ABSTRACT  The human first maxillary molar provides clues about evolution and is functionally important. Crowns of maxillary molars have four main cusps, each having an independent growth pattern and different evolutionary background. The study aims to quantify the morphometric criterion for the maxillary first molar giving a special emphasis to sexual dimorphism. Measurements of the first maxillary molar were taken on 100 casts of Jat Sikh students (50 males, 50 females) studying in the local medical college in the age group of 17-21 years. The Jat Sikh community of Punjab is endogamous at the caste level. Unpaired t-tests were used to compare the samples for males and females. There is statistically significant sexual dimorphism (P < 0.01) for the maxillary first molar’s crown and cusp components in the Jat Sikhs. The sequence of dimorphism in cusp dimensions corresponds to the order of formation of the cusps. The percentage sexual dimorphism for the hypocone is high (right 7.2%, left 7.4%). Dental Anthropology 2010;21(1):1-6.

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MATERIALS AND METHODS

Selection Criteria

One hundred subjects (50 males, 50 females) in the age interval of 17-21 years were selected for the study because attrition is considered to be minimal in this age group. The study was conducted on the students enrolled in the Government Medical College, Patiala, India, and the Government Medical College, Amritsar, India. Consent of the subjects was obtained, and the study casts were made with the help of resident doctors, senior residents, and senior technicians at the local Government Dental College.

Only those Jat Sikh students were selected whose upper and lower arches fulfilled the following inclusion criteria.

- Healthy state of gingiva and peridontium,
- caries free teeth,
- normal overjet and overbite,
- absence of spacing in the anterior teeth,
- normal molar and canine relationship, and
- clearly distinguishable central pit of first maxillary molar.

Odontometry

Measurements were taken with a vernier caliper with a precision of 0.02 mm. The following parameters were measured and computed: (A) the mesiodistal and buccolingual crown diameters and cusp diameters (Fig. 1); (B) the mesiodistal (Fig. 2) and buccolingual (Fig. 3) crown diameters and cusp diameters (Fig. 4). Each cusp diameter is defined as the diagonal distance from the central pit to the most prominent convexity on the crown outline corresponding to the relevant cusp, taken perpendicular to the axis of the tooth (Kondo, 1985).

Three additional variables were calculated for each of these dimensions:

- The crown area provides a measure of overall crown size:
  \[
  \text{Crown area} = \text{MD} \times \text{BL}
  \]
- The cusp index quantifies cusp size relative to overall crown size:
  \[
  \text{Cusp index} = \frac{\text{Cusp diameter}}{\sqrt{\text{MD} \times \text{BL}}} \times 100
  \]
- And, sexual dimorphism:
  \[
  \text{Sexual dimorphism} = \frac{\text{M} - \text{F}}{\text{M}} \times 100
  \]

where \( \text{M} \) and \( \text{F} \) are the mean values in males and females. This formula is applicable for computing sexual dimorphism in mesiodistal width, buccolingual length, and crown area.

Statistical Analysis

Descriptive statistics, including distribution parameters, were calculated using Origin 6.1 software (Origin Lab Corporation, USA, version 6.1052 for Windows). Unpaired t-tests were used to compare the dimensions measured for males and females, and a table of the t distribution was consulted. Attainment of statistical significance was set at alpha = 0.01.

RESULTS

The results have been depicted in Tables 1, 2, 3 and 4. The study quantifies the morphometric criterion for the maxillary first molars in Jat Sikhs. In general the morphometric parameters were found to be quantitatively higher for the left side.

The study establishes the existence of statistically...
**TABLE 1. Descriptive statistics and tests for sexual dimorphism between males and females**

