Morphometric Analysis of Dry Human Mandibles of Sri Lankans

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Abstract

Introduction: Variety of mandibular morphometric measurements determines the population and sex differences of facial skeleton. This study is aimed to determine the mandibular morphometric measurements of Sri Lankan population.

Materials and methods: Thirteen different mandibular measurements were obtained in 75 dry mandibles of which the gender and age were determined referring to the standard literature. Optimum measures were undertaken to reduce the intra and inter observer bias. The data were analysed using Minitab 19 version. Mean ± SD, mean difference and P- value of each morphometric parameter for both sexes were analysed separately by using Minitab 19 version.

Results and discussion: The sample consisted of 40 male and 35 female mandibles, age ranging from 60 – 80 years with the mean age of 67.545 ±4.36765. The mean value of each morphometric parameter in males were higher except in the mandibular angle and the height and breadth of the mandibular body. The maximum mandibular length, bigonial width, maximum ramus height, bicondylar breadth, bicoronoid breadth, bimental breadth and mandibular notch depth of males showed statistical significance ($P<0.05$). The mean values of all the parameters were different from values of the different populations.

Conclusions: Mandibular morphometric characteristics of Sri Lankans showed distinctiveness within the population and a direct relationship with the sex. These findings provide information for objective assessment facial skeletons of Sri Lankans.

Keywords: Morphometry; human mandible; facial skeleton; Sri Lankans

Introduction

The lower jaw is formed by the mandible, which is the largest and strongest bone in the human face skeleton[1,2,3,4,5]. The mandible, the largest bone in the face has horizontally curved body, convex forwards and two broad rami ascending posteriorly. The mandibular body is U shaped and it is formed by union of two left and right halves at the symphysis menti. The angle of the mandible is the place where the inferior margin of the mandible meets the posterior margin of the ramus. The mandibular rami which project perpendicularly upward contains head, neck and coronoid process[2,3,4,5]

The gender, age, stature, life style, and health status of extinct individuals are all addressed in the detailed study of morphology and

morphometry of human skeletons[2,6,7,8,9]. The mandible is one of the skull bones that can be used to establish a diseased person's gender, age, eating habits/diet, and oral health[2,3,4,5,10,11]. The mandible is a compact bone that resists fragmentation and deterioration after death because it is a compact bone. The mandible is one of the most prevalent features in diseased individuals' skeletal remains, and it may be used to determine gender and estimate the age of the human at death because the jaw changes with time[3,4,5,6,12].

The sex determination of the victims found in warfare, tsunami, earth quick, landslides, explosions, forensic remains and archaeological remains is generally based on DNA studies and morphological and morphometrical assessment of pelvic bones and skull bones[3,4,5,8,13,14]. When these bones are unavailable, sex determination of unknown are carried out by assessing mandibular morphometry and morphology such as gross size, robustness, gonion morphology, chin morphology, ramus morphology, muscular markings over the body surface of the mandible etc[3,4,11,14,15].

As mandible is the strongest bone of the face, there is less chances of its damage during disaster and accidents and even decaying after death. It was reported that the mandible remains its shape better than other bones for a long time after death of the individuals[5,14,15,16]. This is of particular importance in relation to human identification as its durability. This quality was exploited to identify extinct individuals gender, age, facial morphologies etc and even determination of the ancestry of the individual using available fragments of mandibles in archaeological skeletal remains by using mandibular dimensions as different populations across the world represented by different morphometric values[5,6,17,14,16].

Male and female mandibles differ from morphological features such as robustness, gonion morphology, chin morphology, ramus morphology, muscular markings over the body surface of the mandible[3,4,11,14,15]. The morphological assessment of mandible of an individual is concluded with the individual's skills and experience and it depends on the person who takes part in the study and hence the morphological assessment becomes subjective and unreliable[11,12,18,19]. Therefore, globally various morphometrical assessments on mandibles have been conducted to determine thee variations of mandibular dimensions among gender in different populations in the globe[20,21,22,23,24,25].

