Original Article

Mandibular Morphometrics: An Age and Gender Determinant in a Sri Lankan Sample – A Digital Panoramic Tomography Study

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Abstract

Objectives: The present study was carried out on dental panoramic images in a group of Sri Lankans to ascertain the mandibular morphometrics, especially in relation to the ramus of the mandible.

Methods: A total of 196 dental panoramic images (106 males and 86 females) between the ages of 5 and 87 years were retrieved from the archives in the Division of Oral Medicine and Radiology, Faculty of Dental Sciences, University of Peradeniya, Sri Lanka.

Results: Average values for condylar ramus height, coronoid ramus height, upper ramus width, and lower ramus width were higher in males, while average values of gonial angle (GA) and area were higher in females. A significant difference between the right and left sides for upper ramus height, lower ramus height, GA, and the area was not observed ($P > 0.05$). There were no significant differences between genders for average values for condylar ramus height, coronoid ramus height, upper and lower ramus widths, GA, and area ($P > 0.05$). However, the significant difference for average condylar ramus height and coronoid ramus height between 17 years or below and above 17 years could be considered a strong predictor for age in the Sri Lankan population.

Conclusions: Mandibular ramus measurements using dental panoramic tomography cannot be considered a valuable tool in sex determination in the Sri Lankan population. Condylar and coronoid ramus heights could be considered predictors for assessment of age. Further studies on wider population to assess the significance of these parameters are recommended.

Key Words: *Age determination, mandibular, morphometric, panoramic radiograph, sex determination*

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Introduction

Age and gender confirmation plays a crucial role in the setting of a crime investigation and mass disasters where the victims' bodies become unrecognizable as a result of mutilation. In addition, it is important in some other medicolegal issues as well. The person's gender and age at death represents a key feature leading to identification, and quite often, these identifications are based on biometric features. The reconstruction of the biological profile of the victim would be incomplete without the age and sex determination, therefore, forensic anthropologists consider bone as an asset in such disasters because skeletons have been used to develop standards for determining sex, age, and ancestry in unknown remains for many years.[1,2]

Mandible is unique, one of the strongest bones in the facial skeleton, and is frequently useful in forensic sciences because of its close connection with the teeth.[3,4] By large, the mandible serves as a good source of deoxyribonucleic acid for the analysis in order to identify human remains.[3,4] The other applications of the mandible as a successful quantitative source are the presence of teeth, as teeth are very much resistant and are able to withstand many external factors.[3] However, yet if the teeth are missing, then the morphological variation of the mandible is a good indicator of age and sex.[4,5] Even though odontologic methods are frequently utilized in age estimation process, there are some variations that need to be considered when applying dental age estimation methods as females tend to be more advanced in their dental development compared to males during most of the growth and development period.[6] Further, sex and ancestry are often not known for juvenile skeletal remains; these issues can pose some limitations. Especially, certain well-established methods are only based on the mandibular dentition and are therefore not applicable to maxillary teeth.[7,8] Therefore, when sex is unknown, a

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combination of dental age estimation together with mandibular morphometrics could be helpful. For this purpose, various anatomical landmarks associated with the mandible have been used in the literature for the estimation of the age and sex with controversial results.[9-11] The morphometrics of the mandibular ramus can differ between gender depending on the stages of mandibular development, growth rates, and duration as there are distinct differences of these parameters between both sexes.[12]

Radiographs are the most frequently performed investigation by dental surgeons. The panoramic radiographs have been used as a base for identification in forensic odontology due to its wide availability, and the specific advantage of the presence of wide range of characteristic features on a single image.[13] Therefore, in addition to the clinical implications of diagnosis and treatment planning this radiograph provides valuable information in legal platforms, which includes dental age estimation and morphometric analysis.[13]

Furthermore, morphometric skeletal characteristics differ in each population emphasizing the need for population-specific osteometric standards for age and sex estimation.[14,15] Only two published studies were conducted in the Sri Lankan population using the mandibular morphometrics for gender determination.[16,17] Further, these studies have looked upon only the gender determination making the present study the first in a Sri Lankan population to determine both age and gender using dental panoramic tomographies (DPTs). Therefore, this study was designed with the intention to ascertain the mandibular morphometrics, especially in relation to ramus of the mandible, and to further analyze any significant correlation between each vertical and horizontal dimension and age and gender in a group of Sri Lankans using dental panoramic images.