| Parameter           | Side | Sex   | Mean   | sd   | t-test | P-value |
|---------------------|------|-------|--------|------|--------|---------|
| Mesiodistal Width   | Right| Males | 11.33  | 0.078| -19.88 | <0.01   |
|                     |      | Females| 10.88  | 0.142| -15.80 | <0.01   |
|                     | Left | Males | 11.39  | 0.195| -13.53 | <0.01   |
|                     |      | Females| 10.87  | 0.187| -14.00 | <0.01   |
| Buccolingual Length | Right| Males | 12.53  | 0.078| -19.51 | <0.01   |
|                     |      | Females| 11.98  | 0.192| -16.00 | <0.01   |
|                     | Left | Males | 12.60  | 0.192| -18.26 | <0.01   |
|                     |      | Females| 11.98  | 0.142| -15.00 | <0.01   |
| Crown Area          | Right| Males | 142.07 | 1.859| -24.83 | <0.01   |
|                     |      | Females| 130.29 | 2.789| -12.50 | <0.01   |
|                     | Left | Males | 143.54 | 4.617| -17.33 | <0.01   |
|                     |      | Females| 130.25 | 2.849| -12.50 | <0.01   |
| Paracone Diameter   | Right| Males | 5.82   | 0.118| -8.73  | <0.01   |
|                     |      | Females| 5.63   | 0.124| -7.50  | <0.01   |
|                     | Left | Males | 5.84   | 0.138| -11.19 | <0.01   |
|                     |      | Females| 5.64   | 0.089| -9.00  | <0.01   |
| Protocone Diameter  | Right| Males | 5.88   | 0.119| -13.39 | <0.01   |
|                     |      | Females| 5.59   | 0.108| -17.50 | <0.01   |
|                     | Left | Males | 5.90   | 0.089| -16.83 | <0.01   |
|                     |      | Females| 5.60   | 0.078| -12.50 | <0.01   |
| Metacone Diameter   | Right| Males | 5.68   | 0.117| -13.48 | <0.01   |
|                     |      | Females| 5.39   | 0.088| -12.50 | <0.01   |
|                     | Left | Males | 5.70   | 0.102| -16.39 | <0.01   |
|                     |      | Females| 5.40   | 0.079| -9.00  | <0.01   |
| Hypocone Diameter   | Right| Males | 6.98   | 0.122| -21.19 | <0.01   |
|                     |      | Females| 6.51   | 0.104| -15.00 | <0.01   |
|                     | Left | Males | 7.00   | 0.102| -25.80 | <0.01   |
|                     |      | Females| 6.52   | 0.092| -12.50 | <0.01   |
| Paracone Index      | Right| Males | 48.82  | 1.114| 2.46   | n.s.    |
|                     |      | Females| 49.31  | 0.902| 3.72   | n.s.    |
|                     | Left | Males | 48.74  | 0.982| 3.72   | n.s.    |
|                     |      | Females| 49.43  | 0.862| 4.26   | n.s.    |
| Protocone Index     | Right| Males | 49.32  | 1.102| -1.77  | n.s.    |
|                     |      | Females| 48.96  | 0.901| 3.72   | n.s.    |
|                     | Left | Males | 49.24  | 0.983| -0.91  | n.s.    |
|                     |      | Females| 49.08  | 0.853| 3.72   | n.s.    |
| Metacone Index      | Right| Males | 47.65  | 1.089| -2.17  | n.s.    |
|                     |      | Females| 47.23  | 0.882| 3.72   | n.s.    |
|                     | Left | Males | 47.59  | 0.982| -1.46  | n.s.    |
|                     |      | Females| 47.32  | 0.845| 3.72   | n.s.    |
| Hypocone Index      | Right| Males | 58.45  | 1.104| -7.12  | <0.01   |
|                     |      | Females| 57.14  | 0.908| -15.00 | <0.01   |
|                     | Left | Males | 58.55  | 1.137| -6.46  | <0.01   |

*Statistical significance was set at P < 0.01; ns = not significant (P > 0.01).*

Significant sexual dimorphism (P < 0.01) for the maxillary first molars in Jat Sikhs. From Table 1, it is evident that the parameters as measured for males and females when compared are found to be statistically significant. Further in males or females individually, i.e. within the same sex (Tables 2 and 3) when these parameters as measured, are compared, they are found to be statistically insignificant. From these findings, it can be inferred that there exists a definite statistically significant sexual dimorphism for the maxillary first molar in Indian Jat Sikhs (P < 0.01). The percentage sexual dimorphism calculated came out to be higher for the buccolingual dimension (4.6% for
DISCUSSION

Dental morphological characteristics are useful for providing information for phylogenetic and genetic studies and understanding variation within and among species. The crown characteristics are known to differ among racial groups; for example, Australian aborigines have larger teeth, Indians have smaller teeth, while whites have teeth intermediate in size (Tedeschi, 1977).

The Jat Sikhs are an endogamous group at caste level. They have distinct customs, traditions and food habits. As such the present study defines the criteria of the first molar tooth size for the Jat Sikhs. In general the morphometric parameters were found to be quantitatively higher for the left side. This observation holds true also for all the maxillary anterior teeth in North Indians (Agnihotri and Jain, 2008) but not in South Indians (Nair et al., 1999). The crown dimensions for the first molar are comparable to those of the Jats (Kaul and Prakash, 1984) in Haryana. The Jats of Haryana constitute an agriculture-based community in North India.

