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Measurement of Length of Mandibular Ramus Using Computed Tomography

Sandesh Gharti Magar[1]*; Swastik Sagar Poudel[1]; Aman Kasula[1]; Arpan Nepal[1]; Bijaya Bhattarai[2]

[1]Department of Radiology and Imaging, Institute of Medicine, TUTH, Kathmandu, Nepal.

[2]Department of Internal Medicine, Kathmandu Model Hospital, Kathmandu, Nepal.

***Corresponding Author(s): Sandesh Gharti Magar**
Department of Radiology and Imaging, Institute of Medicine, TUTH, Kathmandu, Nepal.
Email: sandeshmagar010@gmail.com

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Keywords: Mandible; Ramus; Computed tomography; Gender dimorphism.

Abstract

Background: The determination of age and sex is crucial for establishing a human identity. The mandible is an accessible and durable bone that would be very useful in this respect. It exhibits a high degree of sexual dimorphism.

Aim: To find the length of the ramus of mandible and its correlation with age and sex.

Subjects and methods: The lengths of the ramus of the mandible of 110 individuals (52 males and 58 females) who underwent CT examinations of face, neck or CT angiography of head and neck were measured in MPR sagittal sections using multi detector computerized tomography (MDCT).

Results: The mean length of mandibular ramus in male was 6.13 cm on right side, 6.14cm on left side; and in female it was 5.55 cm on right side and 5.61 cm on left side. Therefore, there was a significant difference between males and females for the mean length of the mandible ramus. The Pearson Correlation for Maximum Length of Right Side (MLRS) with age was only +0.258, and for Maximum Length of Left Side (MLLS) with age was just +0.296, hence, there was a very weak positive correlation between the age and length of mandibular ramus.

Conclusion: The length of ramus of mandible in males were greater than that of females so, this study supports the gender dimorphism. However, it is less efficient in determining age.

Introduction

For a long time, forensic identification based on bone testing has proved useful and reliable. It is simpler, more accessible, and less expensive than more complicated tissue identification procedures. Furthermore, bone fragments are increasingly being discovered to be effective in determining an individual's age and sex [1].

The mandible is the hardest and strongest bone of the skull, and it exhibits a high degree of sexual dimorphism [2,3]. The mandible helps to identify the sex in living as well as in dead individuals and human remains. In cadavers with an advanced degree of decomposition, burns or disfigurement, identification from tissue typing and DNA profiling becomes very difficult, and bone becomes a more reliable tool for identification in these cases [6].

In criminal investigations and civil proceedings, such as immigration, alleged violations of marriage age rules, and cases of immigrant foreigners without valid identification documents, age identification is required. Age estimation is also required in other civil matters, such as asylum or old-age pension ap-

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plications, and in the case of unaccompanied youngsters, for adoption purposes. Additionally, it is needed in investigations of mass disasters and war atrocities [7].

The skull and hip bones are the most useful in determining sex because they are heavily influenced by sex hormones during union and the shape of the bones during adolescence. The developmental and functional characteristics of the mandible, according to Franklin and Cardini [8], make it an appropriate indicator of an individual's age and sex.

During human growth, the mandible undergoes morphological changes related to size and remodelling. The mandible morphology, particularly that of the ramus, has been demonstrated to have a substantial association with chronological age [9]. Ancestry and genetic characteristics are also thought to influence bone age validation for chronological age determination.

To examine bone and soft tissues, Multi Detector Computerized Tomography (MDCT) along with Reconstruction techniques are very useful. The goal of this study was to see if the mandibular ramus length could be used to estimate age and gender using MDCT imaging in a group of Nepalese people.

Materials & Methods

Data collection

This was a quantitative, cross-sectional study conducted in the Department of Radiology and Imaging, Tribhuvan University and Teaching Hospital (TUTH) for the period of three months. Purposive sampling technique was used in sampling of the subjects. All the subjects who visited for CT scan of Face, Neck, CT angiography of head and neck without pathological findings related to mandible were included in the study. Measurement was performed on sagittal MPR.

Data collection tool: CT scan was performed on 128 slice MDCT scanner (Siemen's Somatom Definition AS^{+}, TUTH Biomedical equipment no: 1001915) and data collection and measurement were done in Syngo Via workstation with screen resolution of three megapixels.

Duration of study: January 2022 to April 2022.

Inclusion criteria: Completely dentate patients and patients undergoing CT examination of face, neck or CT angiography of head and neck were included in this study.