Methods

A total of 196 de-identified dental panoramic images (106 males and 86 females) between the age ranges of 5 and 87 years were retrieved from the archives in the Division of Oral Medicine and Radiology, for the assessment. These images assessed for the present study were randomly selected out of the images obtained previously for various diagnostic purposes. The images were acquired Vatech cone-beam computed tomography scanner (Vatech Corporation, South Korea) under standard settings with minimal radiation exposure (following ALARA principle). The selected images fulfilled the following inclusion criteria: either partially or completely dentate, good quality standard panoramic images without any grade of exposure or positioning errors, devoid of any pathological lesions, fracture, or deformity. Each panoramic image measurement was performed bilaterally resulting in a total of 392 rami being assessed.

The angular and linear measurements were obtained using the EzDent software measurement tools with precision values of 0.1° and 0.01 mm, respectively. The area measurements were obtained by saving the digital panoramic images in JPEG file format and then by exporting them to ImageJ an open-source software for processing and analyzing scientific images with calibration (in order to obtain 1:1 magnification). Ethical clearance was obtained from the Faculty Ethics Review Committee (ERC/FDS/UOP/1/2017/06). Informed written consent was obtained from all the participants for using the data for study purposes prior to image acquisition. Data collection was done by a single investigator who was blinded to the date of birth and gender of each case.

A horizontal orientation line was digitally traced passing through the summit of the gonial angle (GA) and used for obtaining the following linear, angle, and area measurements from the images[12] [Figure 1].

Vertical measurements

1. Line No. 1 – Condylar ramus height: A vertical line was drawn from the most superior point of the condyle to the intersection of the orientation line with the inferior border of the ramus (this line was drawn as much as parallel to the posterior border of the ramus).
2. Line No. 2 – Coronoid ramus height: A vertical line was drawn from the most superior point of the coronoid to the intersection of the orientation line with the inferior border of the ramus.

Horizontal measurements

3. Line No. 3 – Upper ramus width: The horizontal distance between the most anterior point and the most posterior point of the ramus passing through the sigmoid notch along a line parallel to the transverse plane.
4. Line No. 4 – Lower ramus width: The horizontal distance between the most anterior point and the most posterior point of the ramus at the level of the occlusal plane along a line parallel to the previous one.
5. Area of the ramus – An extension of the anterior border of the ramus was made until it met the lower border of the mandible (Line No. 5). The bony area posterior to this line was considered for the area measurement, and the outline of the mandible was marked manually using multiple data points in the ImageJ software [Figure 2a and b].
6. *Gonial angles (GA)*: Measured as an angle between a digitally traced line tangential to the most inferior points at the angle and the lower border of the mandibular body

