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ORIGINAL ARTICLE

A morphometric study of the human mandible in the Indian population for sex determination

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Abstract: Sex determination from bones is important in forensic investigations for establishing identity in cases of mutilated bodies. Many morphometric criteria have been laid down for various bones for sex determination in previous studies. The present study aimed at setting up some parameters of the mandible as indicators of sex in the Indian population. The length of body of the mandible, angle of the mandible and minimum ramus breadth were considered as chief parameters for sex determination from dried bones obtained from the Departments of Anatomy in two medical colleges of Punjab and Chandigarh. There was a statistically significant difference found in the diagonal length, horizontal length and minimum ramus breadth with their mean values 79.77 ± 4.68 mm, 71.99 ± 4.54 mm and 30.93 ± 2.56 mm in adult males, respectively and 73.83 ± 4.84 mm, 68.62 ± 4.78 mm and 29.57 ± 2.86 mm in adult females, respectively, whereas no significant difference was found in the mandibular angle of males and females. The parameters used for the present study gave an overall 60% accuracy in determining the sex of the mandible.

1. Introduction

In the adult skeleton, sex determination is usually the first step of the identification process, as subsequent methods for age and stature estimation are sex dependent. Dependability of sex determination relies on the completeness of the remains and the degree of sexual dimorphism inherent in a population, but it is usually considered that the two most sexually dimorphic elements of the skeleton are the skull (including the mandible) and the pelvis.

The need for such a type of research is due to the increased incidents of violence and the increased number of unidentified and mutilated bodies being referred to the forensic expert.[1] If different parameters are tested within specific population groups, both qualitative and quantitative criteria can be identified and used in combination to distinguish sex, age and ethnicity.[2]

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Jaws and teeth have been used since olden times to ascertain the sex of an individual, because they show sexual dimorphism in morphological features, but these are likely to be subjected to variation depending upon the experience of a worker. Therefore, some morphometric criteria need to be put in place which can be used as a reference for sex determination when combined with some other features. Various studies have clearly indicated that the skeletal characters vary by population, and there is a need to lay down population-specific standards.[3]

The mandible is the largest and strongest bone in the face with a horizontally curved body that is convex forwards with two broad rami, which ascend from the posterior end of the body. The rami bears the coronoid and condyloid processes.[4] The mandible is considered suitable for study as it is the most durable bone of the facial skeleton and retains its shape better than other bones. Sexual dimorphism in the mandible may be due to the relative difference in the development of the musculoskeletal system, especially the muscles of mastication attached to the mandible.[5]

A study conducted earlier on the angle of the mandible on a mixed population included three age groups. The angle varied between 110° and 140°. It was also concluded that in the persons who retained their teeth, there is no tendency of increase in the angle with advancing age.[6] A digital radiographic study carried out in 2012[7] on the mandibular ramus indicated that the minimum ramus breadth was the best parameter for sex determination. An anthropological study was conducted by Thakur et al.[8] on the mandibular angle and height of the ramus to know their role in sexual dimorphism, and it was found that both these parameters are greater in males than in females.

A previous study conducted on the facial height for various endogamous communities of Nepal concluded that there are racial differences in upper and lower facial height proportions, but no significant difference in males and females. The upper and lower facial heights increase in the same proportion with the increase in age.[9]

The present study was carried out on dried mandibles to establish some parameters as criteria for sex determination in the Indian population. The findings of this study may be useful in providing anthropological data, which can be used in dental and medical practices too.

2. Materials and methods

The sample of 126 dried adult mandibles belonging to the Indian population was obtained from Gian Sagar Medical College, Ramnagar, Patiala, Punjab and the Government Medical College, Chandigarh. The sex of the mandible was determined according to the following criteria:

1. Gonial eversion marked in males/absent in females.
2. Chin square in males/rounded or pointed in females.
3. Male mandible robust, larger, broader/female slender, smaller.
4. In males lateral aspect of angle shows rough appearance. In females, the lateral aspect of the angle is comparatively smooth.

Six cases with uncertainty in sex determination not fitting into the above criteria were discarded; 93 were adult (63 male and 30 female) and 27 mandibles were old (15 male and 12 female) with resorbed alveolar border. The various parameters as shown in Figs. 1 and 2 were considered in the present study and were taken in accordance with the study conducted by Vodanovic et al.[3] as follows:

- Angle of the mandible: It was taken with the help of a protractor as the angle between the base and a tangent drawn along the posterior border of the ramus, touching the posterior-most point on the condyle and the posterior-most point on the posterior border.
- Diagonal length (DL) of the mandible body: The DL (gonion-gnathion [Go-Gn] length) of the mandible body was measured from the point at the base of the mandible at the level of the symphysis menti (Gn) to the posterior-most point at the angle (Go) at the junction of the body and the ascending rami of the mandible with the help of a digital vernier calipers.

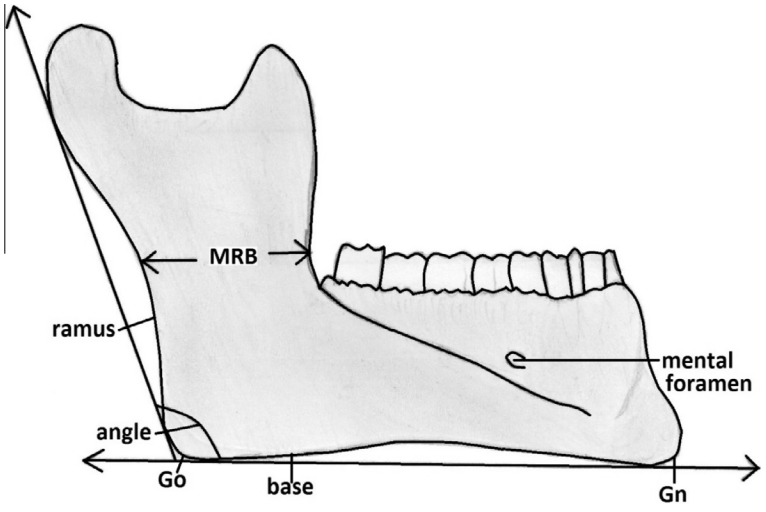

Fig. 1 Showing the parameters including the angle and minimum ramus breadth (MRB).

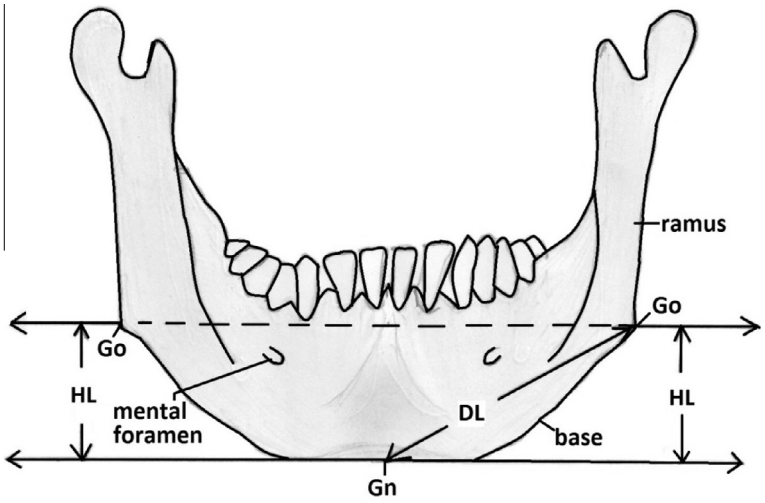

Fig. 2 Showing the horizontal length (HL) and diagonal length (DL) of the mandible (Go-Gonion, Gn-Gnathion).

- Horizontal length (HL): This new parameter was measured as the distance between two horizontal lines between the above-mentioned two bony points with the help of a scale with two limbs set at right angles to each other by keeping the bone on a board and fixing it along a horizontal margin.
- Minimum ramus breadth (MRB): Minimum anteroposterior breadth of the ramus was measured with the help of a digital vernier calipers.

