HOW RELIABLE IS SEX DIFFERENTIATION FROM TEETH MEASUREMENTS

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Abstract:

Gender determination of human remains recovered in forensic contexts constitutes an important step in medico-legal examination. The ability of the inert, mineralized structures of teeth to resist post-mortem degradation and to survive deliberate, accidental or natural change has led forensic experts to focus on the teeth as a possible source for valuable forensic data in fragmentary and poorly preserved human remains. Numerous studies show that tooth size standards based on odontometric investigations are population specific and can be used in age and sex determination. This paper reviews the methods of determining sex by odontometrics, tooth proportions and sexual dimorphism.

Keywords: Odontometrics, sex determination, dental index

Introduction

Sex determination is a vital step in reconstructing a biological profile from unidentified skeletal remains.[1] Sex estimation is crucial in identification as it halves the number of possible matches. Among the various skeletal parts, pelvis and skull are traditional indicators of gender and the accuracy rate of determining the correct sex by morphological assessment of size and shape as well as osteometric techniques has been as much as 100%.[2] The major advantage of the dentition is that the inert, mineralized structures of teeth resist post-mortem degradation and survive deliberate, accidental or natural change better than any other skeletal structure. Odontometrics has been explored as a tool for sex assessment in the forensic literature mostly in the last twenty five years.[3] Tooth size standards based on odontometric investigations are population specific and have shown varying degree of sexual dimorphism.[4] . While not as accurate as the skeleton, tooth crown dimensions are reasonably accurate predictors of sex and are useful adjuncts in sex assessment. Also this is of special importance in young individuals where skeletal secondary characters have not yet developed. This paper reviews the methods and limitations of sex determination using odontometrics, tooth proportions and sexual dimorphism of teeth.

Odontometric methods in assessing sex

Dental features in sex identification can be broadly grouped into non-metrical and metrical methods. Non- metrical features are based on the presence or absence of a particular morphological feature. Studies show that non-metric features of crown and root, such as upper incisor shoveling, cusp of Carabelli, hypocone, and protostylid, are heritable, and therefore, help establish population group or ethnicity.[5]

A non-metric feature which has been found to show sexual dimorphism is the *canine distal accessory ridge*, located on both upper and lower canines, on the lingual surface between the medial lingual ridge and distal marginal ridge. When present, it ranges in size from a small swelling to a pronounced ridge as large or even larger than the distal marginal ridge. Males consistently show higher frequency and more pronounced trait expression of the distal accessory ridge of upper and lower canines.[6] Assessment of morphological features, however, involves a significant level of subjectivity.

Metric features are based on tooth measurements. The use of metrical approach in sex estimation is more structured, less subjective and futhermore, it can repeated to validate the obtained results.[7] The buccolingual (BL) and mesiodistal (MD) tooth dimensions, termed linear measurements may be used for determining sex based on the differences in tooth size and tooth proportions [4]. In addition to linear measurements, diagonal measurements are useful in measuring rotated, crowded and proximally restored teeth. The tooth is measured 'corner to corner', viz, MB-DL and DB-ML.[8,9]

Dental Index

Although studies reveal variable sexual dimorphism in linear measurements, these are not consistent enough to be used as the sole indicator of sex. Efforts to improve on this led to the calculation of dental indices where, in addition to tooth size**,** tooth proportions have been used to differentiate the sexes.[5] Dental index is derived from simple mathematical combinations of linear measurements. They include the Incisor index, Mandibular canine index, 'Crown area, 'crown module' and 'crown index'. Aitchison formulated the Incisor index by the formula: $Ii = (MDI^2 / MDI^1) \times 100$, where, MDI^2 is max MD diameter of upper lateral incisor and MDI^1, max MD diameter of the central incisor. This index is higher in males, which confirms that the lateral incisor is distinctly smaller than the central incisor in females.[10]

Since mandibular canines consistently exhibit sexual dimorphism and are also highly resistant to disease and post mortem insults, Rao et al [11] derived the Mandibular Canine Index (MCI) expressed as the ratio of the mesiodistal (MD) dimension of canines and the inter-canine arch width. Standard Mandibular canine index (MCIs) = [(Mean male MCI - SD) + (Mean female MCI + SD)] / 2 MCIs . The value obtained using this formula was 7.1, i.e 7.1 mm is the maximum possible mesiodistal dimension of mandibular canines in females. Accurancy of sex determination was found to be 84.3% in the male and 87.5% in the female. In contrast, a number of investigators have reported findings which are in variance to this.[12]

Other indices include *Crown area* which is the product of BL and MD dimensions and derived for each tooth by multiplying the linear measurements (i.e. BL × MD). *Crown module* for each tooth is taken as the average of BL and MD dimensions, i.e. (BL + MD)/2. *Crown index*, on the other hand, is the ratio of the two linear measurements expressed as percentage, i.e. (BL/MD) × 100. Results have shown that linear measurements afford better sex discrimination and therefore, these three dental indices have no added utility in forensic sex assessment.[13]