These findings are more useful to maxillofacial surgeons, plastic surgeons, medico legal authorities, archaeologists and anthropologists for confirmation of their interpretation of mandibular observations in different populations and reconstruction of facial morphologies of the respective populations.

Researchers in different regions in the world are still working on dry or living mandibles to evaluate the morphology and morphometry of mandible and to analyse the relationship of the morphology and morphometry of the mandible to the particular population group and they concluded that different population show population specific morphometric parameters of the mandibles[20,21,22,26,27,28]

Thus the present study was designed to determine the morphometrical variations of mandibles among male and female Sri Lankans.

Materials and Methods

The present study has been designed to analyse the morphometric parameters of male and female dry mandibles of Sri Lankans. The dry mandibles were collected from the Department of Anatomy, Faculty of Medicine, Wayamba University of Sri Lanka and Department of Anatomy, Faculty of Medicine, University of Peradeniya, Sri Lanka for the study. The fragmented mandibles and mandibles with abnormal morphologies were excluded from the study. The gender of the selected mandibles for the study was determined by assessing the morphological characteristics of the mandibles reported by Williams et al., 2000. The age of each mandible was determined by following the methods described by Williams et al., 2000. Thirteen mandibular measurements described in table 1.1 were taken from the 75 selected mandibles by following the bony landmarks of the diagrammatic representation (Fig 1.1). All the measurements were taken by using mandibular meter and digital Vernier calliper. Each measurement was taken thrice and mean value was taken for the analysis. Male and female mandibular measurements were analysed separately to generate morphometric parameters for male and female Sri Lankans.

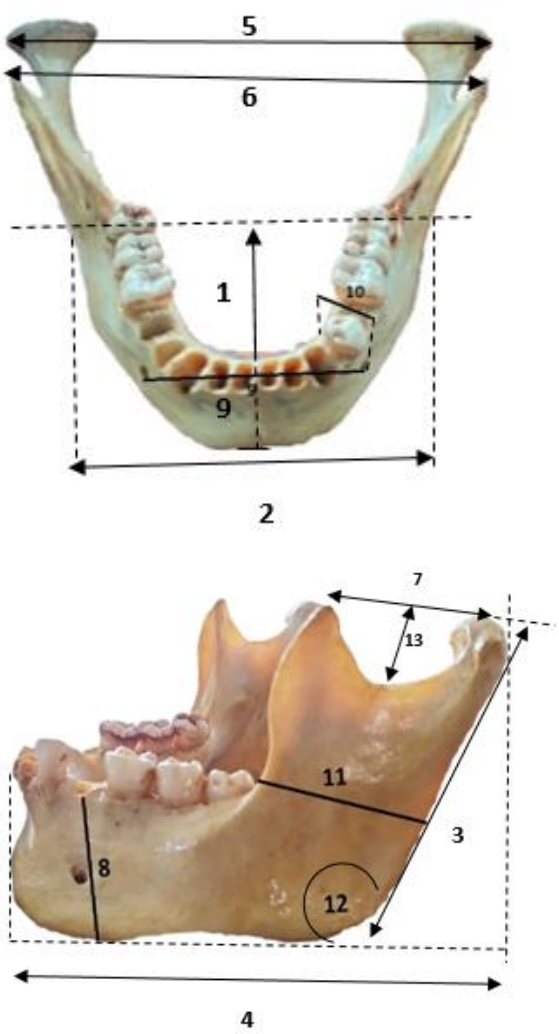

Figure 1.1. Mandible measurements

1-maximum mandibular length 2- bigonial width 3- maximum ramus height, right and left 4-mandibular length (projection) 5- bicondylar breadth 6- bicoronoid breadth 7- mandibular notch breadth 8- height of the mandibular body at the mental foramen 9- bimental breadth 10- breadth of the mandibular body 11- minimum ramus breadth 12- mandibular angle 13- mandibular notch depth