It is a combination of environmental factors and inheritance that controls the mesiodistal and buccolingual dimensions. The dimensions obtained for the male teeth are definitely on the higher side as compared to those for females. This can be explained on the basis of the shape of the first molar tooth, which is controlled by the genetic constitution of the individual. Thus, the male teeth are usually larger in size as compared to the female teeth. It is the Y chromosome that seems to contribute most in the size of teeth by controlling the thickness of dentine, whereas the X chromosome seems to be responsible for modulating thickness of the enamel. The sexual dimorphism in tooth morphology is attributable to the presence of relatively more dentine in the crowns of male teeth (Iscan and Kedici, 2003).

The present study indicates that there exists a definite statistically significant sexual dimorphism for the maxillary first molar in Indian Jat Sikhs ($P < 0.01$). This is in concordance with the work done on Taiwan Chinese (Kondo, 1998) and on Jordanian subjects (Hattab et al., 1996). While dental difference between the sexes in several human groups has been found highly dimorphic, it was not found so in Turks (Iscan and Kedici, 2003), where the lack of dimorphism comes from male subjects. This validates the perception that sexual dimorphism is population specific.

The percentage sexual dimorphism calculated came out to be higher for the buccolingual dimension (4.6% for the right side and 5.18% for the left side) as compared to the mesiodistal dimension. This is consonant with the findings for American white (Garn et al., 1966) and South Indian (Nair et al., 1999) subjects. Since size dimorphism was consistently greater for the buccolingual tooth diameter, its more extensive use is indicated in like-sex and unlike-sex sibling and parent-child comparisons for tooth size. Among the various crown dimensions, crown

Fig. 3. Illustration showing the measurement of maximum buccolingual crown dimension.

Fig. 4. Depiction of the method of measuring cusp diameters. Clockwise from the upper left are the paracone, protocone, metacone, and hypocone.
The hypocone is considered to be the key innovation in mammalian evolution (Hunter and Jernvall, 1995). Mammals that developed the hypocone became preadapted for masticating fibrous plants and subsequently demonstrated a markedly increased species diversity. The percentage sexual dimorphism for the hypocone (right 7.2%; left 7.4%) is high in present study as compared to the other cusps. This value is in fact comparable to the values for canine in North Indian population (right 7.3%; left 8.1%). The canine is known to exhibit the largest sexual dimorphism in the human dentition.

The present pioneer study on the maxillary molar tooth in Indian Jat Sikhs provides data useful for anthropological, genetic, odontologic, and forensic investigations. This is particularly so since tooth morphology is known to be influenced by cultural, environmental, and racial factors (Agnihotri and Gulati, 2008).

The maximum cusp size in decreasing order came out to be hypocone > protocone > paracone > metacone. This order has been found to differ among populations. For the Japanese, Kondo et al. (2005) found the sequence to be: protocone > hypocone > paracone. For American whites, Biggerstaff (1976) reported the order to be protocone > metacone > paracone > hypocone. The sexual dimorphism in the cusp dimensions corresponds to the order of cusp formation, namely hypocone > metacone > protocone > paracone. Thus, the ontogenetic hypothesis, that later forming structures show greater sexual dimorphism than earlier forming structures, can apparently be extended to dental crown components.

The hypocone is considered to be the key innovation in mammalian evolution (Hunter and Jernvall, 1995).
establishes the existence of a statistically significant sexual dimorphism (P < 0.01) for the maxillary first molars in Jat Sikhs. This study suggests that the hypocone index and hypocone diameter are the most dimorphic parameters for the Jat Sikh population.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. Satish Agnihotri, Colonel (Retd) and Dr. Vikram Agnihotri (Capt) for their invaluable suggestions and encouragement. We also appreciate our statistician Mrs. Shaweta Agnihotri, Lecturer, BBK DAV College, Amritsar for her efforts and hard work. We are indebted to the resident doctors, senior residents, and senior technicians working in the local Government Dental College for their wholehearted support for the timely completion of the study.

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**TABLE 4. Sexual dimorphism for the crown and cusp dimensions**

| Parameter      | Right side | Left side |
|----------------|------------|-----------|
| Mesiodistal width | 4.14% | 4.78% |
| Buccolingual length | 4.68% | 5.18% |
| Crown area       | 9.04% | 10.20% |
| Paracone         | 3.37% | 3.55% |
| Protocone        | 5.19% | 5.36% |
| Metacone         | 5.38% | 5.56% |
| Hypocone         | 7.22% | 7.36% |