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RESEARCH ARTICLE

ORTHODONTIC STUDY MODELS AS AN AID FOR SEX DETERMINATION IN UTTARAKHAND POPULATION

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ABSTRACT

Introduction: Physical characteristics and the protection from the bone jaw preserve the dentition even when the bony structures of the body are destroyed. Due to this, the use of dental morphology to determine sexual dimorphism is a procedure established in anthropological and biological studies.
Aim: This study aims to evaluate sexual dimorphism in crown width and cusp parameters of permanent maxillary first and second molars in Uttarakhand population.
Materials and methods: A sample of 100 maxillary dental casts of Uttarakhand population (50 males, 50 females, and aged 15-25 years) was selected. Eight parameters were determined for each of the left maxillary first and second molars using a digital vernier caliper: four crown width measurements (buccolingual, mesiodistal, mesiobuccal–distolingual and distobuccal–mesiolingual) and four cusp measurements (hypocone, protocone, paracone and metacone) were taken. The percentage of sexual dimorphism for each parameter was computed.
Results: BL width showed highest sexual dimorphism when compared all eight parameters in both first and second molars. The highest sexual dimorphism was shown by paracone in the first molar and hypocone in the second molar.
Conclusion: Based on this study, odontometric measurements of maxillary molars provide low to moderate sexual dimorphism.

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INTRODUCTION

One of the challenges faced by man in earlier days was to establish the identity of an individual (Narang *et al*., 2015). Human identification is based on scientific principles: mainly involving dental records, fingerprints, estimation of age and sex, measurement of height, postmortem reports, differentiation by blood groups and DNA comparisons (Narang *et al*., 2015 and Sharma *et al*., 2009). Odontometrics is the measurement and study of tooth size (Kieser, Julius *et al*., 2008).

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Odontometric studies are utilized for age and sex determination in forensic investigations and in orthodontics, accurate knowledge of tooth dimensions is important in the diagnosis and treatment of malocclusions. Sex assessment is one of the prime factors employed to assist with the identification of an individual. Though, when available, more standard approaches to sex identification are used, in times where the archaeological remains are not completely discovered or preserved, odontometrics are used. Because teeth are "made from the most enduring mineralized tissues in the human body", they are resistant to many types of destruction, including physical, thermal, mechanical and chemical.

According to Marin Vodanović *et al*., "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 lower first molars, distal accessory ridge of the upper and lower canines or shoveling of the upper central incisors" (Vodanovic *et al*., 2007). In sex assessment, molars are considered as the most dimorphic teeth (Zorba *et al*., 2013). It scores an advantage over canine, which have greater chances of being impacted and thus unavailable for odontometric analysis. Similarly, the incisors are more prone to trauma, developmental anomaly (peg lateral), and frequently show crowding; resulting in difficulty in odontometric analysis. The crowns of maxillary molars have four main cusps, namely the paracone (mesiobuccal), protocone (mesiolingual), metacone (distobuccal) and hypocone (distolingual) (Fig 1) (Sharma *et al*., 2013; Kondo *et al*., 2005 and Sheikhi, 2015). Odontometric characteristics of each molar crown are thought to represent a cumulative effect of individual cusp dimensions, so analysis based on measurement of cusp dimensions promises to be more meaningful biologically than conventional measurements of whole crown.

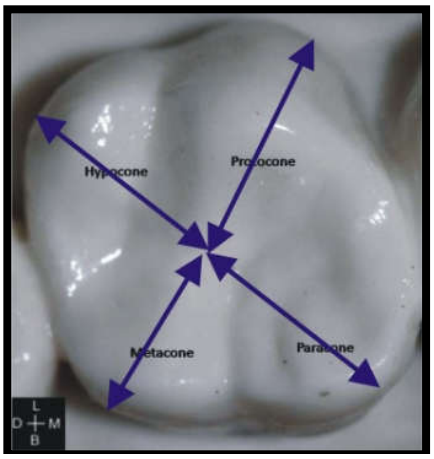

Fig 1. Primary cusps of maxillary first molar

Several studies have reported tooth size variations between and within different ethnic and racial groups. So, the present study aims to determine the sex determination potential of a permanent maxillary molar crown widths and cusp diameters in Uttarakhand population.