Exclusion criteria: Patients with Pathological fractures, Developmental disturbances of the mandible, Congenital deformities and Images with artefact were excluded.

Method of measurement: Patients' consents were obtained and careful history taking and medical examination were performed.

In this study, the length of ramus of mandible was measured in MPR (Multi Planner Reconstruction) sagittal sections of face. Computer assisted measurement of length of ramus of mandible was performed from Condylon superior (Cs), the highest point of the condyle of the mandible, to the Gonion (Go), the outermost point at the junction between the body and the ramus of the mandible.

For every image and every side, three points (Co, Go, and In) were defined, and a linear measurement was performed parallel to the tangent at the posterior border of the ramus. Ramus height (MLRS and MLLS): was measured parallel to the tangent at the posterior border of the ramus between the most cranial point of the condyle (Co) and the intersection point with the lower border of the ramus mandibulae [the gonial point (Go)]. The intersection with the lower border of the ramus mandibulae was obtained using a line parallel to the tangent at the posterior border of the ramus that ran through the most cranial point of the condyle (Co).

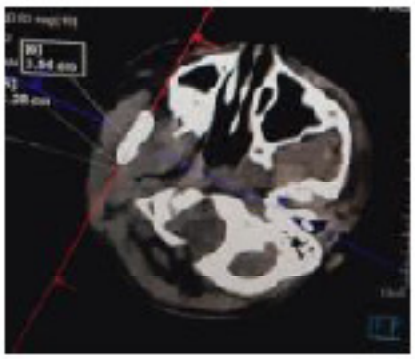

Figure 1: Planning sagittal section in axial plane.

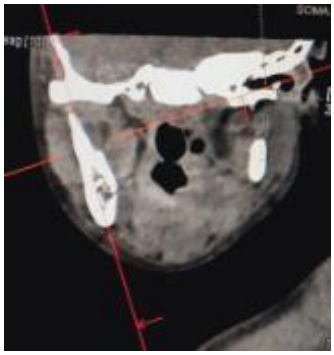

Figure 2: Planning sagittal section in coronal plane.

Figure 3: VRT image showing lateral view of left mandible.

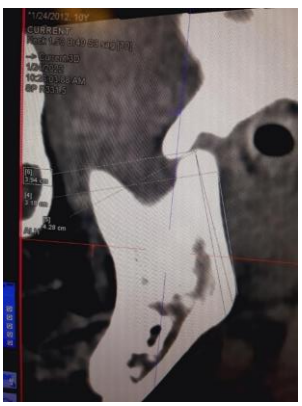

Figure 4: Measurement of Length of ramus of mandible.

Statistical analysis

Statistical analysis was carried out with the help of SPSS version 26 (IBM, Version: 1.0.0.1406, Window OS, Free trial license) and Microsoft Excel version 2013 (64-bit OS). Both descriptive such as mean; standard deviation and inferential statistical analysis was applied to analyse the data. Mean and standard deviation (SD) were calculated to describe the data. P-value and independent t- test were used to evaluate the association between the parameters and genders. Pearson correlation coefficients were used to test the correlation between the parameters and ages.

Result

A total of 110 samples were taken out of which 52 (47.27%) were male and 58 (52.73%) were female.

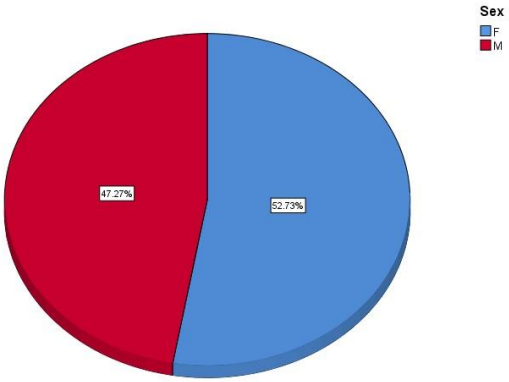

Figure 5: Pie chart showing distribution of sample size according to gender

Table 1: Distribution of sample size according to gender.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	52	47.3	47.3	47.3
	Female	58	52.7	52.7	100.0
	Total	110	100.0	100.0	

