex determination was correct (P values above or below 50% for females and males respectively); otherwise it was regarded as a failure. The overall success rate in sex determination in the Lebanese population sample was determined and compared to that of the French population[1] using the Z value (test of equality of two rates in the two studied populations) to confirm or refute the null hypothesis (success rates in sex determination are similar in both Lebanese and French populations).

RESULTS

The accuracy of sex prediction in the present study ranged from 63.3% for males to 90% for females. Overall, the application of the Dimodent equation was successful in sex prediction in 76.7% in the Lebanese population sample (Table 1).

When compared to the accuracy obtained with the Dimodent equation in the French population, the difference in accuracy was highly significant. The application of this equation in the French and Lebanese populations yielded a Z value of 3.1225 (superior to the threshold of 2.58) which allows rejecting the null hypothesis and confirming that the overall rates of success in sex determination in the two populations are significantly different. The difficulty or the lack of dimorphism seems to originate from male subjects.

DISCUSSION

The applicability of the Dimodent equation was successful in sex determination in 90.6% of the French sample and 76.7% in the Lebanese population sample. The percentage of Lebanese men and women where the sex was successfully determined by the Dimodent equation was lower than that obtained by Fronty *et al.*[1] in the French

population. Previous studies have demonstrated that sexual dimorphism in tooth dimensions varies between populations and that the application of sex predictive equations yields different degrees of predictability in different populations.[4,9,17,19,24] Because of the limited study sample included in this investigation, it may be suggested that application of equations to determine the sex of young Lebanese individuals is less useful than when applied to other populations. Differences can most likely be attributed to sample size and/or to odontometric differences.

The use of the Dimodent equation was suggested by the high degree of sex discrimination obtained with the mandibular canine and the high correlation coefficients between the mandibular canine and lateral incisor widths.[1,25] The selection of the population sample was based on the inclusion of individuals of similar age, of Lebanese descent and representing different regions of the country. It remains to be investigated if a random and larger sample of the Lebanese population has specific odontometric values that can be better predicted with customized equations. Further investigations should include the preparation of population-specific prediction tables and testing their accuracy in a larger sample with a stronger Lebanese background.

REFERENCES

1. Fronty P, Coignet F, Ingrand P. Détermination du sexe par l'analyse odontométrique des dents monoradiculées. Biom Hum et Anthropol, 1998;16:41-7.

2. Fronty P. Aspects anthropologiques et génétique du dimorphisme sexuel dentaire. Cah Soc Anthrop Gen Dento Faciales 1979;5:11-24.

3. Koyoumdjisky-Kaye E, Steigman S, Gudelevitch B. A comparative study of tooth and dental arch dimensions and sexual dimorphism in Israeli children of Cochin and North-African descent. Z Morphol Anthropol. 1978;69:32-42.

4. Iscan MY, Kedici PS. Sexual variation in bucco-lingual dimensions in Turkish dentition. Forensic Sci Int 2003;137:160-4.

Table 1: *summarizes the percentages of correct and failed sex prediction in the Lebanese sample compared with those reported for the French population sample.*[1]

Population	Success in Males	Success in Females	Failure In Males	Failure in Females	Overall Success	Overall Failure
French	—	—	—	—	317 (90.6%)	33 (9.4%)
Lebanese	19 (63.3%)	27 (90%)	11 (36.7%)	3 (10%)	46 (76.7%)	14 (23.3%)

5. Dean MC, Beynon AD. Tooth crown heights, tooth wear, sexual dimorphism and jaw growth in hominoids. Z Morphol Anthropol 1991;78:425-40.

6. Frayer DW. Dental sexual dimorphism in the European Upper Paleolithic and Mesolithic. J Dent Res 1977;56:871.

7. Sciulli PW. Size and morphology of the permanent dentition in prehistoric Ohio Valley Amerindians. Am J Phys Anthropol 1979;50:615-28.