All the measurements were taken with the help of an electronic sliding digital vernier calipers with a resolution of 0.02 mm and a protractor. Values were taken up to 2 decimal places. The measurements were taken on the right side of all the mandibles (right side being dominant). The calipers was checked for accuracy and precision regularly while collecting the data. To prevent inter-observer error, all the measurements were taken by the first author. To rule out any intra-observer error, measurements were taken twice on 20 mandibles forming the sample. It was observed that the measurements were reproducible without any significant intra-observer error.

3. Theory/calculation

The values, thus obtained, were subjected to further analysis to confirm their significance in sex determination. Sexual difference was analyzed by Student's *t*-test. Discriminant function analysis was performed using SPSS19. The constants and coefficients were calculated. The functions applied to the means of male and female values for different parameters gave the values at group centroids for males (Zm) and for females (Zf). The demarcation point (Zo) was calculated by the formula given by Xavier[10] as follows:

$$\mathrm{Zo} = \frac{(\mathrm{Zm} \times \mathrm{Nf}) \pm (\mathrm{Zf} \times \mathrm{Nm})}{(\mathrm{Nm} + \mathrm{Nf})}$$

4. Results

The results obtained in the present study have been grouped into adult and elderly groups, which were further divided into males and females. Mean diagonal length in adult males was 79.76 ± 4.68 mm and in adult females was 73.83 ± 4.84 mm. Mean horizontal length was 71.99 ± 4.54 mm and 68.61 ± 4.78 mm for adult males and females, respectively. Minimum ramus breadth for adult males was 30.93 ± 2.56 mm and for adult females 29.57 ± 2.86 mm.

Subjecting the values of the mandibular angle to the analysis of variance, it was found that the *p*-value of the angle was 0.3846, i.e., greater than 0.05, making it insignificant, as far as sex determination is concerned. These values for all the groups, along with *p*-values, are depicted in Table 1.

Table 2 depicts the function coefficients and constant for all the parameters in all the groups in the present study. Discriminant function was calculated for the sample under study from the values given in Table 2 as follows:

Table 1 Showing analysis of various groups.

Sr. no.	Parameter	Adult male		Adult female		*p*-Value	Elderly male		Elderly female		*p*-Value
		Mean	Std. deviation	Mean	Std. deviation		Mean	Std. deviation	Mean	Std. deviation	
1.	DL (mm)	79.7670	±4.67766	73.8320	±4.84304	0.000	79.1400	±5.94919	74.8842	±3.68599	0.040
2.	HL (mm)	71.9914	±4.54049	68.6183	±4.78538	0.001	72.6980	±4.80436	67.9983	±3.69596	0.010
3.	MRB(mm)	30.9289	±2.55873	29.5670	±2.86174	0.026	28.4807	±1.93900	26.0667	±2.67920	0.007
4.	Angle	124.00°	±6.27077	124.03°	±5.30116	0.384	124.13°	±5.18055	127.25°	±7.46050	0.384

Table 2 Classification function coefficients.

Parameter	Groups			
	Adult male	Adult female	Elderly male	Elderly female
DL	1.048	.670	.898	.845
HL	1.378	1.561	1.760	1.639
MRB	6.258	6.183	5.560	5.411
Angle	4.567	4.567	4.499	4.546
(Constant)	−472.687	−454.313	−459.324	−448.483

Table 3 Functions at group centroids.

Groups	Function			Prediction of group (%)
	Z(m)	Z(f)	Z(0)	
Adult male	.566	.156	−.057	63.5
Adult female	−.294	−.827	.086	56.7
Elderly male	−.671	.742	.378	53.3
Elderly female	−1.399	.321	−.392	58.3

F (1) = −472.687 + 1.048(L) + 1.378(HL) + 6.258(MRB) + 4.567(angle).
F (2) = −454.313 + .670(L) + 1.561(HL) + 6.183(MRB) + 4.567(angle).
F (3) = −459.324 + .898(L) + 1.760(HL) + 5.560(MRB) + 4.449(angle).
F (4) = −448.483 + .845(L) + 1.639(HL) + 5.411(MRB) + 4.546(angle).