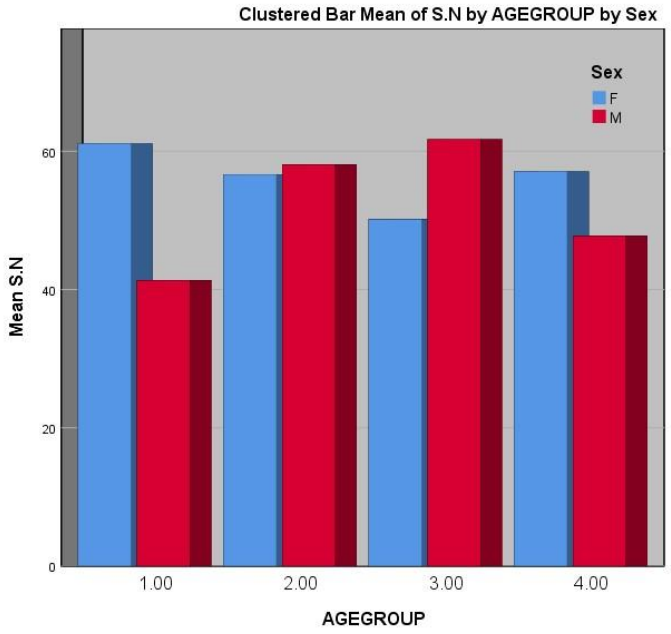

Figure 6: Clustered Bar Mean of S.N by age group by sex.

Table 2: Showing age grouping.

Age Group	Age Intervals
1	10-29
2	30-49
3	50-69
4	70-89

Table 3: Mean, SD, Median and range of male sample.

Male		
	MLRS	MLLS
Mean	6.1258	6.1381
Standard Deviation	0.45750	0.43345
Median	6.1400	6.1400
Minimum	4.90	4.91
Maximum	7.34	7.06

Table 4: Mean, SD, Median and range of female sample.

Female		
	MLRS	MLLS
Mean	5.5490	5.6047
Standard Deviation	0.52513	0.56120
Median	5.5850	5.6050
Minimum	4.20	4.22
Maximum	6.66	6.86

Among the participants, the male participants were more from the age group of 50-69 years whereas, the female participants were more from the age group of 10-29 years.

The mean length of mandibular ramus in male was 6.1258 cm in right side 6.1381cm in left side and in female was 5.5490 cm in right side and 5.6047 cm in left side. The maximum value for length of mandibular ramus in male was 7.34 cm in right side and 7.06 cm in left side and in female was 6.66 cm in right side and 6.86 cm in left side. The minimum value for length of mandibular ramus in male was 4.90 cm in right side and 4.91 cm in left side and in female was 4.20 cm in right side and 4.22 cm in left side.

The SD for male was 0.45750 cm on right side and 0.43345 cm on left side whereas for that of female was 0.52513 cm on right side and 0.56120 cm on left side respectively.

Table 5: Mean length of ramus of mandible in different age group.

	Mead ± SD	
Age group	MLRS	MLLS
10-29	5.3064 ± 0.5942	5.02979 ± 0.6042
30-49	5.8885 ± 0.627	5.9246 ± 0.6578
50-69	5.89 ± 0.44	5.9123 ± 0.4489
70-89	5.9123 ± 0.5618	5.9826 ± 0.4835

The mean length of the ramus of mandible was found to be the longest in the age range of 70-89 years i.e., 5.9123 ± 0.5618 cm for MLRS and 5.9826 ± 0.4835 cm for MLLS whereas, it was found to be shortest in the age range of 10-29 years i.e., 5.3064 ± 0.5942 cm for MLRS and 5.02979 ± 0.6042 cm for MLLS. Similarly, the mean length of ramus of mandible was 5.8885 ± 0.627 cm for MLRS and 5.9246 ± 0.6578 cm for MLLS in the age group of 30-49 years and 5.89 ± 0.44 cm for MLRS and 5.9123 ± 0.4489 cm for MLLS in the age group of 50-69 years.

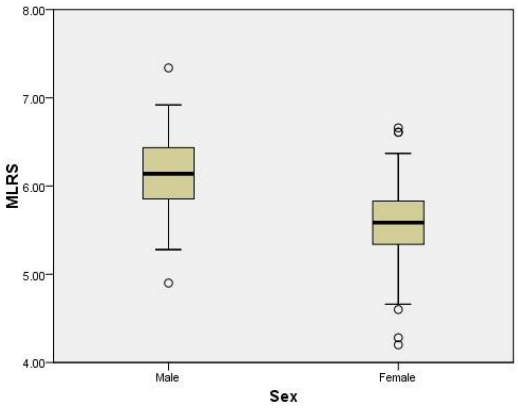

Figure 7: Box-plot of MLRS.