8. Thompson GW, Anderson DL, Popovich F. Sexual dimorphism in dentition mineralization. Growth. 1975;39:289-301.

9. Hattab FN, al-Khateeb S, Sultan I. Mesiodistal crown diameters of permanent teeth in Jordanians. Arch Oral Biol 1996;41:641-5.

10. Teschler-Nicola M. Sexual dimorphism of tooth crown diameters. A contribution to the determination of the sex of subadult individuals from the early Bronze Age graveyard of Franzhausen I, lower Austria. Anthropol Anz. 1992;50:51-65.

11. Yuen KK, So LL, Tang EL. Mesiodistal crown diameters of the primary and permanent teeth in southern Chinese - a longitudinal study. Eur J Orthod 1997;19:721-31.

12. Stroud JL, Buschang PH, Goaz PW. Sexual dimorphism in mesiodistal dentin and enamel thickness. Dentomaxillofac Radiol 1994;23:169-71.

13. Alvesalo L, Tammisalo E, Townsend G. Upper central incisor and canine tooth crown size in 47, XXY males. J Dent Res 1991;70:1057-60.

14. 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;46:407-13.

15. Pettenati-Soubayroux I, Signoli M, Dutour O. Sexual dimorphism in teeth: Discriminatory effectiveness of permanent lower canine size observed in the XVIIIth century osteological series. Forensic Sci Int 2002;126:227-32.

16. Rao NG, Rao NN, Pai ML, Kotian MS. Mandibular canine index - a clue for establishing sex identity. Forensic Sci Int 1989;42:249-54.

17. Sherfudhin H, Abdullah MA, Khan N. A cross-sectional study of canine dimorphism in establishing sex identity: comparison of two statistical methods. J Oral Rehabil 1996;23:627-31.

18. Introna F Jr, Cantatore F, Dragone M, Colonna M. Sexual dimorphism of deciduous teeth in medico-legal identification. Boll Soc Ital Biol Sper. 1993;69:223-30.

19. Axelsson G, Kirveskari P. Crown size of permanent teeth in Icelanders. Acta Odontol Scand 1983;41:181-6.

20. Balciuniene I, Jankauskas R. Odontometry of Lithuanian paleopopulations. Anthropol Anz 1993;51:31-9.

21. Bermudez de Castro JM, Sarmiento S, Cunha E, Rosas A, Bastir M. Dental size variation in the Atapuerca-SH Middle Pleistocene hominids. J Hum Evol 2001;41:195-209.

22. Diagne F, Diop-Ba K, Ngom PI, Mbow K. Mixed dentition analysis in a Senegalese population: Elaboration of prediction tables. Am J Orthod Dentofacial Orthop 2003;124:178-83.

23. Kondo S, Funatsu T, Wakatsuki E, Haung ST, Change SY, Shibasaki Y, Sasa R. Sexual dimorphism in the tooth crown dimensions of the second deciduous and first permanent molars of Taiwan Chinese. Okajimas Folia Anat Jpn 1998;75:239-46.

24. Yadav S, Nagabhushana D, Rao BB, Mamatha GP. Mandibular canine index in establishing sex identity. Indian J Dent Res 2002;13:143-6.

25. Anderson DL, Thompson GW. Interrelationships and sex differences of dental and skeletal measurements. J Dent Res 1973;52:431-8.

26. Seipel CM. Variation of tooth position. Svensk Tandläk Tidskr 1946;39 Suppl:1-176.

27. Moorrees CFA, Thomsen SO, Jensen E, Yen PKJ. Mesiodistal crown diameters of the deciduous and permanent teeth in individuals. J Dent Res 1957;36:39-47.

Address for correspondence:
Dr. Fouad Ayoub,
Ras El-Nabeh, El-Khattab Street,
Rida Building, 9th floor,
Beirut,
LEBANON
Tel: +961-3-215290
Email: prof.ayoub@intracom.net.lb