Table 1.1 Mandible measurements

Mandibular measurements	**Description of measurement using bony landmarks of mandible**
1- Maximum mandibular length	Distance from the anterior midline point on the chin (pogonion) to a center point of the bigonion line.
2- Bigonial width	Direct distance between the right and left gonion.
3- Maximum ramus height	Direct distance from the highest point on the mandibular condyle to the gonion.
4- Mandibular length (projection)	Distance from the anterior midline point on the chin (pogonion) to the perpendicular line tangent to the posterior point of the left condyle.
5- Bicondylar breadth	Direct distance between the most lateral points on the two condyles (condylion laterale).
6- Bicoronoid breadth	Direct distance between the points at the tip of the two coronoid processes (coronion)
7- Mandibular notch breadth	Direct distance from the condylion superior point to the coronion.
8- Height of mandibular body	Direct distance from the alveolar process to the inferior border of the mandible perpendicular to the base at the level of the mental foramen.
9- Bimental breadth	Direct distance between the most inferior point on the margin of the mandibular mental foramen (mentale).
10- Breadth of mandibular body	Maximum breadth measured in the region of the mental foramen perpendicular to the long axis of the mandibular body
11- Minimum ramus breadth	Minimum breadth of the mandibular ramus measured perpendicular to the height of the ramus
12- Mandibular angle	Angle formed by the inferior border of the corpus and the posterior border of the ramus.
13- Mandibular notch depth	Distance from the deepest part of the mandibular notch, to a center point of the condylion superior – (coronion) line.

Mean ± SD, mean difference and P- value of each morphometric parameter for both sexes were analysed separately by using Minitab 19 version. Sexual difference for each morphometric parameter was analysed with reference to p values. If the morphometric parameter's P value was less than 0.05, the parameter was substantially different between genders.

Results and Analysis

Forty male and 35 female mandibles were identified from 75 samples of mandibles. The age of the studied mandibles ranges from 60 – 80 years and mean age of the studied samples was 67.545 ±4.36765. In the present study thirteen measurements were taken from male and female mandibles as described in the material and methods. The mean, standard deviation, mean difference and P value for each measurement of male and female are given in the table 1.

Table 1.2 Mean ± SD, mean difference and P- value of mandibular measurements among male and female Sri Lankans

N = 75	Sex	Mean	SD	Mean Difference	p-value
1.Maximum mandibular length (mm)	Male	82.3337	±6.63680	3.89229	0.016
	Female	78.4414	±5.36765		
2.Bigonial width(mm)	Male	96.2799	±6.01647	6.30268	0.018
	Female	89.9772	±12.41491		
3.Maximum ramus height(mm)	Male	57.8569	±4.77926	3.40508	0.020
	Female	54.4518	±6.00606		
4.Mandibular length(mm)	Male	112.4155	±9.74738	11.34182	0.001
	Female	101.0737	±13.38091		
5.Bicondylar breadth(mm)	Male	118.3070	±3.62744	8.86046	0.000
	Female	109.4466	±3.57986		
6.Bicoronoid breadth(mm)	Male	96.2194	±5.52801	4.27446	0.002
	Female	91.9449	±4.29034		
7. Mandibular notch breadth(mm)	Male	34.4180	±2.91490	1.28335	0.118
	Female	33.1346	±3.26412		
8. Height of mandibular body(mm)	Male	26.6168	±5.46892	-0.13913	0.909
	Female	26.7559	±3.76178		
9.Bimental breadth(mm)	Male	45.1018	±1.72666	1.01899	0.038
	Female	44.0828	±1.94414		
10.Breadth of mandibular body(mm)	Male	10.8167	±2.02543	-0.04925	0.910
	Female	10.8659	±1.26282		
11.Minimum ramus breadth(mm) (R)	Male	31.7475	±2.74973	0.78997	0.250
	Female	30.9575	±2.46941		
12.Mandibular angle (◦)	Male	125.5718	±7.58553	-1.05219	0.621
	Female	126.6240	±8.55523		
13.Mandibular notch depth(mm)	Male	14.5824	±1.94141	2.17786	0.000
	Female	12.4045	±1.67448		

The mean mandibular measurements of males are higher than the female values except height and breadth of the mandibular body and mandibular angle. The maximum mandibular length, bigonial width, maximum ramus height, bicondylar breadth, bicoronoid breadth, bimental breadth and mandibular notch depth of males were significantly higher (<0.05) than the females.

