



Evaluation of Various Morphology and Location of Lingula and Prevalence of Accessory Mandibular Foramina Using Cone Beam Computed Tomography: A Retrospective Study

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Abstract

Background: The Mandibular Lingula (ML) is a tongue-shaped bony prominence that overlies the Mandibular Foramen (MF). Due to its association with important structures, it is used as an important anatomical landmark. The Accessory Mandibular Foramen (AMF) is an anatomical variation occasionally found on the ramus. The purpose of current study was to evaluate and standardize the various morphologies and precise locations of the lingula and the prevalence of accessory mandibular foramina using Cone-Beam Computed Tomography (CBCT). To observe the age and sex differences in ML.

Methods: This was a retrospective institution-based study conducted using 400 samples of CBCT images acquired from the dental archives of the Radiology Department. All the data samples were assessed using RadiAnt DICOM viewer software. The data were subjected to statistical analysis using the chi-square test, and an independent sample t-test was used to assess the height and position of ML between males and females. A One-way ANOVA were used to compare the age-wise difference in height and position of the ML.

Results: The most commonly observed morphology of mandibular lingula in the study was nodular (41.8%). Based on sex, nodular shape was most common in males (55.1%), and triangular shape was more common in females (47.3%). The overall incidence of AMF is 1.5% in this study.

Conclusion: Hence, these imaging findings will be helpful to oro-dental surgeons to avoid complications and anthropologists in forensic aspects.

Keywords: Accessory mandibular foramina, Cone beam computed tomography, Forensic, Mandibular lingula

Introduction

Anatomical landmarks are the features that are seen on humans' bodies that are useful for descriptive and identification purposes (1). Also, these anatomical landmarks play a significant role in forensic anthropology. Forensic anthropology is a branch of physical anthropology for forensic purposes that deals with the identification of more or less skeletonized remains for the identification process that provides an opinion on the age, sex, ethnic group, stature, and other characteristics of the identified individual (2). The mandibular lingula is a tongue-shaped bony prominence that overlies the Mandibular Foramen (MF). Because of this association with important structures, it is used as an important anatomical landmark (3).

It is also an important landmark for various clinical procedures, such as oral and maxillofacial surgical procedures such as Sagittal Split Ramus Osteotomy (SSRO), mandibular trauma management, eradication of benign and malignant lesions, pre-prosthetic surgery, and avoiding nerve injury during inferior mandibular nerve block (4-6).

The most important anesthetic technique in dentistry is inferior alveolar nerve block (7). In the literature, a nearly 15% to 20% failure rate is reported (8). One of the reasons for failure is the position and incidence of accessory foramina in the mandible, which is important for dental surgeons and anesthetists in achieving complete nerve blocks and avoiding injury to neurovascular structures passing through them (6). In this study, various morphologies and positions of the mandibular lingula and the presence of AMF are evaluated using Cone-Beam Computed Tomography (CBCT). Previously, these studies were done using dry mandibles (9). Now, with advances in imaging, CBCT has been shown to overcome many disadvantages and can be performed on individuals. This CBCT image is more reliable and accurate for the evaluation of anatomical structures, and its advantages over other imaging modalities are that it provides better image resolution, a shorter acquisition time, a reduced radiation dose, and lower costs.

Another advantage of current study is that location and various related parameters of the lingula are evaluated in sagittal and coronal sections, whereas in most of the studies, they were assessed in

three-dimensionally reconstructed images of CBCT. This further makes this study more accurate and standard. And also, age- and gender- wise differences were evaluated. This will be further helpful and valuable in forensic aspects.

Materials and Methods

It is a retrospective institution-based study conducted using 400 samples of CBCT images acquired from the dental archives of the Department of Oral Medicine and Radiology. The scans were generated using the Planmeca Promax 3D MID Proface CBCT machine obtained at 90 kV, 10 mA, and a large FOV of 13 x15 cm and evaluated using RadiAnt DICOM viewer software and version 2023.1 created by Medixant company. The institutional ethical committee approved the study proposal.

Inclusion criteria

- CBCT images have good resolution and image clarity.
- Patients from the age group of 18 yr and older of both genders were included in the study.

Exclusion criteria

- CBCT images with artifacts.
- Mandibles with developmental deformities, fractures, odontogenic pathologies, and surgical corrections are excluded.

Sample size

A total sample of 400 sides of CBCT images was collected from people aged 18 and above.

Age is divided into three groups:

Group I: 18–30 yr (samples: 132).

Group II: 31–50 yr (samples: 136).

