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A BIOMETRICAL STUDY OF HUMAN MANDIBLE IN INDIAN POPULATION FOR SEX DETERMINATION

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ABSTRACT

The biometrical study of the mandible in human remains will help us in identification of age, sex and race of the individual with available broken pieces of mandible pool with accuracy and clarity. A total of 70 (n=70) adult human mandibles belonging to the Indian population were collected for morphological and morphometric features using ramus breadth, symphysis and condyle height, bigonial breadth, weight, volume and density of the mandible. Based on the maximum and minimum ramus breadth 40 samples could be considered as adult male while, 30 as adult female. Statistical analysis data with mean and SD of various parameters of the mandible viz., ramus breadth, symphysis and condyle height, bigonial breadth, weight, volume and density in male and female were 33.04±0.348 and 27.866±0.668, 31.6±0.327 and 27.6±0.444, 61.125±0.591 and 55.5±0.446, 90.675±0.833 and 81.866±0.919, 61.087±0.712 and 40.433±0.518, 39.025±3.908 and 28.9±0.4022, 1.5628±0.029 and 1.373±0.1255 respectively. Therefore, these results indicated that the average values of all the parameters studied were more in male compared to females. In the present study, there was no statistically significant difference between male and females with respect to different variables however, showed higher values in males compared to females. In conclusion, a large study groups and comprehensive assessment of various parameters related to the mandibles may be required for more definitive and confirmatory results.

KEY WORDS: Bigonial breadth, mandible, ramus breadth, symphysis and condyl height.

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INTRODUCTION

The identification of sex from human remains is of fundamental importance in forensic medicine and anthropology, especially in criminal investigations as well as in the identification of missing persons and in attempts at reconstructing the lives of ancient populations. One of the important aspects of forensics is to determine sex from fragmented jaws and dentition[1]. It is evident from the earlier studies skull is the most dimorphic and easily sexed portion ofskeleton after pelvis, providing accuracy up to 92%[2]. But in cases where intact skull is not found, mandible may play a vital role in determination of sex as it is the most dimorphic, largest and strongest bone of skull[2-5]. Bones often survive the process of decay and therefore provide the major evidence of human age, sex and race after death. The mandible is the strongest bone in the human body and persists in a well-preserved state longer than any other bone. The identification of human skeletal remains is considered an initial step in forensic investigations and is crucial for further analysis[2]. The mandible has been extensively studied[5-11]. Therefore, mandibular characteristics are extremely useful or determining sex[5]. Mandible next to the pelvis in human remains will help us in identification of age, sex and race. Male bones are generally bigger and more robust than female bones[3]. Measurements of the mandibular ramus tend to show higher sexual dimorphism, and differences between the sexes are generally more marked in the mandibular ramus than in the mandibular body[12]. Several studies have been conducted on dry adult mandibles for sex determination[1,2,5,12,13]. Mandible and its variations in age, sex and race will help physicians, surgeons, medico-legal authorities and anthropologists to give correct interpretations for the results of diagnostic procedures in living[14,15]. The present study was undertaken because today the society is conscious of beauty and usefulness of orthodontics and the thought of taking up the profession of modelling has increased. Not only this but also for determining age and sex of the individual with available broken pieces of mandible with accuracy and clarity in medico-legal cases. The biometrical study of the mandible is useful in maxilla facial surgery, anthropological study, forensic medicine, dentistry, oral surgery, plastic surgery in correction of craniofacial deformities, maxillofacial surgery, to determine age and sex of the individual. The study of identification of sex for a single bone is not only important medico legally but also anthropologically. Mandibular ramus can be used to differentiate between sexes and it also expresses strong sexual dimorphism. If the mandible alone is available besides sex, age and race also can be determined. Hence, this paper aims to evaluate the usefulness of mandibular ramus in sex discrimination in Indian population and propose the use of same in forensic and other analysis.

MATERIALS AND METHODS

The present study was conducted at the Department of Anatomy at Gandhi Medical College, Musheerabad, Secunderabad, Telangana state, India. A total of 70 (n=70) adult human mandibles (specimen numbers were designated as S1, S2, S3 --------- S70) from large samples belonging to the Indian population were obtained from the Department of Anatomy and Forensic Medicine at Gandhi Medical College, Musheerabad, Secunderabad, Osmania Medical College, Koti, Hyderabad and Shadan Institute of Medical Sciences, Hyderabad, Telangana state, India. For diagnostic determination of sex a study on morphological and morphometric features by using different parameters of the mandible viz., ramus breadth of the mandible, mandibular symphysis height, mandibular condyle height, bigonial breadth, weight, volume and density (weight / volume) of the mandible were recorded. All the measurements were recorded to the nearest in millimeters. All the measurements were taken with the help of 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 Vernier Calipers was checked for accuracy and precision regularly while collecting the data.