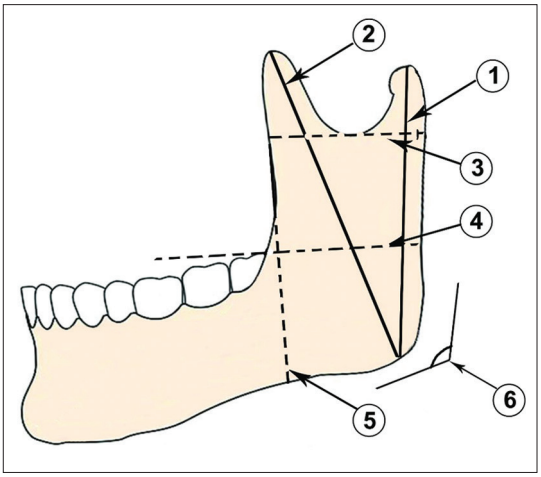

Figure 1: Line diagram depicting the linear and angular measurements obtained

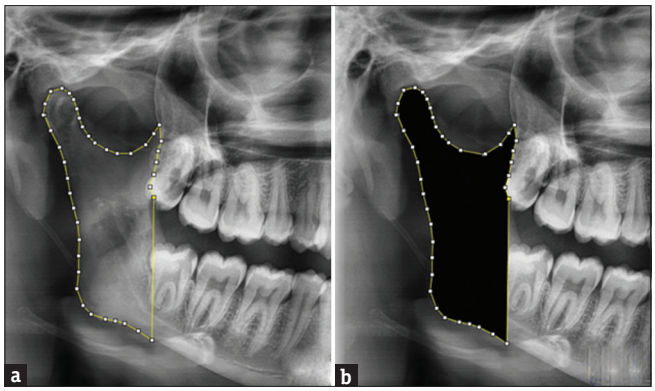

Figure 2: Cropped dental panoramic tomography images (a) Indicating the multiple data points selected to outline the area of the mandible posterior to Line No. 5; (b) Highlighting of the selected areas using the ImageJ software

and another line tangential to the posterior borders of the ramus and the condyle [Figure 3].

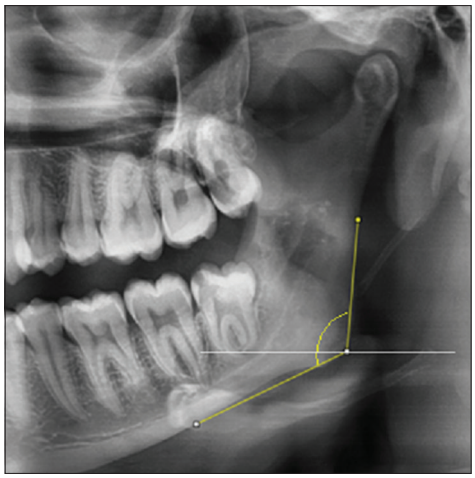

Figure 3: Measurement of the gonial angle on a cropped dental panoramic tomography image, note the horizontal orientation line (white) that was drawn through the summit of the gonial angle

Results

DPTs belonging to 196 patients (392 rami in 106 males and 86 females) within the age range of 5–87 years (mean age was 26.86 years for males; 27.3 years for females and 27.06 ± 18.5 years for the total sample) were assessed. The descriptive statistics of the male and female subjects are presented in Table 1. Average values for condylar ramus height, coronoid ramus height, upper ramus width, and lower ramus width were higher in males compared to females, while average values of GA and area were higher in females compared to males.

As the data were in a normal distribution, parametric tests were used to compare between different measurements. Paired sample *t*-test was used to compare measurements between right and left sides, and independent sample *t*-test was used to compare the differences between age groups (17 years or below and above 17 years) and gender.

A statistical difference was observed between means of right and left sides for condylar ramus height and coronoid ramus height ($P < 0.05$). However, a significant difference between the right and left sides for upper ramus height, lower ramus height, GA, and the area was not observed ($P > 0.05$) [Table 2].

An average score was calculated for right- and left-side measurements for each individual. Means of the average values were calculated for age groups and gender groups. There were no significant differences in gender between average values for condylar ramus height, coronoid ramus height, upper and lower ramus widths, GA, and area. ($P > 0.05$) [Table 3].

However, a significant difference for average condylar ramus height and coronoid ramus height between the two age groups were noted in this study and this fact could be considered as a strong predictor for age in Sri Lankan population (17 or below, above 17) [Table 4] ($P<0.05$).

Discussion

Skeletal remnants play a vital role in identification of sex in forensic odontology in many cases.[18] The mandible has been identified as the most long-lasting component of the facial skeleton and maintains its shape more than other bones. Further, measurements in mandibular ramus can help in differentiating sexes and growth levels of human beings.[19] Therefore, it is important to study differences in mandibular measurements in the Sri Lankan population as regional variations do exist. It further provides opportunities in comparing and studying values among various regional and ethnic groups.

It is worth mentioning that the GA varies in different population and regional groups where the average value is 110° for Chinese, 119° for Indians, and 128° for Europeans.[10] In our study, the average GA for females (132.83°) was higher than the value for males 124.07° while the overall value 129.91° which is comparatively a higher value reported. This was in par with a previous study in Sri Lanka which reported a higher mean GA measurement in females compared to males at a value of 134.37° on lateral cephalometric radiographs.[16] Further, it was interesting to note that the Sri Lankan values are lying in a closer range to the Europeans rather than the Indians, which highlights the necessity of population studies to obtain population-specific norms. Further, this could be considered a good predictor for comparison of Sri Lankan mandibular measurements with population from other regions.

Mandibular ramus and condyle are generally the most sexually dimorphic as they are the components associated with the greatest morphometric changes in size and remodeling during growth.[20] Therefore, we also have selected those measurements to assess differences for sex and age estimation. Panoramic radiographs provide a wider coverage with less radiation exposure, commonly accessible and is used in routine clinical practice to assess bilateral mandibular structures.[21] Therefore, it was considered in our study too as an accurate and commonly available technique.

Table 1: Descriptive statistics of all measurements for males and females

	Males				Females			
	Minimum	Maximum	Mean	Median	Minimum	Maximum	Mean	Median
Age	5	87	26.86	18	7	81	27.3	24
CyRH (mm)								
Right	39.445	73.07	51.55	50.92	36.41	60.45	50.08	50.29
Left	35.99	66.2	49.53	49.15	34.32	57.69	48.10	48.33
Average	38.16	68.33	50.54	50.51	35.37	58.75	49.09	48.93
CRH (mm)								
Right	35.47	66.5	48.67	48.25	31.28	60.07	47.68	48.56
Left	34.52	62.34	47.77	46.75	34.87	56.79	45.85	46.47
Average	18.69	64.42	48.21	47.87	34.38	57.40	46.76	47.8
URW (mm)								
Right	20.16	408.04	31.68	28.58	22.25	34.28	28.32	28.21
Left	21.08	45.85	27.72	27.38	19.24	32.4	26.89	26.79
Average	21.65	218.68	29.70	28.14	20.74	32.38	27.60	27.59
LRW (mm)								
Right	18.78	351.63	28.51	25.69	17.84	33.19	25.26	25.3
Left	2.18	45.85	24.75	24.727	18.67	30.19	24.16	23.71
Average	13.61	188.64	26.63	25.14	18.34	31.08	24.71	24.77
GA (°)								
Right	113.29	141.47	122.22	125.77	109.25	1363.79	140.09	126.19
Left	103.72	178.98	125.92	124.95	13.46	143.531	125.56	126.60
Average	2.68	152.46	124.07	125.84	73.76	748.58	132.83	125.69
Area (mm^2)								
Right	1.988	14,446.39	1381.61	1238.94	134.45	97,196	2565.74	1222.5
Left	701.51	1685	1205.38	1186.46	631	24,234.13	1394.69	1151.78
Average	497.19	7910.66	1293.49	1198.28	617	49,058.51	1980.22	1207.07

CyRH: Condylar ramus height, CRH: Coronoid ramus height, URW: Upper ramus width, LRW: Lower ramus width, GA: Gonial angle

Table 2: Comparison between right and left sides of measurements

	CyRH (mm)		CRH (mm)		URW (mm)		LRW (mm)		GA (°)		AR (mm^2)	
	R/S	L/S	R/S	L/S	R/S	L/S	R/S	L/S	R/S	L/S	R/S	L/S
Mean	51.23	48.93	48.23	46.93	30.20	27.35	27.08	24.49	130.06	125.76	1901.18	1288.45
SD	6.63	5.65	7.64	6.06	27.29	3.35	23.47	3.65	90.53	11.89	6996.73	1666.26
P	0.000		0.000		0.168		0.27		0.218		0.896	