Discussion

In this study, all mandibular measurements were obtained and documented using conventional literature, and male and female mandibles were compared. Except for height, breadth of the mandibular body, and mandibular angle, the results of this study revealed that males have higher morphometric parameters than females. Males had greater maximum mandibular length, bigonial width, maximum ramus height, bicondylar breadth, bicoronoid breadth, bimental breadth, and mandibular notch depth and breadth than females, and these morphometric parameters were substantially different between males and females.

According to the literature, it was reported that male mandibular morphometric parameters are often higher than female mandibular morphometric parameters[20,23,27,29,28]. The present findings of morphometric dimorphisms of mandibles in this study are equivalent to other studies' findings of mandibular dimorphism[22,23,27]. Gender disparities were discovered in these morphometric characteristics, which were similar to those identified in a study of South African indigenous, Indian, and Thai populations[22,23,27]. Maximum mandibular length, bigonial width, maximum ramus height, bicondylar breadth, mandibular length, bicoronoid breadth, bimental breadth and mandibular notch depth of males in this study higher than the females and these eight mandibular morphometric characteristics are varied significantly between male and female Sri Lankans. In general, the findings revealed that male Sri Lankan mandibles were larger than female mandibles, which is consistent with previous researches that have found male mandibles to be larger than female mandibles[20,22,27].

Varying ethnic groups around the world have different morphometry and morphology in their mandibles[20,21,22,27,28,30]. The mean morphometric parameters of male and female Sri Lankans differ from those recorded for other populations around the world, such as Indians, Thais, and South Africans, as well as Brazilians[20,22,27,31]. Males have a substantially greater bigonial width (96.28 mm) than females (89.98 mm) in this study, and the mean male and female values of bigonial width in this study are higher than those of Indians, who have a mean bigonial width of 79.76 mm for adult males and 73.83 mm for adult females[20]. In this study, adult males had a bigonial width of 96.28 mm and adult females had a bigonial width of 89.97 mm, which is higher than the males' (83.20 mm) and females' (79.2 mm) recorded in the Thai population[27]. The studied minimum ramus breadth for adult males and females in this study was 31.74mm and 30.95mm, respectively, which is larger than the Indians' minimum ramus breadth of 30.93mm for adult males and 29.57mm for adult females[20].

The reported Brazilian male and female mandibular morphometric values differ from the mandibular morphometric values of the Sri Lankans. Brazilian males and females have longer mandibular lengths (110.82 mm and 105.47 mm, respectively) than Sri Lankan males and females (82.33 mm) (78.44 mm). Bigonial widths are wider in Brazilian males (97.31 mm) and females (90.35 mm) than in

Sri Lankan males (96.28 mm) and females (90.35 mm) (89.98 mm). Brazilian males have a wider bicondylar width (119.10 mm) than Sri Lankan males (118.30 mm), and Brazilian ladies (114.68 mm) have a wider bicondylar width than Sri Lankan females (109.44 mm). The examined mandibular values of Sri Lankan males and females are, on average, lower than those reported for Brazilians[31].

In adults, the angle of the mandible is around 140° [4], The mean angle of the mandible in adult males was 125.57° ±7.58553 in this study, and 126.62° ±8.55523 in females. The gender differences in the examined metrical angle of the mandible were compared to gender differences in the mean mandibular angle reported for young Indians (119.92° ±6.27°) and female (125.20° ±5.3°) 20. The mean mandibular angle was higher than that of Indian senior males (124.13° ±5.18°) and lower than that of females (127.25° ±7.46°)[20].