MATERIALS AND METHODS

The present study was based on 100 pretreatment study models of subjects who visited the out-patient department of Seema Dental College & Hospital, Rishikesh. The maxillary plaster casts of 100 subjects of known sex (Males-50, Females-50) of Uttarakhand population were selected for the study. The age of the subjects ranged from 15-25 years.

Inclusion criteria

- Caries Free Teeth
- Free Of Pathology and Attrition
- Completely Erupted and Intact First and Second Permanent Molars
- Molars possessing all the four principal cusps and a clearly distinguishable central pit

Exclusion criteria

- Teeth with unclear crown morphology
- Teeth with dental restorations or marked occlusal wear

Methodology

After models were made, mesiodistal (MD), buccolingual (BL), and diagonal mesiobuccal-distolingual (MD-DL) and distobuccal-mesiolingual (DB-ML) and all four cuspal dimensions of the left permanent maxillary first and second molars were measured on the models using the digital vernier calipers calibrated to 0.01mm (0-300mm, Masel Ortho,UK) with resolution of .01mm,accuracy of +/- .02mm and repeatability of .01mm/0/.0005 inch [Fig 2]. All measurements were made by a single observer who was blinded to the sex of the person's cast being measured and 20 randomly selected casts were reexamined by the same observer at an interval of 10 days and by another observer to avoid intra and inter observer error.

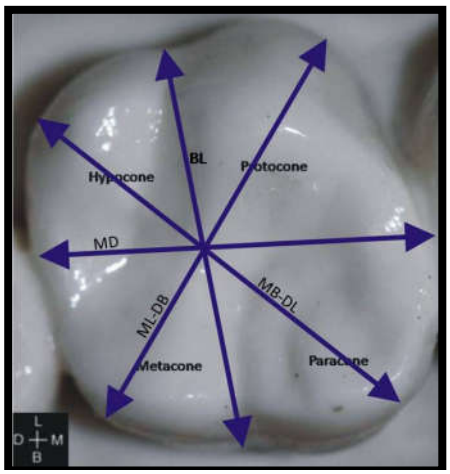

Fig. 2. Schematic representation of all measurements made: 1. Buccolingual width (BL); 2. Mesiodistal width (MD); 3. mesiobuccal-distolingual diameter (MB-DL); 4. Mesiolingual-distobuccal diameter (ML-DB); 5. Hypocone(Hy); 6. Protocone (Pr); 7. Paracone(Pa); 8. Metacone(Me)

Statistical Analysis

Descriptive statistics (mean and standard deviation) and sexual dimorphism (unpaired t-test) of the crown widths and cusp diameters of maxillary first molar were performed. The percentage of dimorphism is defined as the percent by which tooth size of males exceeds that of females.

The percentage of dimorphism for each tooth was calculated using the formula: (Macaluso, 2010)

Percentage of dimorphism = $(X_m/X_f)\quad 1 \times 100$

Where X_m=mean male tooth dimension, X_f=mean female tooth dimension.

The crown widths and cusp measurement data were subjected to direct discriminant function analyses to develop a set of equations for determining sex. Discriminant function analysis was carried out by taking the gender to be the dependent function of independent variables such as BL, MD, MD-BL, and DB-ML crown widths and all cusp diameters.

RESULTS

The descriptive statistics of crown widths and cusp diameters for both maxillary molars are shown in Tables – 1 & 2. Mean values were significantly different between the sexes (P<0.001), with male values exceeding those of females for all measured dimensions. The percentages of sexual dimorphism (Tables 1 & 2) revealed that among the cusp diameters, the protocone and paracone displayed the greatest dimorphism in the first maxillary molar, whereas the hypocone and the MB-DL crown width showed the greatest dimorphism in the second maxillary molar.

Table 1. Descriptive statistics and sexual dimorphism of crown widths and cusp diameters of maxillary first molar (M1)

Parameters (M1)	Males (n=50) Mean (mm)+/-SD	Females (n=50) Mean (mm)+/-SD	P	Sexual dimorphism %
MD	10.23+/-0.68	9.987+/-0.52	0.045	2.423
BL	11.35+/-0.59	11.010+/-0.67	0.008	3.088
MB-DL	12.82+/-0.63	12.40+/-0.64	0.001	3.403
ML-DB	11.31+/-0.76	11.05+/-0.63	0.066	2.334
HY	7.18+/-0.53	6.94+/-0.58	0.055	3.112
PR	7.17+/-0.59	6.85+/-0.54	0.006	4.598
PA	6.20+/-0.67	5.91+/-0.61	0.027	4.890
ME	5.95+/-0.51	5.73+/-0.44	0.022	3.874

P value > 0.05 - not significant, P value <0.05 – significant, P value < 0.01 – highly significant, M1- first molar, MD-mesiodistal, BL-buccolingual, MBDL –mesiobuccal distolingual, MLDB-mesiolingual distobuccal, HY-Hypocone, PR-Protocone, PA-paracone, ME-metacone

Table 2. Descriptive statistics and sexual dimorphism of crown widths and cusp diameters of maxillary second molar (M2)

Parameters (M2)	Males (n=50) Mean (mm)+/-SD	Females (n=50) Mean (mm)+/-SD	P	Sexual dimorphism %
MD	9.24+/-0.65	8.74+/-0.86	0.0016	5.626
BL	11.22+/-0.71	10.63+/-0.81	0.0002	5.511
MB-DL	11.87+/-0.88	10.97+/-0.86	0.0001	8.233
ML-DB	10.76+/-0.79	10.36+/-0.82	0.0142	3.890
HY	5.78+/-0.90	5.21+/-0.87	0.0018	10.891
PR	6.39+/-0.59	5.97+/-0.70	0.0017	6.981
PA	5.87+/-0.53	5.57+/-0.53	0.0064	5.516
ME	5.45+/-0.56	5.19+/-0.58	0.0230	5.053

P value > 0.05 - not significant, P value <0.05 – significant , P value < 0.01 – highly significant, M2- second molar

DISCUSSION

Revealing sexual identity is a key factor in the recognition of human skeletal remnants as it lessens the number of potential suspects by half (Macaluso, 2010). However, in many circumstances the only feasible specimen for sex discrimination are teeth as they can resist taphonomic decay more than other parts of the skeleton (Kieser *et al*., 1990). Thus, odontometric measurements have been widely used in the identification of skeletal remains from a forensic perspective. A number of techniques for measurement of tooth dimension have been reported in the literature; Macaluso [11] assessment tool was occlusal view photographs rendered from a digital camera, but the drawback with this technique was standardization. Eboh *et al*. (2011) and Sonika *et al*. (2011) measured cusp parameters directly from the participants' mouths employing a digital vernier caliper, but the drawback was accessibility while measuring second molar parameters. Sharma *et al*. (2013) and Sheikhi *et al*. (2015) measured cusp parameters from study casts using digital vernier calipers as dental casts are a precise replication of teeth in a proportion of 1:1. So, in this study measurements were made on dental casts. Kieser has done research on sex determination by odontometric measurements and found significant differences between male and female teeth using MD and BL dimensions (Kieser *et al*., 1989). Diagonal measurements would be of help in determining gender and also these diagonal axes do not include the contact points of the crown, and are therefore not affected by interproximal attrition. Recently, a number of published researches used the four main maxillary molars cusp parameters - paracone, protocone, metacone, and hypocone in human biological investigations and sex discrimination research (Sharma *et al*., 2013).

Paracone develops prior to hypocone and it has been reported that teeth which develop later are prone to be more variable in size and reveal greater sexual discrepancy because of the increasing difference in hormone secretion (Bugaighis *et al*., 2013). Further more, various antemortem and taphonomic processes can differentially affect the dentition; thus rendering conventional mesio-distal and bucco-lingual crown dimensions useless, y*et al*lowing individual cusp diameters to be measured. In the present study, the dimensions obtained for the male teeth were larger compared to those for females; thus exhibiting sexual dimorphism. The sexual dimorphism in tooth morphology is attributable to the presence of relatively more dentine in the crowns of male teeth (Işcan *et al*., 2003 and Alvesalo *et al*., 1991). In the present study, the bucco-lingual

dimensions of maxillary first and second molars exhibited greater sexual dimorphism than mesio-distal dimensions of the same teeth. This result was in agreement with the findings of Garn *et al*. (1968) who also found greater sexual dimorphism for the BL diameter (5.6%) as compared to the MD diameter (4.2%) of the same teeth in white adolescents. Similar outcome was noticed in the Caucasian cohort (Kondo *et al*., 2005), Sharma *et al.* (2013) study and a study done by sheikhi *et al* (2015) in Libyan subjects.