Group III: 51 yr and older (samples: 132).

The following parameters were analyzed:

Morphology of lingula: Four shapes of lingula, such as triangular (broad base with rounded or pointed apex, Figure 1), truncated (four-sided plane, Figure 2), nodular (like a small nodule, Figure 3), and assimilated (entire lingula is merged in the ramus, Figure 4) were observed. Apart from the four defined shapes, other shapes were also noted.

Standardization: In the axial section, the horizontal line is drawn in such a way that it connects the right

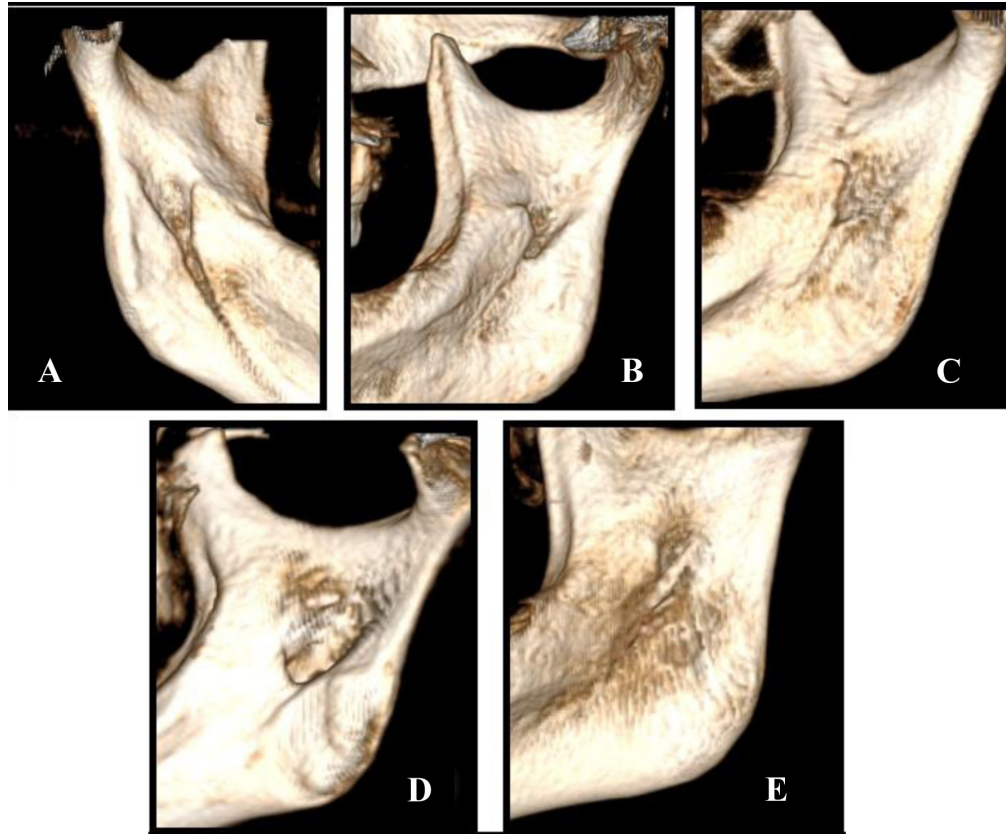


Figure 1. A) Triangular shape, B) Truncated shape, C) Nodular shape, D) Assimilated shape, E) Inverted triangle.



Figure 2. Height of lingula.

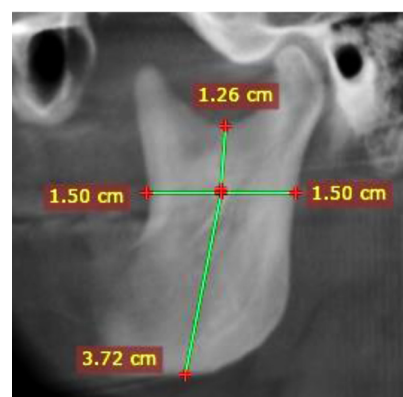


Figure 3. Position of lingula.

and left MF at a straight line.

- The vertical line passes at the MF.
- The intersection point between the horizontal and vertical lines meets at the MF.
- This traced line is cross- checked in sagittal and coronal views.
- Height of the lingula (distance from the ML to the MF assessed in coronal section Figure 2).
- Location of the lingula by measuring the following parameters in the sagittal section (Figure 3):
- Distance from the lingula to the anterior border of

the ramus

- Distance from the lingula to the posterior border of the ramus
 - Distance from the lingula to the lower border of the mandible
 - Distance from the lingula to the mandibular notch
 - The relation of the ML and MF to the occlusal plane
- The presence of accessory mandibular foramina was analyzed and coronoid foramina (Figure 4) in a three-dimensional reformatted CBCT image and in a sagittal section.