After defining these points the following measurements were recorded

1. Ramus breadth is measured between the anterior and posterior borders of the ramus of the mandible.
2. Mandibular symphysis height is measured from the point of infradentale to the point of gnathion.
3. Mandibular condyle height is measured from the point of gonion to the condylar process by the bone calipers.
4. Bigonial breadth is the measurement between one gonion to the opposite gonion.
5. Weight of the mandible measured in grams.
6. Volume of the mandible (cc) measured by immersing mandible in measuring jar and adding water in it and noting the raised water level.
7. Density (weight / volume) of the mandible.

Theory/calculation

The data collected is statistically analyzed, subjected to Factor analysis and tabulated. The values, thus obtained, were subjected to further analysis to confirm their significance in sex determination. Statistical analysis was done by calculating student's 't'-test, to test the significant difference between two means of males and females, *p*-value ≤ 0.05 was considered statistically significant.

RESULTS AND DISCUSSION

The ramus breadth of 70 mandible specimens are presented in Table 1. The ramus breadth of the 40 mandibles ranged from 33.388 to 32.692mm while that of

30 mandibles was 28.534 to 27.198mm (Table 2). The maximum breadth of the ramus in 40 samples was 35 and minimum 32mm (Table 1), with a mean value 31.2mm and in 30 samples the maximum and minimum was 30 and 24mm respectively, with mean value 27.198mm (Table 2). With the help of these parameters, out of 70 mandibles studied 40 could be said to be male, 30 as female. Statistically also the range of ramus breadth considered to be adult male was from 33.388 to 32.692mm while, that of adult female 28.534 to 27.198mm. Our results are in agreement with the results of Hanihara[16], who reported mean ramus breadth of male as 31.2mm which is very close to our results. However, the mean female ramus breadth (27.198) was little lesser (31.1mm). This may be attributed to poor nutritional status in the Indian women. In the present study, the average ramus breadth of those considered as adult males is more than that of those considered as adult females, which is in accordance with the findings of Hanihara[16]. In this connection it is interesting to note that the mandibles that are regarded as belonging to male in the present study showed that the maximum and minimum breadth of ramus are in correlation with the earlier observations[16-18]. Thus, the results obtained in the present study, 40 mandible samples have been grouped into adult males and 30 into adult females. Therefore, by comparing the mean values of male and female mandibles we concluded that the average of male ramus breadth will be more than the average ramus breadth in the females.

Table 1
Mandibular ramus breadth (mm) in 70 (n=70) specimens grouped as adult male (n=40) and adult female (n=30) based on the mean maximum and minimum values

S No	Adult male			Adult female		
	Specimen No	RB	SD	S No	RB	SD
1	S1,3,15,21, 37,41,45,51,59,62,68	32	-1.08	S4	24	-3.866
2	S31,33,57,63,67,69,70	33	0.08	S12,16,34,46,52,	26	-1.866
3	S5,7,9,13,17,19,25,27,29,35,39,47,49,53,55,64,65,66	34	0.92	S36,40	27	-0.866
4	11,23,43,61	35	1.92	S2,6,8,10,14,18,28,30,32,38,42,48,54,60	28	0.134
5				S22,24,26,50,56	29	1.134
6				S20,44,58	30	2.134

RB- Ramus breadth, SD- Standard deviation, S- specimen, level of significance at 0.05%

In the present study, 40 mandibles that were grouped as adult male minimum mandibular symphysis height was 30mm and maximum 34mm (Table 2). However, in 30 mandibles grouped as adult female, maximum and minimum symphysis height was 30mm and 25mm respectively. With the help of these parameters the symphysis height of 40 mandibles grouped as adult males ranged from 31.927 to 31.273 mm with mean value 31.85mm and of 30 mandibles grouped as adult females ranged from 28.044 to 27.156 mm with mean value 27.1mm. A great variation was observed between male and females. The present study results showed that the mean mandibular symphysis height is more in males than in females in agreement with the findings of Hanihara[16]. Higher mandibular symphyseal height in male has been reported earlier[17-18]. This is in correlation with the present observation.

Table 2
Statistical analysis data of various parameters with mean and standard deviations in 70 samples those grouped as adult male and female

Parameters	Male			Female		
	Min	Max	Mean ± SD	Min	Max	Mean ± SD
Ramus breadth (mm)	32	35	33.04±0.348	24	30	27.866±0.668
Symphysis height (mm)	30	34	31.6±0.327	26	30	27.6±0.444
Condyl height (mm)	58	64	61.125±0.591	54	60	55.5±0.446
Bigonial breadth (mm)	87	94	90.675±0.833	80	86	81.866±0.919
Weight of mandible (gm)	56.5	66	61.087±0.712	37	43	40.433±0.518
Volume of mandible (cc)	33	45	39.025±3.908	28	31	28.9±0.4022
Density of mandible	1.3	2.0	1.5628±0.029	1.233	1.535	1.373±0.1255