CyRH: Condylar ramus height, CRH: Coronoid ramus height, URW: Upper ramus width, LRW: Lower ramus width, GA: Gonial angle, SD: Standard deviation

Although our study indicated no significant differences between sexes in mandibular measurements, the study reported a significant difference among the minimum ramus breadth, condylar height, and coronoid height among males and females ($P < 0.05$).[16] In addition, another study in Egypt had identified significant differences between sexes in all measurements carried out.[12] Further, another study on measurements in mandibular ramus using orthopantomograph had shown strong evidence to suggest the possibility of using mandibular ramus for sex determination in forensic analysis.[20] However, a large sample in Sri Lanka could act as a determinant of sex by using measurements of mandible.

Our observation on higher average condylar ramus height, coronoid ramus height, upper ramus width, and lower ramus width among males was equal to the previous two studies conducted in Sri Lanka.[16,17] Further, it was also observed that the previous reported mean values for both genders were higher than the present study, and one of the main reasons for these observations may be inclusion of an elderly population; a study has reported that their study included radiographs of patients between the age groups of 20–60 years, while the other study has not reported the age group of the subjects included.[16] This present study included an age range of 5–87 years, and we observed a statistically significant positive (direct) correlation between age and ramus linear measurements (average condylar and coronoid ramus height) which behaved same as previous studies where an increase in age is associated with an increase in these measurements.[12] In addition, the other contributory factors may be variation of the data measurement points and insufficient description of the methodology as to how these measurements were obtained in both studies. However, interestingly, the average GA and average area of ramus were higher in females, and this similar to the results on GA measurements reported

Table 3: Comparison between gender groups

	Gender	Mean	SD	*P*
Average CyRH	Female	49.09	5.01	0.098
	Male	50.54	7.22	
Average CRH	Female	46.76	5.34	0.110
	Male	48.22	7.35	
Average URW	Female	27.60	2.48	0.295
	Male	29.70	18.42	
Average LRW	Female	24.71	2.47	0.269
	Male	26.63	15.87	
Average GA	Female	132.83	67.71	0.188
	Male	124.07	14.27	
Average area	Female	1980.22	5352.28	0.240
	Male	1293.49	700.15	

SD: Standard deviation, CyRH: Condylar ramus height, CRH: Coronoid ramus height, URW: Upper ramus width, LRW: Lower ramus width, GA: Gonial angle

Table 4: Comparison between age groups

	Age category	Mean	SD	*P*
Average CyRH	17 or below	45.45	4.99	0.000
	Above 17	53.39	5.02	
Average CRH	17 or below	43.06	5.41	0.000
	Above 17	51.11	5.06	
Average URW	17 or below	28.63	20.92	0.895
	Above 17	28.89	2.19	
Average LRW	17 or below	25.94	17.99	0.878
	Above 17	25.67	2.40	
Average GA	17 or below	125.36	14.69	0.495
	Above 17	129.91	60.29	
Average Area	17 or below	1728.99	5234.53	0.645
	Above 17	1489.92	1282.88	

SD: Standard deviation, CyRH: Condylar ramus height, CRH: Coronoid ramus height, URW: Upper ramus width, LRW: Lower ramus width, GA: Gonial angle

previously.[17] Even though our study did not demonstrate a significant difference between genders some other studies report controversial findings.[16] Nevertheless, the findings with regard to the relationship between age and GA are consistent with the literature where no significant differences between the two age groups were observed.[12]

Conclusions

Although it has resistance to damage and disintegration, mandibular ramus measurements according to the present study using DPT cannot be considered a valuable tool in sex determination in the Sri Lankan population. However, condylar and coronoid ramus heights could be considered predictors for assessment of age. However, further studies on wider population to assess the significance of these parameters are recommended.

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Conflicts of interest

There are no conflicts of interest.

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