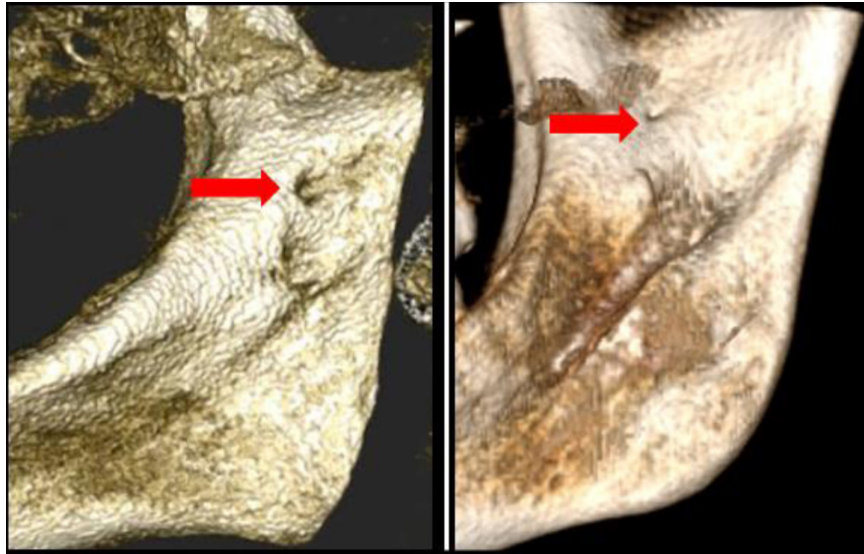


Figure 4. Accessory mandibular foramen and of Coronoid foramen in CBCT reformed image.

Statistical method

- The images were evaluated using RadiAnt
- DICOM viewer software and version 2023.1 created by Medixant company.

Chi-square test was used to find the association of regions around lingula and also to find association of age and gender to ML.

Independent sample t-test was used to compare continuous variables between males and females. One-way ANOVA was used to compare the continuous variables between different age groups. All the descriptive results are presented in tables (Tables 1-3).

Since the p-value is less than 0.001, the level of

significance suggests very strong evidence against the null hypothesis.

Results

The data obtained was entered in a Microsoft Excel spreadsheet and subjected to statistical analysis. All the analyses were carried out using Statistical Package for Social Sciences (version 26; IBM, Chicago, USA). Continuous variables were expressed as mean $\pm$ standard deviation ($M \pm SD$). Categorical variables were expressed as frequency (n) and percentage (%). The level of significance was set at 5%. Among the 400 study samples, about 207 (51.7%) were males and 193 (48.3%) were female. About 132 (33%) of

Table 1. Comparison of various parameters related to mandibular lingula between males and females

	Gender	N	M $\pm$ S.D	p-value
Height of lingula	Male	207	10.19 $\pm$ 1.83	<0.001**
	Female	193	9.49 $\pm$ 1.60	
Distance of mandibular lingula to anterior border of ramus	Male	207	16.10 $\pm$ 2.32	<0.001**
	Female	193	15.31 $\pm$ 2.37	
Distance of mandibular lingula to posterior border of ramus	Male	207	14.44 $\pm$ 2.08	<0.001**
	Female	193	13.51 $\pm$ 2.09	
Distance of mandibular lingula to lower border of mandible	Male	207	34.27 $\pm$ 4.19	<0.001**
	Female	193	30.34 $\pm$ 4.29	
Distance of mandibular lingula to mandibular notch	Male	207	11.83 $\pm$ 2.34	0.87
	Female	193	11.88 $\pm$ 2.40	

Table 2. Relation of mandibular lingula to occlusal plane based on age

		Relation of mandibular lingula to occlusal plane n (%)				Total	p-value
		Not applicable	Above	Below	At the level		
Age (yr)	18-30	2(2.4)	132(41.2)	0(0)	1(20)	132(33)	<0.001**
	31-50	13(15.6)	120(38.4)	0(0)	3(60)	136(34.0)	
	51 and above	68(82)	60(19.3)	0(0)	1(20)	132(33)	
Total		83(20.75)	312(78)	0(0)	5(1.25)	400(100)	