The most popular statistical model in dental sex assessment is the discriminant function analysis. Discriminant analysis which considers teeth as a unit (multivariate analysis) was more reliable in sex differentiation than comparing teeth one by one independently as in students's t-test (univariate analysis).[14] Recently, Logistic regression analysis is considered a better alternative and its application yielded correct sex allocation rates ranging from 76% to 100%, which proved superior to sex assessment using discriminant analysis (~52-71%). Logistic regression analysis enabled optimal sex prediction when all teeth in both the jaws were included.[15]

Research on sex identification from teeth

. The use of dental morphology to determine sexual dimorphism is a procedure established in anthropological and biological studies; especially in forensic odontology, it determines sex from fragmented jaws and dentition[16]

In 1938, Buthz and Ehrhardt demonstrated that human dental sexual dimorphism can be estimated from measurements of the crowns of permanent teeth. In general male teeth have been found to be larger than those of the female. However, these authors concluded that the size ranges are not sufficiently distinctive to establish a sexual determination.[17]

Schrantz and Bartha proposed seven dental morphological types used for sex determination—the BL diameters of teeth are smaller in females than males; the upper central incisor is larger than the upper canine in females, while the MD diameters are equal in males; the difference of MD diameter of the upper central incisor and the upper lateral incisor is about 2.1 mm in females and 1.8 mm in males; the difference of the MD diameter of the lower canine and the lower lateral incisor is smaller in females (0.7 mm versus 1.8 mm in males); the fusion of second molar roots is more frequent in females; the frequency of hypoplasia and agenesia of the third molar is higher in females; the phenomenon of hyperdontia is more frequent in males.[5,17]

In their study in a XVIIIth century archeological series from Marseilles in France, Soubayroux, Signoli and Dutour showed the existence of a relative dental dimorphism in humans (male > female mesiodistal diameters) and the mandibular canine is the most accurate tooth for analysis of dental sexual dimorphism.[17] According to Fronty, sexual variations are more important in the buccolingual direction. According to Garn et al. the measurements of the mesiodistal diameters allow a better sexual differentiation. Iscan and Kedici[3] analysing the sexual variation in a buccolingual dimension in Turkish dentition showed that males exceeded females significantly in dimensions and the canine teeth of both jaws are more dimorphic than others. The accuracy of sex differentiation was average at about 77%. The findings are similar to studies in an Egyptian population.[18] In Thai population BL dimension of upper left second molar exhibited highest degree of sexual dimorphism. The canines were as the second order variable.[19] Studies on a Saudi population found that canines were the only teeth to exhibit dimorphism, but there was no statistically significant difference between the left and right canines.

Acharya & Mainali in their study on Nepalese subjects found that MD dimensions had recognizably greater accuracy (77.4–83%) in sex identification than BL measurements (62.3–64.2%). However, the accuracy of MD variables is not high enough to warrant their exclusive use in odontometric sex assessment—higher accuracy levels have been obtained when both types of dimensions were used,concurrently.[4] .

Odontometric sex assessment in Indians found that the extent of sexual dimorphism in Indians is less when compared to other populations but similar to South Asian groups with merely 37.5% of all tooth variables being statistically larger in Indian males.[20] While canines have, conventionally, shown the greatest degree of sexual dimorphism across populations, in Indians the mandibular first molar was found to be most dimorphic followed by the canines and BL dimension of the maxillary first and second molars. Certain tooth variables exhibit greater mean dimensions in *females,* referred to as *reverse dimorphism*. Among Indians the premolars show higher levels of reverse dimorphism[20] and the mandibular left canine was seen to exhibit greater sex differentiation compared to the mandibular right canine.[21]

These studies emphasize there are differences in odontometric features in specific populations, even within the same population in the historical and evolutional context. Both BL and MD teeth measurements allow sex differentiation. However, higher accuracy levels in odontometric sex prediction are obtained when both types of dimensions are used concurrently. The mandibular canines traditionally exhibit the greatest sexual dimorphism.[17,18] The premolars, first and second molars, as well as maxillary incisors are also known to have significant differences.[5] Presently, the accuracy rate of odontometric sex assessment is ~72%. This accuracy rate in correct sex prediction is reflected in several other countries as well.

Conclusion

Forensic odontology in India is an emerging field and relies a lot on inexpensive and easy means of identification of persons from fragmented jaws and dental remains. Tooth size standards based on odontometric investigations are population specific and have shown varying degree of sexual dimorphism. Yet it is not uniform in all humans and sexual variation in tooth size is continuum rather than anything discrete. Hence, teeth are considered a useful supplement and adjunct to sex determination, and not recommended as the sole indicator of sex. Nevertheless, teeth may be one of the very few biologic parameters available for sex determination due to destruction and fragmentation of bones.

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Source of Support: Nil .
Conflict of Interest: None declared

How to cite this article:
Joseph P Anna, RK Harish, Mohammed Rajeesh PK, RB Kumar Vinod; How reliable is sex differentiation from teeth measurements;*Oral Max Path J*, 4(1), Jan-Jun 2013: