Can human maxillary premolar crown dimensions discriminate between males and females?*

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Abstract

Studies showed that odontometry can be used to analyse the influence of sexual dimorphism on the size of the teeth in specific ancestries. The aim of this study was to explore the bucco-lingual dimensions expressed as a ratio of human maxillary premolar crowns in males and females from polled ancestries. If this measurement could discriminate sex, it would have application in forensic cases, mass disasters and archaeology where the number of mingled human remains is high and the ancestry is unknown or multiple; Moreover, methodologies applied on radiographs or biochemical analysis in the laboratory is not always possible. The sample studied consisted of unworn premolars from 51 skeletal remains, 19 females and 32 males of known sex from collections: the Hunterian Museum, Royal College of Surgeons, England and the Natural History Museum, London and 100 archived orthodontic plaster casts of young adult dental patients (50 females and 50 males) of Royal London Hospital. Digital photographs were taken parallel to the occlusal surface and intercuspal distance and maximum bucco-lingual distance were captured using ImageJ 1.47v (U. S. National Institutes of Health, Maryland, USA), and the ratio of both distances calculated. Results were compared using a t-test and showed that for both upper premolars, the overall ratio was greater in males than females; however this was not significantly different to zero. The overall ratio for first premolar (P1) was less than second premolar (P2) in males and females. These findings show that maxillary premolar, measured in this way, are not significantly different and cannot discriminate between the sexes in this sample of different ancestries.

Keywords: Odontometry; morphology; premolar; sex; discrimination

** Author is responsible for language correctness and content.*

Introduction

Sexing forensic or archaeological specimens is successfully estimated from the pelvis and/or skull (1). If a specimen consists of isolated teeth or a jaw fragment, sexing is more difficult. In forensic odontology, methods based on metric (2) and non-metric dental features, patterns of dental development and tooth eruption, expression of the amelogenin protein as well as DNA analysis of the teeth are available. (3) Biochemical analysis of teeth is considered to be the most accurate odontological method but it has limitations in forensic practice due to the availability of biochemical predictors and the costs involved. (4) Dental measurements can be used for sex determination in adults from mesio-distal (MD), bucco-lingual (BL) widths of crowns or root length (5) in specific ancestries. The BL width of all upper and lower teeth of males is greater than female in Iranian showing a sex diagnosis ranged from 73 to 77% (6). In Brazilian subjects, MD and BL widths of different teeth, demonstrated different means between sexes as female presented reduction when compared to males in 26 of 48 variables (7).

The BL dimension of maxillary first molars of sample from North India also showed to be greater in male than female (8). These dimensions show significant sexual dimorphism in different groups thought to be due to differences in proportion of enamel and dentine such as enamel thickness (9) or dentin thickness (10). The intercuspal distance in maxillary premolars has been shown to be similar in males and females in a study of Australian Aborigines (11) whilst Garn et al. showed that the ratio of intercuspal distance and BL width differed between males and females and this ratio would be useful to discriminate sex in forensic identification, archaeology and palaeontology (12).

The aim of this study was to explore the bucco-lingual dimensions expressed as a ratio of human maxillary premolar crowns in males and females from polled ancestries. This could be particularly useful in analysis of specimens from mass graves where the number of mingled human remains is high and the ancestry is unknown or multiple.

Materials and methods

The sample studied was from two sources: anthropological specimens and dental casts. Firstly, unworn maxillary premolars from 51 skeletal remains of known sex from the Hunterian Museum, Royal College of Surgeons, England and the Natural History Museum, London. The material is fragmentary and data were collected from 13 males and 8 females for the first premolar (P1) and 19 males and 11 females for the second premolar (P2). Ancestral origin varied with individuals from Europe and Asia. The second source of material was 100 plaster casts of young adults attending a dental hospital (50 males and 50 females). Ancestral origin was Bangladeshi and white British. The exclusion criteria were: caries or restorations on upper premolars, premolars not fully erupted or worn and poor dental cast quality. Ethical approval was not required for any source because the subjects are anonymous and the material from collection/archive can be assessed for research purposes.

Because the bucco-lingual dimensions of premolars, in particular, are prone to variation in camera orientation, the occlusal surface of maxillary premolars were photographed at right angles to the central groove and mesial and distal pits of the crowns, using a copy-stand (photography tripod) so that distance between tooth and camera was standardised. The occlusal view of the crowns should show the total circumference and apexes of both cusps. Image J 1.47v (13) was used to identify the cusp tips and maximum buccal and palatal surfaces. Two measurements of each premolar were done: maximum BL width and inter-cuspal width (Figures 1 and 2). The ratio of these dimensions were calculated and compared between males and females using a t-test for each collection. Accuracy of tooth dimensions from plaster casts compared to isolated teeth was a good representation of the actual tooth because of the quality of the dental impression. The ratio of these dimensions was unaffected by magnification.

The SPSS Statistics software Version 19.0 (IBM Corp., Armonk, NY) (14) was used to analyse the data. An intra observer error was analysed assessing 15 digital images (7 plaster casts and 8 specimens) by the main author in an interval of a week followed by Cohen's kappa coefficient test. A comparison of ratios between Ancestral group and sex was done using a t-test. If the ratios were significantly different between males and females, discriminant function statistics could be applied.

Results

Measurements from 15 digital images were valid and reproducible (K=.81). Descriptive results showed that the ratio of BL intercuspal distance

of upper premolars in the documented sample was smaller in females than males (mean differ=.02; N=100); however this was not significantly different to zero. The ratio for P1 was less than P2 in males and females. These findings show that crown dimension, measured in this way, is not significantly different and cannot discriminate between the sexes in this sample.

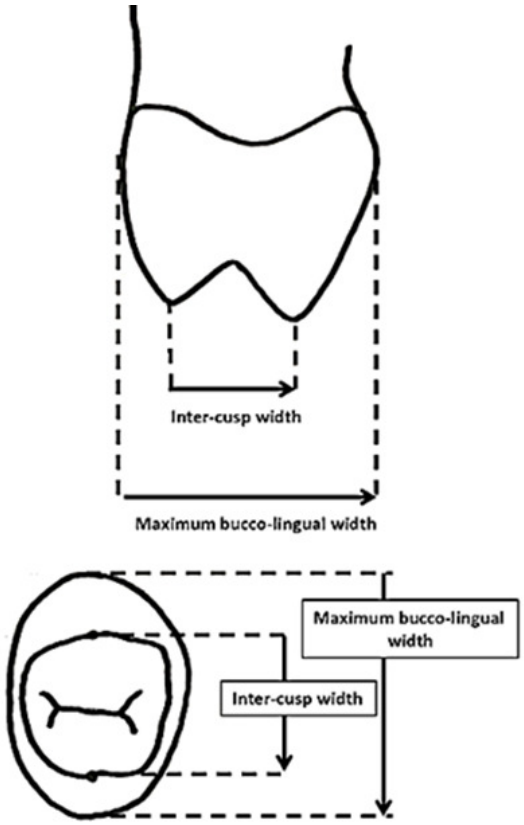

Figure 1 Schematic measurement of side and chewing surface view of second upper premolar.

Results for the specimens of both collections showed no significant difference between the ratio of BL intercuspal distance of upper premolars (NHM, mean differ=.02; N=25/ HM, mean differ=-.01 and -.04; N=26); the ratio for P1 was less than P2 in males and bigger in females (Table 1).

Discussion

Human dental sexual dimorphism was greater during the Palaeolithic era compared to modern human populations and this phenomenon seems to be related to gracilization of the male (15). Current studies continue to show that permanent tooth size for male is greater than female (6, 7, 16, 17). However, it appears to be less pronounced in the deciduous than in the permanent dentition (18). Considering permanent teeth, the canines (3, 15) were the most sexually dimorphic, possibly because an evolutionary remnant of aggressive function in male primates. Following, the molars, particularly the first ones succeeded by the second ones (19-21).

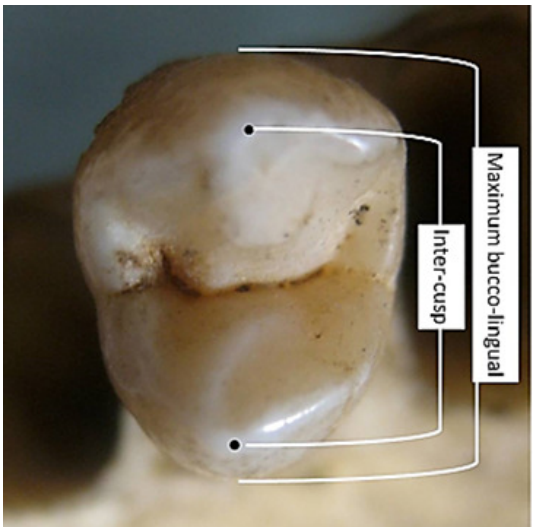

Figure 2 Measurements in the image of second upper premolar of anthropological specimen.