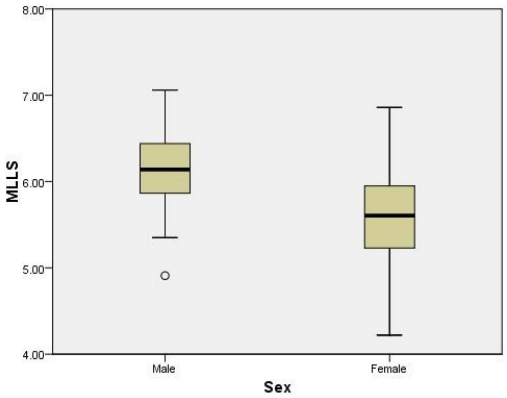

Figure 8: Box-Plot of MLLS.

These Box-plots of ramus length shows highly significant difference between males and females. There is one outlier below the minimum value and one outlier above the maximum value in case of MLRS of male (Figure 5). In case of MLRS of female there are three outliers below the minimum value and two outliers above the maximum value. Similarly, there is one outlier below the minimum value in case of MLLS of male while there is no any outlier in case of MLLS of female (Figure 6).

T test

Table 6: Independent Samples Test.

		t-test for Equality of Means						
		t	df	Sig. (2tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
MLRS	Equal assumed variances	6.110	108	.000	.57680	.09441	.38967	.76394
	Equal variances not assumed	6.156	107.918	.000	.57680	.09370	.39107	.76253
MLLS	Equal assumed variances	5.532	108	.000	.53342	.09643	.34228	.72456
	Equal variances not assumed	5.609	105.758	.000	.53342	.09510	.34488	.72196

The test of Normality was done using Shapiro-Wilk test, and the null hypothesis was accepted as the p value was greater than 0.05. The p value for MLRS and MLLS were 0.350 and 0.352 respectively. Hence, the data was normally distributed and the outcomes of MLRS and MLLS were numeric therefore, the parametric test, i.e., independent sample t-test was applied.

In the independent sample t-test, since p<0.05 (p = 0.000), the null hypothesis Ho is rejected and H1 is accepted. Hence, in case of both MLRS and MLLS, the length of mandibular ramus is not equal in males and females. The mean difference between male and female in terms of MLRS is 0.57680 cm and in terms of MLLS is 0.53342 cm.

Correlation with age

Table 7: Correlation of age with MLRS.

Correlations			
		Age	MLRS
Age	Pearson Correlation	1	.258**
	Sig. (2-tailed)		.006
	N	110	110
**. Correlation is significant at the 0.01 level (2-tailed).			

Table 7: Correlation of age with MLRS.

Correlations			
		Age	MiLLS
Age	Pearson Correlation	1	.296**
	Sig. (2-tailed)		.002
	N	110	110
**. Correlation is significant at the 0.01 level (2-tailed).			

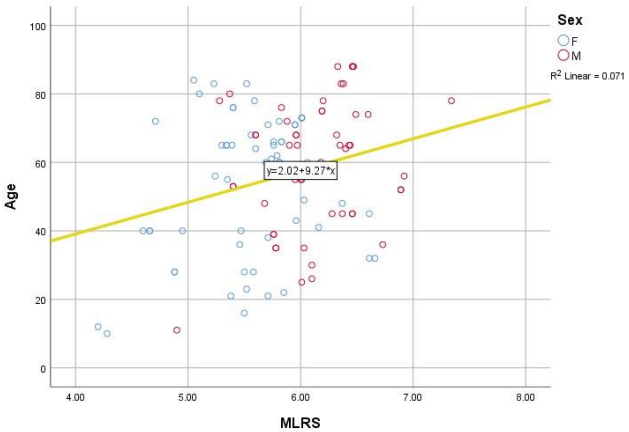

Figure 9: Box-plot of MLRS.

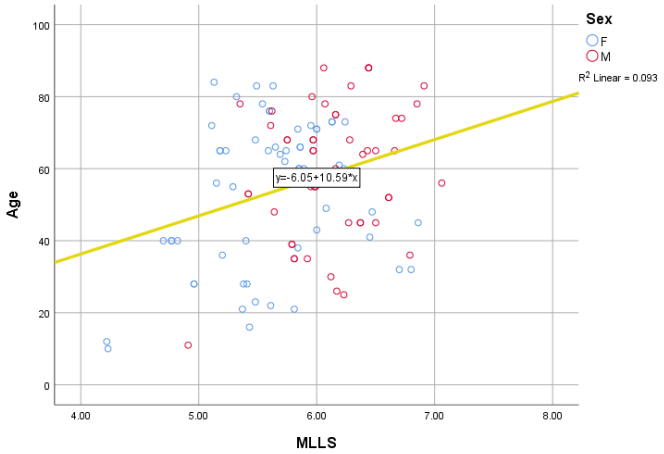

Figure 10: Scatter diagram of correlation between age and MLLS.