The mean angle of the mandible of females is larger than that of males, according to the literature[32,33], showed that the mean mandibular angle was greater in adult females (121°) than that in adult males (118°)[32]. The mean mandibular angle of Brazilian males (126.56 °) and females (130.18 °) were also in a same agreement that females are having larger angle of mandible than males. The gender differences of studied angle of mandible in this study (females > males) was compare with the Brazilians (females > males) and others too[31]. Although the mean value of the angle of mandible is higher in female than male in this study, the p-value was found to be greater than 0.05. Therefore, angle of mandible is insignificant among the two genders in Sri Lankans. This is compared with reported study on Indians and Brazilians. The angle of mandible in Indians and Brazilians was insignificant among gender[20,31], Most of the recent studies showed that the angle of mandible has no correlation between the gender although the angle shows different in male and females[32,33].

The differences in muscular skeletal systems seen in males and females may account for the sexual dimorphism in mandibular morphometry and morphology. Because males have a more robust skeleton than females, muscles involved in the masticatory cycle adhere more strongly to the jaw, perhaps increasing the size and robustness of the mandible. Variable lifestyles and chewing habits may be linked to the size and form of the mandible. Male and female mandibles have different growth rates and developmental stages, according to research[26].

As reported in other investigations, there were discrepancies in the results of mandibular morphometry in this study. This could indicate that, aside from gender, different populations have distinct mandible sizes. To be able to apply the findings of this study to the best benefit, comprehensive studies must be undertaken and the mean difference morphometrical values for Sri Lankan male and female mandibles must be determined. The findings of this study will be useful in forensic medicine, forensic dentistry, anthropological investigations, and in the diagnosis and treatment planning of maxillo-facial surgeons and plastic surgeons, among other fields.

More research is needed, particularly to discover the morphological and morphometric variances in mandibles across the globe, as well as gender disparities. The morphometry of the mandible contributes significantly to the various shapes of the face, including facial angulation and chin prominence, which aids in the identification of persons belonging to various populations in various parts of the world.

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Conflict of Interest

None declared

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References

1. Dutta A. *Essential of Human Anatomy: Head and Neck*. In: Essential of Human Anatomy. 5th ed. Current Book International Calcutta; 1994. p. 40–4.

2. Lockhart R. *Anatomy of human skeleton*. In: Arnold E, editor. 2nd ed. London; 1965. p. 52.

3. Horan F. Gray's *Anatomy: the anatomical basis of clinical practice*. J Bone Joint Surg Br. 40th ed. 2008;91-B(7):983–983.

4. Williams PL, Bannister LG BM. *Gray's Anatomy*. 38th ed. Newyork: Churchill Livingstone; 2000. 409 – 419 p.

5. Bass WM. *Human Osteology A Laboratory and field manual*. 1979.

6. Humphrey LT, Dean MC, Stringer CB. *Morphological variation in great ape and modern human mandibles*. J Anat. 1999;195(4):491–513.

7. Naccarato, Shawn; Petersen, Steven; John GL. *Skull features as clues to age, sex, race, and life style*. J Forensic Identif. 2008;58(2):172–81.

8. Jayachandra Pillai T, Sobha Devi T, Lakshmi Devi CK. *Bigonial dimeter, (11) Bicondylar diameter, (12) Bimental breadth, (13) Mandibular angle, (14) Length of lowe jaw, (15) Interincisor width, (16) Interprmolar width*. 2014;13(1):8–15.

9. Inderbir Singh. *Textbook of Human Osteology*. 3rd editio. Jaypee Brothers Medical Publishers (P) Ltd.; 2006. 198–203 p.

10. Frayer DW, Wolpoff MH. *Sexual Dimorphism*. Annu Rev Anthropol. 1985;14(1):429–73.

11. Heeresh, C, Malaviya G. *The sexing of human mandible*. J Indian Acad Forensic Sci. 1972;2(2):7.

12. Hu KS, Koh KS, Han SH, Shin KJ, Kim HJ. *Sex determination using nonmetric characteristics of the mandible in Koreans*. J Forensic Sci. 2006;51(6):1376–82.

