



Morphometric Analysis of the Canine in the Determination of Sex: Study on a Senegalese Population

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Abstract

Forensic dentistry plays an important role in human identification by using dental evidence. The characteristics of the teeth can remain unchanged even after exposure to extreme environmental conditions, making the tooth an excellent forensic investigative tool. One of the most important steps in the human identification process is sex determination. The gold standard in this field is DNA, but its use may be limited under certain conditions requiring the use of other methods such as odontometry.

Materials and methods: A total of 205 casts of melanoderms subjects of Senegalese parents and grandparents (102 women, 103 men), were studied. The mesio-distal diameters of the mandibular canine and the inter-canine distance were measured with a digital display caliper on plaster models. The measurements obtained made it possible to determine a canine mandibular index (MCI) of 0.251 from the sexual prediction equation. From this index, prediction rates were determined.

Results: In this study, the overall rate of positive sexual prediction is 67.31%. The success rate was higher for men 69.9% than for women 64.70%.

Conclusion: The method used in this study is simple, easy to implement and can therefore be used in forensic dentistry for sex estimation.

Introduction

Forensic dentistry is a branch of forensic science that provides information in support of court decisions, particularly with regard to human identification [1]. Indeed, approximately 70% of the identifications

made worldwide in the event of mass disasters have been confirmed by forensic dentistry [2]. Teeth are known to be the most durable and resistant organs of the human body, capable of withstanding very high temperatures and the process of cadaveric decomposition. Thus, a thorough analysis of some of their characteristics can help to

reconstruct the forensic biological profile of unknown individuals. Indeed, dental elements make it possible to estimate age, ethnic group and sex[3].The determination of sex is of paramount importance in cases where its visual identification is impossible. Although some of the dental characteristics may change over the course of a lifetime, anatomical features, procedures (surgical extraction, orthodontic care, prosthetic restorations) provide specific data for ante and post mortem comparisons.

Odontometric studies, which include measurements of the mesio-distal and vestibulo-lingual diameters of some permanent teeth, have shown statistically significant differences between men and women[4]. Sexual dimorphism refers to the differences in size and shape between men and women. Thus, tooth size analysis based on odontometric examinations could be a reliable method of sex determination when limited skeletal remains are discovered or confirmed[5]. Mandibular canines are considered reliable elements of human identification, as they are the last teeth to be extracted and are rarely affected by oral diseases and are more likely to survive severe trauma such as an air crash, hurricane or fire[6]. Recent studies present the mandibular canine as the most dimorphic tooth in human dentistry[7]. The objective of this work was to determine the degree of sexual dimorphism using the method described by Rao et al[8].

Materials and Methods

This descriptive study was conducted with the institutional authorization of the Ethics Committee among 205 melanoderms subjects of Senegalese parents and grandparents, including 103 men and 102 women, at the Institute of Dentistry of the Faculty of Medicine, Pharmacy and Dentistry of the Cheikh Anta Diop University in Dakar.

The subjects with the following criteria were selected:

- Parents and grand parents of Senegaleseorigin
- Ages from 20 to 60 years
- Absenceofmorphologicaltoothabnormalities
- Absenceofcrowdingor spacing in the anterior teeth;
- Absence of carious lesions or filling in the interproximal aspects of the mandibular canines
- Absenceofsevereabrasion,attrition,orfractureonthe involvedteeth

Measurements

Dental casts were made for each subject, with alginate: irreversible hydro-colloid. The impressions obtained are then cast with extra hard yellow plaster and measurements were taken along the major axis of each

tooth, using a digital display caliper (MitutoyoHeadquaters), accurate to 0.01mm according to the method described by Rao et al. The mesio-distal (MD) diameters of the lower canine and the dimension of the inter-canine distance were measured (Figures 1,2).The mesio-distal (MD) dimension has been defined as the greatest distance between the contact points on the proximal surfaces of the dental crown.The canine intercanine diameter has been defined as the linear distance between the cuspidian tip of the right mandibular canine and that of the left side.



Figure 1: Impression materials.



Figure 2: Impression taking.



Figure 3: Inter-canine diameter.



Figure 4: Mesio-distal distance.

All measurements were made by a single observer; after 15 days, a second measurement was made on 1/3 of the sample (60 models) taken at random to assess intra- and inter-examiner variability. From the values obtained, the mandibular canine index was calculated using the formula developed by Rao et al.

Statistical Analysis

The collected data were analyzed with Microsoft Excel software version 2013. The Student test was used to compare the means of all measurements between men and women. A significance level of $p \leq 0,05$ was used. Inter- and intra-observer variabilities were assessed with Cohen's Kappa test.