According to the results of the present study, the diagonal measurements were significantly greater in males than females. The results are in accordance with various other studies revealing clear dimorphic differences between male and female teeth.[19,20] In the present study, in the first molar, sexual dimorphism was significant in MBDL diameter and not significant in MLDB. In the second molars, both the diagonal diameters were significant in sex determination. The cusp size in decreasing order was found to be hypocone > protocone > paracone > metacone in maxillary first molar. This order is in consistent with study conducted by Agnihotri and Sikri[21] on Jat Sikhs. Sheikhi *et al* found the sequence to be hypocone > metacone > protocone > metacone. In the present study the order was protocone >paracone > hypocone >metacone in maxillary second molar in contrast to a study conducted by Sharma *et al*, where the order was found to be hypocone > paracone > protocone > metacone in both maxillary first and second molars and for American whites, Biggerstaff (1976), reported the order to be protocone > metacone > paracone > hypocone. This can be attributed to racial differences in the populations studied. In this study, sexual dimorphism was significant in paracone, protocone and metacone and not significant in hypocone in maxillary first molar which is in contrast to study conducted by Sharma *et al* in which sexual dimorphism was significant in protocone and paracone in the first molar and not significant in the hypocone and metacone. In a study by Sheikhi *et al*, significant sexual dimorphism was noticed in both the hypocone and metacone and not significant in protocone and paracone in maxillary first molar. In present study, sexual dimorphism was significant in all four cusps in maxillary second molar in contrast to study conducted by Sharma *et al* in which it was significant in hypocone and paracone and not significant in protocone and metacone. In Sheikhi *et al* study there was no significant sexual dimorphism in second molar cusps.

The sexual dimorphism in the cusp dimensions in the first molar was in the order of paracone > protocone > metacone > hypocone, and in the maxillary second molar corresponded to hypocone > protocone > paracone > metacone. In the study on Indian Jat Sikhs in which the order is different from present study in first molar (ie hypocone > metacone > protocone > paracone) and the order is same for maxillary second molar (ie hypocone > protocone > paracone > metacone). In Sharma *et al* study the order was protocone > paracone > metacone > hypocone in first molar and in the maxillary second molar corresponded to hypocone > protocone > paracone > metacone. In Sheikhi *et al* study,the sequence of sexual dimorphism was hypocone > metacone > paracone > protocone in both maxillary first molar and second molars. In the present study, the paracone displayed the highest percentage of sexual dimorphism among all first molar dimensions, which is in contrast with the South African study and Sharma *et al* where protocone displayed highest dimorphism. In the current study, the least dimorphic cusp was hypocone in the first molar and metacone in the second molar which is in accordance with Sharma *et al* study. Furthermore, metacone diameter was the least dimorphic cusp for both the first and second molar in black South Africans, which was not the case in Japanese dentitions. The apparent difference in the pattern of sexual dimorphism between these geographically disparate populations was likely due to a combination of environmental and genetic factors. Orthodontists can play an important role in the post-mortem profiling of forensic remains, which includes identifying the sex and age, when other means of identification are not feasible because of fragmented remains. The present study shows that orthodontic records can be of significant use in forensics dentistry for identifying the sex of Uttarakhand human skeletal remains when it is not reasonable to undertake other forensic methods due to degradation of the examined remains.

Conclusion

The evolving field of forensic odontology in India depends a lot on simple and economical methods to identify persons with their dental remains and fragmented jaws. In those conditions, a dentist may be called upon to render expertise in forensic science. To conclude both the maxillary first and second molars exhibited sexual dimorphism, with male dimensions being larger than females. Paracone showed the highest sexual dimorphism in the first molar and hypocone showed the highest sexual dimorphism in the second molar.

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