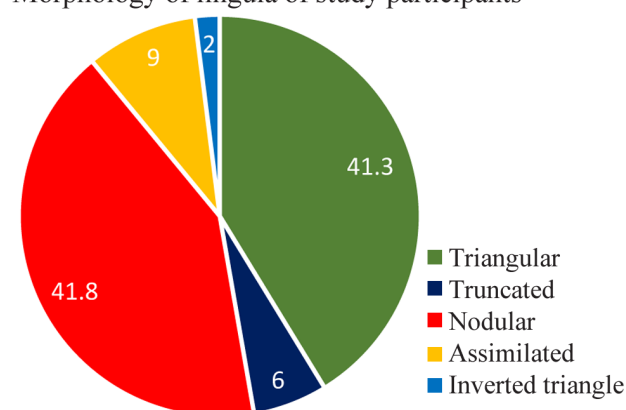
Table 3. Relation of mandibular foramen to occlusal plane based on age

		Relation of mandibular foramen to occlusal plane n (%)				Total	p-value
		Not applicable	Above	Below	At the level		
Age (yr)	18-30	2(2.4)	12(75)	54(35.7)	66(32.6)	132(33)	<0.001**
	31-50	13(15.6)	4(25)	69(45.8)	50(33.4)	136(34.0)	
	51 and above	68(82)	0(0)	28(18.5)	36(24)	132(33)	
Total		83(20.7)	16(4)	151(37.7)	150(37.6)	400(100)	

them were between 18 and 30 yr of age, about 136 (34%) of them were between 31 and 50 yr of age, and 132 (33%) of them were more than 50 yr of age. Among the 400 study samples, about 167 (41.8%) of them had nodular lingula, 165 (41.3%) of them had triangular lingula, 36 (9%) of them had assimilated lingula, 24 (6%) of them had truncated lingula, and 8 (2%) of them had inverted triangular lingula (Figure 5).

The lingula with the shape of a nodular was found more in males (55.1%), and the shape of a triangular was more common in females (47.3%) (Figure 6). Based on age, lingula with the shape of a nodular were common in 18-30 yr of age. Triangular shape in 31-50 yr of age; and nodular shape was common in those above 51 yr of age. However, the distribution of the morphology of the lingula did not show much difference across age, gender, and region, as the p-value obtained from the chi-square test was >0.05. The mean height of the lingula of males and females was 10.19 ± 1.83 and 9.49 ± 1.60 , respectively, and was found to be highly statistically significant ($p < 0.001$ & confidence interval 95%) (Table 1).

The mean distance of the ML to the anterior border of

Morphology of lingula of study participants**Figure 5.** Morphology of lingula of study participants

the ramus, the posterior border of the ramus, and the lower border of the mandible of males and females were 16.10 ± 2.32 and 15.31 ± 2.37 , 14.44 ± 2.08 and 13.51 ± 2.09 , 34.27 ± 4.19 and 30.34 ± 4.29 , which was found to be highly statistically significant ($p < 0.001$). The mean distance of the ML to the mandibular notch of males and females were 11.83 ± 2.34 and 11.88 ± 2.40 , respectively. However, this negligible difference found between males and females was not

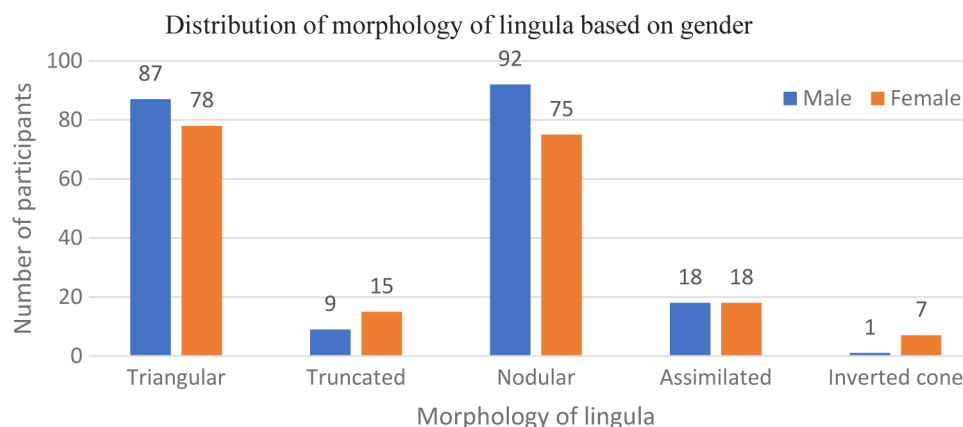


Figure 6. Distribution of morphology of lingula based on gender.

statistically significant) (Table 1 independent sample t-test).