Results

The study of the intra-observer agreement studied determined a satisfactory kappa of 0.70. (Table 1,2) present the means and standard deviations observed at the mesio-distal diameter of the canine and the intercanine distance. The results showed that the mean value for men was $26.55 \text{ mm} \pm 2.191 \text{ mm}$ and for women was $26.22 \pm 2.099 \text{ mm}$. However, there are no significant gender differences.

Gender	Minimum mm	Maximum mm	Means mm	SD	p
Females	20,580	32,170	26,227	$\pm 2,099$	0,278
Males	22,350	32,410	26,553	$\pm 2,191$	

Table 1 : Inter-canine distance of the mandibular arch.

Mesio-distal diameter measurement

The mean value of the mesio-distal diameter of the canine measured at the line of the largest contour shows a

statistically significant difference $p < 0.0001$ between men and women.

The mean value found in men was higher than that found in women.

Gender	Minimum	Maximum	Means	SD	p
Males	5,370	7,950	6,910	$+/-0.823$	$p < 0,0001$
Females	5,020	7,830	6,312	$+/-0.819$	

Table 2: Mesio-distal diameter of the mandibular canine. Mandibular Canine Index (MCI)

The mandibular canine index (MCI) was calculated using the formula below proposed by Rao et al.

A statistically significant difference $P \leq 0.0001$ was found (Table 3).

$$\text{Standard MCI} = \frac{(\text{Mean male MCI} - \text{SD}) + (\text{Mean female MCI} + \text{SD})}{2}$$

Parameters	Minimum	Maximum	Means	SD	p
Males	0,173	0,312	0,242	0,033	$P \leq 0,0001$
Females	0,191	0,323	0,261	0,033	

Table 3: Canine mandibular index (MCI standard).

Sexual Prediction

(Table 4) shows the percentage of positive sexual prediction obtained using the standard value of $\text{MCI} = 0.251$ calculated and found from the formula given by Rao et al.

Gender	Number of cases studied %	Correct prediction	% succès
Males	103	72	69.9%
Females	102	66	64.70%
Total	205	138	67.31%

Table 4: Positive prediction rates obtained.

All values below $\text{MCI} = 0.251$ were considered to correspond to those of women, while for men it is the values above that are considered to be male. It was observed that sex was correctly predicted in 72 out of 103 men, which corresponds to a positive sexual prediction rate of 69.9%. For women, a positive sexual prediction of 64.70%, i.e. 66 out of 102, was obtained. (Table 5) shows the prediction rates obtained using the MCI indices of 0.274 and 0.256 found in the studies of Rao et al. And Reddy et al. respectively.

MCIs	0,251/SUCCES		0,274/SUCCES		0,256/SUCCES	
	n	%	n	%	n	%
Females	66/36	64,70%	92/10	90,19%	75/27	73,52%
Males	72/31	69,90%	28/75	19,41%	62/41	60,19%

Table 5: Success with indices 0.274 by Rao et al. And 0.256 by Reddy et al.

When we apply the MCI value of Rao et al. 0.274 to our sample, we observe that the positive prediction rate increases among women from 64.70% to 90.19%. For men, the percentage of 19.41% obtained is lower than that found in this study. The MCI 0.256 index offers, unlike the Rao et al. Index, a higher positive prediction rate for both men and women. In short, the discriminant analysis of the mesio-distal diameter of the lower canine and the width of the mandibular arch according to the Rao et al. method indicates 64.70% positive prediction rate in women and 69.90% in men.

Discussion

The study of dental measurements has been the subject of several studies around the world [1,6]. The results obtained are disparate and vary from one population to another. In response to this situation, this study was undertaken to assess the applicability of the proposed odontometric sex estimation method Rao et al. Subjects with dento-maxillary dysmorphoses were not included in the study because when the alignment of the anterior mandibular teeth is not correct it is impossible to determine sex using the Canine Mandibular Index as confirmed by studies by Ahmed Mughal et al. And Muller et al [9, 10]. Measurements were made on plaster models with a 0.01 mm digital caliper and intra- and inter-observation variability was also tested to reduce the observer's share of subjectivity. Indeed, it is established that teeth can provide reliable and crucial information in establishing an individual's identity when the observer's subjectivity is considerably reduced. Thus, permanent maxillary and mandibular teeth can be used for sexual diagnosis because statistically significant differences have been observed between men and women in mandibular canines, and many studies report a real sexual dimorphism of the mandibular canine compared to other teeth. Mesio-distal and bucco-lingual diameters of the dental crown are more commonly used and studied in sex determination.