Since, the data was normally distributed, the parametric correlation test, i.e., the Pearson's

Correlation test was done.

The value of Karl Pearson's Correlation was only +0.258 for MLRS and +0.296 for MLLS,

therefore, there was a very weak correlation between the age and length of mandibular ramus.

From the scatter diagrams, it was seen that there was no perfect correlation between the length of ramus of the mandible and age however, there was some very weak positive correlation between them.

Discussion

Skeletal identification has a long history in forensic anthropology. New methods are continuously introduced and routinely used methods are constantly evolving.

The observation of the union of the epiphyses and the length of the diaphyses of long bones is the most frequently used method for identifying age, and an examination of the skull and hip bones is the most commonly used method for identifying sex. In this study, we used the mandible to identify both the age and the sex of individuals. We used three-dimensional craniofacial CT scans because this imaging modality is non-invasive and can be used for living and dead individuals and in both civil and criminal cases.

CT proved efficient, simple, rapid, reliable and safe as an imaging technique. CT has been

demonstrated to be more accurate and more informative than routine X-ray.

The results of this project work showed that men had longer ramus lengths of the mandible than women. There was found a significant difference for the mean length of the ramus of the mandible between men and women in the studied sample. However, there is a very weak positive correlation in between the age and the length of ramus of the mandible.

In this study, the mean (±SD) distance between the bottom of mandible and the highest point of the condylon process of mandible was 6.1258±0.4575 cm and 6.1381±0.43345 cm on right and left side respectively in males and 5.5490±0.52513 cm and 5.6047±0.56120 cm on right and left side respectively in females. The utmost height of mandibular ramus in male was 7.34 cm and 7.06 cm on right and left side respectively and in female was 6.66 cm and 6.86 cm on right and left side respectively. Independent sample t test was carried out for the two sets of Mean value. P value was (<0.05) and the result was significant.

Hoque Md.et .al found out that the mean (±SD) distance between the base of the mandible and the highest point of the head of the mandible was 64.22±5.77 mm and 64.05±5.92 mm on right and left side respectively (10).

In this study, the lengths of ramus of mandible were found to be similar to the findings of our

study. The height of the ramus is found to be more in males when compared to females with the difference being statistically significant, which is the same outcome we got in our study.

Taleb N S A et al (11), and associates in 2015 carried out a study among Egyptians, where 191 Panoramic images were studied. They also found the mean mandibular ramus height to be 8.43 cm in males and 7.29 cm in females. The mean length of mandible in male was found to be 8.42 cm in right side and 8.44 cm in left side while that in female was 7.3cm in right side and 7.28 cm in left side respectively. The standard deviation was found to be 0.82 in male and 0.67 in female. In this study, the measurements of length of ramus of mandible were found to be greater in compared to the measurements of our study. This may be the result of the geographical variations.

Carried [12] out a study in 2015 on sex determination from human mandible using various morphometric parameters and their study had conclusions similar to our study. Their study was carried out on 50 random adult dry intact mandibles from Southern India ramus height was measured using a mandibulometer and digital calipers. They found the mean height of ramus to be 6.798 cm in males and 5.510 cm in females with standard deviation 0.440 in male 0.533 in female.

Both their study as well as ours shows similar length of mandibular ramus in right and left side. and statistically significant difference in linear measurements of mandible between males and females. Like our study, this study too found the height of the ramus to be more in males when compared to females with the difference being statistically significant. The gender differences in mean values of Height of Ramus of male and female are statistically highly significant (p=0.00) for mandible.

Conclusion

In this study, 58 females & 52 males were studied in Nepalese population. The multiplanar reconstruction of the CT image was very useful for evaluation of length of ramus of the mandible.

The length of ramus of mandible in males were greater than that of females hence, this study

supports the gender dimorphism. The gender differences in mean values of Height of Ramus of male and female were statistically significant (p=0.00) for mandible. The study found that ramus measurements using Computed Tomography were reliable indicators in the prediction of sex.

However, the length of mandibular ramus is less helpful in determining the age. Since, there were only 3 participants who were below 20 years of age in our study, the accurate correlation between the age below 20 years and length of ramus of mandible could not be calculated. For this reason, there must

be further study in the participants of below 20 years of age.

Declaration by Authors

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Conflict of Interest: The authors declare no conflict of interest.

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