The mean distance of the ML to the anterior border of the ramus, the posterior border of the ramus and the lower border of the mandible of participants belonging to 18-30 yr, 31-50 yr, and significant. The mean distance of ML to mandibular notch of participants belonging to 18-30 yr, 31-50 yr, and above 51 yr were 33.45 ± 4.30 , 31.81 ± 4.95 , and 31.87 ± 4.56 , respectively, and this difference found between different age groups was statistically significant ($p=0.005$).

Based on age, relation of the ML to the occlusal plane is situated mostly above in age of 18-30 yr (41.2%), 31-50 yr (38.4%) and above 51 yr (19.3%), respectively. This relation of ML to occlusal plane based on age was highly statistically significant ($p<0.001$) (Table 2 chi square test).

Based on age, the relation of the MF to the occlusal plane is situated at the level of 18-30 yr (32.6), below at 31-50 yr (45.8%), and at above 51 yr (24%), respectively. This relation of the MF to the occlusal plane based on age was highly statistically significant ($p<0.001$) (Table 3 chi square test).

The overall incidence of AMF is 1.5%. Among the 6 participants who had AMF, 4 were in the right region and 2 were in the left region. The overall incidence of CF among the study participants was 4.5%.

Discussion

The mandible is one of the most significant bone s in dentistry and has various important anatomical

landmarks. One such important landmark is the ML which is in close proximity to the MF. This ML serves as a crucial point of identification for the MF (10). Forensic dentistry involves the processing, review, evaluation, and presentation of dental evidence with the purpose of contributing scientific and objective data to legal processes (11). In forensic anthropology, the mandible can be used as an elective bone for human identification (12). Few studies were conducted in different populations to analyze whether the ML is used as an anthropological marker. But, in the Indian population, there are very limited studies in ML aiming at forensic aspects.

The present study aims to analyze the various morphologies and precise locations of lingula and also evaluate the age- and gender-wise differences of ML. In addition, the prevalence of accessory mandibular foramina was analyzed using CBCT.

In adult dry human mandibles of Indian origin, various morphologies of lingula were first classified by Tuli *et al* (9) (dry mandible) in 2000. This classification was followed in this present study to analyze the morphology of ML. Similarly, this classification was followed in various other studies of ML by Murlimanju *et al* (13) in 2012 (dry mandible), Samanta *et al* (14) in 2012 (dry mandible), Senel *et al* (3) in 2015 (CBCT), Lopes *et al* (15) in 2017 (dry mandible), Asdullah *et al* (16) in 2018 (dry mandible), *etc.*

In the current study, apart from the four defined shapes of mandibular lingula, another variant was identified, *i.e.*, the inverted triangle shape of ML which was found in 8 sides out of 400, among which most commonly found in females (98.8%).

Previously, ML was evaluated in dry mandibles. But recently, CBCT images were used to analyze the ML. Also, the ML and various other parameters were evaluated using CBCT. The advantage of CBCT over dry mandibles is that it is not affected by the production and preservation processes, unlike in dry mandibles (17).

In the present study, the most common shape of ML was the nodular shape. This was in accordance with the studies conducted by Sekerci *et al* (18) in 2014 (CBCT), Senel *et al* (3) in 2015 (CBCT), Jung *et al* (19) in 2018 (CBCT), and Akcay *et al* (20) in 2019 (CBCT). This was not in accordance with the study done by Samanta *et al* (14) in 2012 (dry mandible), Lopes *et al* (15) in 2017 (dry mandible), and Asdullah *et al* (16) in 2018 (dry mandible). The studies that evaluated the morphology of ML using CBCT had a mostly positive correlation, whereas studies conducted in dry mandibles had a negative correlation. This is possibly due to the blurring of divisions between the nodular and triangular types in CBCT images compared to the dry mandible (17).

In this study, among the four defined shapes of lingula, the assimilated shape is one of the least common. The study done by Tuli *et al* (9) in 2000 (dry mandible), Kositbowornchai *et al* (21) in 2007 (dry mandible), Jansisyanont *et al* (22) in 2009 (dry mandible), Murlimanju *et al* (13) in 2012 (dry mandible), Sekerci *et al* (18) in 2014 (CBCT), Jung *et al* (19) in 2018 (CBCT), and Akcay *et al* (20) in 2019 (CBCT) had assimilated as the least shape.