In this study, the measurements were made on one side only because the morphology of the tooth is practically the same on both sides, with a few exceptions. Moreover, very few studies report a significant difference between the right and left side. Hashim et al. in their study of a Saudi population aged 13-20 years noted that the canines were the only teeth to show real dimorphism. They also

determined that there was no statistically significant difference between the left and right canines, suggesting that the measurement of teeth on one side could be truly representative when the corresponding measurement on the other side was not possible [11]. In this study, the mean mesio-distal diameter of the lower canine is larger in men than in women $p \leq 0.001$. These values are corroborated by the results of several studies showing a significant difference between men and women in the mesio-distal diameter of the mandibular canine. Fouad et al. found in their study of Lebanese subjects a statistically significant difference between men and women $p \leq 0.001$ [12].

The mean value of the mesio-distal diameter of the canine in males (7.188 ± 0.314 mm) was higher than that of females (6.549 ± 0.332 mm). Contrary to the results of this present study, other authors have shown in their work a reverse sexual dimorphism, where women have wider teeth than men. Boaz and Gupta in their study of 100 dental casts from a population in southern India aged 14-20 years, found that the average buccolingual and mesio-distal dimensions of the canine in women were larger than in men without significant statistical differences [13]. Similarly, Acharya and Mainali found a reverse dimorphism without a statistically significant difference in dental dimensions; women had wider teeth than men [14].

This difference in dental dimensions seems to be related to genetic rather than environmental factors. Human amelogenin, a protein consisting of amino acid proline, glutamic acid, leucine and histine representing 90% of the organic components of dental enamel, is produced by a single gene with two copies; one copy on the X chromosome (AMGX) and another on the Y chromosome (AMGY). The AMGX copy located on the X chromosome expresses 90% amelogenin. The differences between AMGX and AMGY also induce differences in the amino acid that produces a row of amelogenin. AMGX AND AMGY do not undergo recombination, making amelogenin a genetic marker of choice in sex estimation in the forensic field. The Y chromosome causes a slower and longer maturation process of the enamel than the X chromosome [15]. There is a combination of environmental and genetic factors that control the buccolingual and mesio-distal diameters. Sex determination using dental parameters is used in forensic identification. Canine and molar have proven to be more

reliable indicators for sex determination. Sexual dimorphism based on tooth size varies across studies and populations and even within the same population for historical and evolutionary reasons. Thus, criteria established in one population may not apply in another requiring validity verification for each population. The method of Rao et al applied in our study yielded an overall positive sexual prediction rate of 67.31%. The percentage of prediction was higher for men 69.9% compared to women 64.70%.

These results confirm the trends observed in several similar studies. The MCI standard found in this study is lower than that of Rao et al; Reddy et al found a value of 0.256 close to the present study. The application of the MCI found by Rao et al 0.274 increases the percentage of prediction. Garn et al had correlated the sexual dimorphism of the canines with the stature, weight, bone age and time of the union of the epiphyses. These associations suggest a direct influence of steroid hormones on tooth development and maturation. They found that tooth eruption is accelerated in young girls with early maturation, indicating that steroid hormones from the gonads and adrenals may be involved in the relationship between sexual maturation and dental development [16]. This study, like that of Rao et al., which included a sample of Indian subjects, including 384 women and 382 men, found significant sexual dimorphism. In this study, the difference in mandibular canine index values between men and women was statistically significant, unlike the study by Acharya, Mainali et al [14]. Using the standard value of the mandibular canine index of Rao et al, a precision of 90.19% was obtained for females in sex identification, whereas for males the rate of 19.41% obtained does not reach 50%.

Muller et al. tested the standard MCI of Rao et al. on a sample of French subjects including 210 girls and 214 boys and were able to correctly identify sex in 59.4% of cases. The mandibular canine index found in this study was also close to that found in previous studies and was equally effective in sex determination.

The ability to correctly identify men was slightly higher than for women. The results of this study are similar to those of the study by Reddy et al. where a rate of 78% was observed in men and 66% in women [17]. Rao et al. Report more convincing results with an overall success rate of 85.9%, 84.3% in favour of men and 87.5% for women. On the other hand, Acharya and Mainali obtained lower results than those of this present study with only 57.14% success in men, while for women the rate obtained does not exceed 50% [1]. Notwithstanding the

fairly significant results and in agreement with most of the similar studies conducted around the world, this study has its own limitations.

- a. A small sample size of 205 subjects including 102 women and 103 men
- b. A single examiner who may have caused biases in measurements and results.

In addition, this study only measured linear dimensions because of its simplicity and reliability. Greater accuracy could have been achieved by applying the Moire topographic method and Fourier analysis, which however require sophisticated equipment and the use of complex mathematical equations. Future studies should include a larger sample size, several observers to verify intra-observer variability and inter-observer agreement.

Conclusion

Our study exhibits a real dimorphism based on the odontometric analysis. Observed variations in the dimorphic character could be the result of genetic, cultural, or environmental factors. Further studies should be done with larger sample size to evaluate the accuracy of these parameters in gender determination

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