Min- minimum, Max- maximum

Mandibular condyle in 40 mandibles that were considered as adult male ranged from 61.716 to 60.534mm and of 30 mandibles considered as adult females ranged from 55.946 to 55.055mm. Maximum and minimum condyle height in male measured 64 and 56mm respectively. While, in female maximum was 60mm and minimum being 54mm. The present study indicates that the mandibular condyle height in female is less than that in male by which 40 mandibles can be said to be adult males and 30 as adult females. In the present study those mandibles that are designated as belonging to females showed smaller condyles resulting in lesser height. This is in accordance with the findings of Hanihara[16] and Tedeshi[19]. Statistically the range of bigonial breadth of mandibles considered as adult males was 91.508 to 89.842mm with a mean value 90.67mm. While, those of adult females the range was 82.785 to 80.947mm with a mean value 81.86mm (Table 2). The bigonial measurements of breadth in the present study measured upto a maximum of 94mm and minimum 87mm in males. While, in females it was 88 and 80mm respectively. From these results it is understood that the average bigonial breadth is more in males than in females, which is in accordance with the findings of Hanihara[16]. The mandibular weight measured in this study as shown in the Table 2 indicates that the maximum mandibular weight recorded in males was 65 and minimum 56gm. While, those in females maximum was 43 and minimum 37.5gm. Statistically, the weight of 40 mandibles grouped as adult males ranged from 61.799 to 60.374gm with mean value 61.09gm. While, weight of 30 mandibles groups as adult females the range was 40.951 to 39.92gm with mean value 40.43gm. It was observed that there was a great variation in the weight of the mandibles of those regarded to belong to adult males and females. These results are similar to the observations of Keen[20]. The range of mean volume of mandible in those considered as adult males was 40.212 to 37.837cc with mean value 39.03cc and in those of adult females the range was 29.302 to 28.497cc with a mean value 28.90cc. The female mandible volume measured was less than the volume of male mandible. The mandibular density (weight / volume) measurements in the present study as shown in the Table indicate that the maximum density measurement in male was up to 2 and minimum 1.3. While, in female the maximum density measurement was 1.535 and minimum 1.233. Statistically the range in adult male was 1.5717 to 1.5538 with mean value 1.57 and in adult female 1.4985 to 1.2475 with mean value 1.37. In the present study the average mandibular density is more in males than in females which is in accordance to the findings of Broman, Trotter, Peterson[21] who studied 80 adult skeletons and reported bone density was less in females than in males. In this study there was no statistically significant difference between males and females with respect to different variables. However, large study groups and comprehensive assessment of various parameters related to the mandibles may be required for more definitive and confirmatory results. The mandibular ramus demonstrated greatest sexual dimorphism in terms of ramus breadth, symphysis height, condylar height, bigonial breadth, weight, volume and density of mandibles. Earlier studies on mandible by[6,7,9,12] have established the usefulness of mandible for determination of sex. They found that the sexual differences were highest in height of the ramus, thus emphasizing that sex differences are more pronounced in mandibular ramus. Hence, mandibular condyle and ramus in particular are generally the most sexually dimorphic as they are the sites associated with the greatest morphological changes in size and remodeling during growth. Giles[11] measured mandibles of known sex using anthropometric measurements and reported mandibular ramus height, maximum ramus breadth, and minimum ramus breadth as highly significant, with an accuracy of 85% in American Whites and Negroes. Steyn and Iscan[22] achieved an accuracy of 81.5% with five mandibular parameters (i.e. bigonial breadth, total mandibular length, bicondylar breadth, minimum ramus breadth, and gonion–gnathion) in South African Whites, which is comparable with the present study results[2,22]. Minimum ramus breadth measurement was found to be the best parameter in the present study, which is consistent with other osteometric studies by Vodanovic, Dumancic, Demo, Mihelic[1] and Giles[11], where breadth measurements were found to be very dimorphic. This is related to the differences in musculoskeletal development and to the differences related to a different growth trajectory in males and females[11,22]. It has been established that socio-environmental factors (e.g. nutrition, food, climate, pathologies, etc.) influence the development, and thus the appearance of bones[2,23]. Mandibular ramus can be considered as a valuable tool in gender determination since it possesses resistance to damage and disintegration processes. We found that mandibular ramus measurements followed by the parameters studied in the present study were reliable for sex determination. Hence, the results strongly suggest the use of mandibular ramus as an aid for gender determination in forensic analysis. In view of these findings, further studies on more diverse populations to assess the significance of these parameters could be recommended.

CONCLUSION

The present study suggests the use of mandibular ramus as an aid for gender determination. In conclusion, a large study groups and comprehensive assessment of various parameters related to the mandibles may be required for more definitive and confirmatory results.

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