13. Rosa MA, Reimers EG, Fregel R, Vazquez JV, Darias TD, Gonzalez MA LJ. *Canary Island aborigine sex determination based on mandible parameters contrasted by amelogenin analysis.* J Archaeol Sci. 2006;

14. Scheuer L. *Application of osteology to forensic medicine*. Clin Anat. 2002;15(4):297–312.

15. Singh I. *Text book of human osteology*. 3rd ed. New Delhi: Jay Pee Brothers Medical Publisher; 2009. 198–203 p.

16. Vodanović M, Duman\vcić J. *Determination of Sex by Discriminant Function Analysis of Mandibles From two Croatian Archaeological Sites.*

17. Kaifu Y. *Changes in mandibular morphology from the Jomon to modern periods in eastern Japan*. Am J Phys Anthropol. 1997;104(2):227–43.

18. Loth SR, Henneberg M. *Mandibular ramus flexure: A new morphologic indicator of sexual dimorphism in the human skeleton*. Am J Phys Anthropol. 1996;99(3):473–85.

19. Tanveer Ahamed Khan H.S J. S. *Observation on morphological features of human mandibles in 200 South Indian subjects*. Anat Karnataka. 2011;1(5):44–9.

20. Sharma M, Gorea RK, Gorea A, Abuderman A. *A morphometric study of the human mandible in the Indian population for sex determination*. Egypt J Forensic Sci. 2016;6(2):165–9.

21. Fabian F, Mpembeni R. *Sexual dimorphism in the mandibles of a homogenius black population of Tanzania*. Vol. 28, Tanzania Journal of Science. 2004.

22. Franklin D, O'Higgins P, Oxnard CE. *Sexual dimorphism in the mandible of indigenous South Africans: A geometric*

morphometric approach. S Afr J Sci. 2008;104(3–4):101–6.

23. Reale M, Wilson GT. *A biometric study of one hundred and ten asiatic mandibles*. 2014;89(2):457–61.

24. Hoque MM, Ara S, Begum S, Kamal AM, Sayeed S. *Morphometric Analysis of Dry Adult Human Mandibular Ramus*. Bangladesh J Anat. 2014;12(1):14–6.

25. Morant AGM, Collett M, Adyanthaya NK, Morant BYGM. *Biometrika Trust A Biometric Study of the Human Mandible A biometric study of the human mandible*. *and N. K. Adyanthaya*, 2014;28(1):84–122.

26. Franklin D, Oxnard CE, O'Higgins P, Dadour I. *Sexual dimorphism in the subadult mandible: Quantification using geometric morphometrics*. J Forensic Sci. 2007;52(1):6–10.

27. Ongkana N, Sudwan P. *Gender Difference in Thai Mandibles Using Metric Analysis*. Chiang Mai Med J. 2009;48(2):43–8.

28. Singh R, Mishra SR, S, Passey J, Kumar P, Singh S, et al. *Sexual Dimorphism in Adult Human Mandible of North Indian Origin*. Forensic Med Anat Res. 2015;03(03):82–8.

29. Rosas A, Bastir M. *Geometric morphometric analysis of allometric variation in the mandibular morphology of the hominids of Atapuerca, Sima de los Huesos site*. Anat Rec - Part A Discov Mol Cell Evol Biol. 2004;278(2):551–60.

30. Thakur KC, Choudhary AK, Jain SK, Kumar L. *Racial Architecture of Human Mandible-an Anthropological Study*. J Evol Med Dent Sci. 2013;2(23):4177–88.

31. Lopez TT, Michel-Crosato E, Benedicto E de N, Paiva LAS de, Silva DCB, Biazevic MGH. *Accuracy of mandibular measurements of sexual dimorphism using stabilizer equipment*. Braz Oral Res. 2017 Jan;31:e1.

32. Rai R, Ranade AV, Prabhu LV, Pai MM, Madhyastha S KM. *A pilot study of the mandibular angle and ramus in Indian population*. Int J Morphol. 2007;25(2):353–6.

33. Keen JA. *A study of the angle of the mandible*. J Dent Res. 2015;2(24):77–86.