Table 3 depicts the functions at group centroids for males (Zm), females (Zf), demarcation point (Zo) and the predicted accuracy for a particular group.

5. Discussion

According to the textbooks of anatomy, in elderly subjects the angle of the mandible is 140° and is lesser in adults.[4] In the present study, the mean angle of the mandible in adult males was 124° ± 6.27°, in females 124.03° ± 5.3°, in elderly males 124.13° ± 5.18° and in elderly females 127.25° ± 7.46°. The mean value of the angle in elderly females is greater than males, but when subjected to statistical analysis, the *p*-value was found to be greater than 0.05, making this difference insignificant. In the previous studies conducted on the angle of the mandible, it was observed to be 123.5° in adults in the age group 50–76 years,[6] making the two studies in close agreement with each other. Rai et al.[11] in their study found that the mean mandibular angle was greater in adult females (121°) than that in adult males (118°). In a recent study, it was found that there is no correlation between the gender and the mandibular angle, although the angle increases in elderly mandibles, especially if the dentures are not worn.[12]

The diagonal length in the present study was 79.77 ± 4.68 mm in adult males and 73.83 ± 4.84 mm in females, as compared with 8.32 ± 0.52 cm in males and 7.92 ± 0.46 cm in females observed by Ongkana and Sudwan[5] in the Thai population. In both the studies, the diagonal length is significantly greater in males as compared with the females. In these studies, the difference in the values might be due to different population groups included in these studies.

The horizontal length of the mandible in the present study was 71.99 ± 4.54 mm in adult males and 68.62 ± 4.78 mm in females, whereas in elderly males and females, it was 72.69 ± 4.8 mm and 67.99 ± 3.69 mm, respectively. No previous data were found to compare this parameter. In the present study, this parameter was found to be sexually dimorphic with values in males greater than females in both the adult and elderly groups.

Minimum ramus breadth (MRB) was 3.28 ± 0.34 cm in males and 3.14 ± 0.31 cm in females in a study conducted by previous workers[5] in 2009; while in the present study, it was observed to be 30.93 ± 2.56 mm in males and 29.61 ± 2.86 mm in females in the adult group and 28.48 ± 1.94 mm and 26.07 ± 2.68 mm in males and females, respectively, in the elderly group. Both the studies indicate that MRB is an important indicator for determination of sex.

The differences observed in male and female mandibles may be explained on the basis of genetically determined factors, like the size of teeth, and local factors, like muscle forces (weaker in females as compared with males). Sexual division of labor and access to adequate nutrition are the other factors responsible for sexual dimorphism of bones.[13] Mean values of DL, HL, and MRB in the present study have been observed to be significantly higher in males, both adult and elderly, as compared with females, with a *p*-value less than 0.05. This indicates that these features are sexually dimorphic and hence can be used for sexing the mandible.

The accuracy of different discriminant functions in correctly sexing the mandible was 63.5% in adult males, 56.7% in adult females, 53.3% in elderly males and 58.3% in elderly females, with an overall accuracy of 60% in the present study. It is lower as compared with previous studies, which showed an accuracy of 70.9–82.9%,[14] 60.3–80.2%,[15] and 76%.[7]

6. Conclusion

From the present study, it can be concluded that parameters like the length of the body of the mandible and the minimum ramus breadth can prove to be of aid in identifying the sex of mutilated and unidentified bodies when combined with some other criteria used for sex determination. These data can be improved upon by further studies on elderly mandibles, as the sample for this group was small in the present study.

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Conflict of interest

No conflict of interest.

Informed consent

Not applicable.

Ethical approval

Necessary ethical approval was obtained from the College ethics committee.

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