The tooth size dimorphism could be from differences in enamel or dentine thickness, or some combination of both. There is evidence of the effect of genes on both osseous and dental structures (22). The Y chromosome is largely responsible for size of teeth by controlling the thickness of dentine, whereas the X chromosome only controls the thickness of enamel (23). Past research found that odontoblast activity differs in the two sexes. A study showed that dentin thickness, measured on the roof of the pulp chamber, was significantly greater in boys than in girls, mainly during puberty. (24) Another study carried out in radiographs of incisors showed sexual dimorphism in mesio-distal (MD) widths, greater in males, due to the dentine thickness (25). Conversely, a study on measurements of mesiodistal width of permanent teeth of Greek subjects proved not be a reliable method for

determining sex of human remains from a forensic context (26).

A radiographic assessment of enamel thickness was carried out on the mesial and distal margins in maxillary incisors. The findings demonstrated no sexual dimorphism in the maximum mesial or distal enamel thicknesses but a greater width of the dentine of the crowns in males. (25) The number of assessments of enamel width in order to explore sex dimorphism should increase, however, data of recent research found indicated that thinner dental enamel is associated with the derived ENAM genotype which provides instructions for making the protein called enamelin. (27)

Odontometric parameters can be used for sex assessment (28) because they are simple, reliable and inexpensive (8). However, the extent of dimorphism varies among populations (15, 25). It is necessary to establish specific population values in order to determine sex on the basis of dental measurements and these values can be applied in individuals as well as in group (2). A great limitation of the odontometrics is the application in a sample of unknown or pooled ancestries. Another limitations of odontometrics include the alteration of normal dimensions of teeth such as abrasion of the incisal, occlusal and proximal surfaces and in the procedure itself for the lack of exact odontometric values needed for comparison as the real ones would be altered (2).

The development of discriminant functions for sex determination in teeth (26) can be estimated by determining the percentage of cases in the population correctly classified (29), with good number of subjects and number of variables.

Interestingly, a research brought attention to the usefulness of wet tooth weight as a measure of sexual dimorphism. Permanent third molars and canines were significantly heavier in males than those of females proving to be a useful for forensic studies. (30)

Modern techniques such as sex chromatin determination through Barr body (31) specific to female cells or the analysis of the amelogenin marker. The amelogenin (AMEL) locus encodes a matrix protein forming tooth enamel. The AMEL locus has two homologous genes: AMELX (X chromosome) and AMELY (Y chromosome).The length variation in the X and Y homologues of the amelogenin gene is the basis in forensic analysis. (32) DNA analysis by means of polymerase chain reaction (PCR) have remarkable results when sexing teeth (33). However, some degraded tooth samples may not be suitable for DNA analysis. The reasons are moist environments or the fragmentation of DNA from burial conditions. DNA contamination is also other issue, so that, there is still a need for reliable odontometric methods for the sex determination (26).

These findings show that the intercusp to bucco-lingual ratio of both upper premolars cannot discriminate between the sexes in this sample. Limitations of this study might be the small sample size (the selection criterion was unworn premolars) and the different populations with different average tooth sizes that combined could obscure any sex-specific differences. The authors suggest further exploration in a bigger sample, particularly in groups with known sexual dimorphism in tooth size.

Source	Tooth	Sex	N	Mean	Mean difference (M-F)	SE diff.	P value
Natural History Museum (NHM)	P1	M	5	.73	N/A	N/A	N/A
	P2	M	12	.76	.02	.04	.64
		F	8	.74			
Hunterian Museum, Royal College of Surgeons (HM)	P1	M	8	.76	-.01	.03	.78
		F	8	.77			
	P2	M	7	.76	-.04	.06	.53
		F	3	.80			
Royal London Hospital (RLH)	P1	M	50	.75	.02	.01	.03
		F	50	.73			
	P2	M	50	.76	.02	.01	.04
		F	50	.74			

Table 1 Ratio of cups tip to maximum BL width in permanent maxillary first (P1) and second (P2) premolars. SE=standard deviation; F=female; M=male.

Conclusions

The ratio of maximum BL width and inter-cuspal width of upper premolars could not discriminate between males and females in this sample.

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