In the current study, gender differences were noted in lingula morphology, the nodular type was prevalent in males, and triangular and nodular types of lingula were nearly as frequent in females. This was in accordance with the study conducted by Senel *et al* (3) in 2015 (CBCT) in Turkey. A study of Indian origin carried out by Asdullah *et al* (16) in 2018 (dry mandible) also found similar gender differences in lingula types. But this difference was statistically analyzed by the chi square test, like in the present study and found no significance.

In this study, the mean height of lingula in males was 10.19 ± 1.83 , and females was 9.49 ± 1.60 , and there was no much difference on the right and left sides. This is similar to a study done by Hsu *et al* (17) in 2020 (CBCT), where the ML height was identified to

be bigger in males than females, with no relation to the side.

In the present study, the mean distance from the anterior border of the ramus to the ML was 15 ± 2.3 mm. This was nearly similar to the study by Sekerci *et al* (18) in 2014 (CBCT), Senel *et al* (10) in 2015 (CBCT), Hsu *et al* (17) in 2020 (CBCT). In this study, the mean distance of the lingula to the posterior border of the ramus and mandibular notch was 13.9 ± 2.09 and 11.8 ± 2.35 , respectively. This was not in accordance with the study by Senel *et al* (10) in 2015 (CBCT). In our study, the mean distance from the ML to the lower border of the mandible was 32 ± 4.6 , respectively. This was in accordance with a study by Senel *et al* (10) in 2015 (CBCT).

In the current study, the mean distance from the ML to the anterior border of ramus, the posterior border of ramus and the lower border of mandible was greater in males when compared to females and these parameters were also statistically significant, while the mean distance from the ML to the mandibular notch was nearly equal and found no significance. This was similar to a study carried out by Hsu *et al* (17) in 2020 (CBCT). He also found significance for the mean distance from the ML to the anterior border of ramus, the posterior border of the ramus and the lower border of the mandible and no significance for the mean distance from the ML to the mandibular notch in gender. This implies that the lingula was longer and more protruding in males than females.

In this study, no significant difference was found in the mean distance from the lingula to its reference points on the right and left sides. This was in accordance with the study done by Hsu *et al* (17) in 2020 (CBCT).

According to the results of present study, the ML is situated mostly above the occlusal plane, and the MF is situated mostly below the occlusal plane. This was in accordance with the study by Zhou *et al* (23) in 2017 (CBCT).

In this study, the prevalence of AMF was 1.5%. This was stated by Pancer *et al* (24) in 2014, who reported the incidence of AMF to vary from 0.88% to 10.66%. Out of 6 AMF, 4 were noted on the right and 2 on the left. This is in accordance with the report of Hanihara *et al* (25) in 2001, which states that there is a higher prevalence of AMF in Asian males.

Later, Padmavathi *et al* (26) in 2014 (dry mandible), found a higher incidence of AMF in Indians. This finding differs from Asdullah *et al* (16) in 2018 (dry mandible). CF, a recently identified anatomic variant, was incidentally found in our study. The prevalence of this CF was 4.5% in our study. This was nearly similar 4.4% was noted by Firdoose *et al* (27) in 2022 (CBCT). This was more frequently noted on the right side than left side, and was most commonly seen in females than males, and was found commonly at 18-30 yr of age. This finding was similar to the study by Firdoose *et al* (27) in 2022 (CBCT) except for the age group.

The clinical significance of Inverted lingula lies in its relationship with inferior alveolar nerve. Thus, some technical alterations may be required during anesthesia. And, this newly observed morphological variation may impact surgical planning.

For clinical aspect, in this study, the morphology of ML was analysed. The most common is nodular type of lingula and height and precise location of ML and also relation of ML and MF to occlusal plane. All these results will provide important morphometric information to prevent the complications during anesthetic and various oral and maxillofacial surgical procedures. For instance, in sagittal split ramal osteotomy procedure, horizontal osteotomy should be done superior to the ML and it should extend posteriorly in order to prevent injury to inferior alveolar nerve.

Forensic aspect, based on the results of this study, highly significant difference in position of the ML was noted between males and females and significant difference in distance from ML to mandibular notch was noted in the age groups (18-30, 31-50 and >above 50). Also, a highly significant age wise difference was noted in relation of ML and MF to occlusal plane. These observed results will support this ML as an

anthropological marker.

There is a lack of literature evidence for gender-wise differentiation in ML morphology and position. To the best of authors' knowledge, this is the first study carried out to assess the age-wise difference in ML morphology and position.

The other advantage of this study was done in two aspects, one is clinical aspect and the other is forensic aspect. Specially, Indian studies are limited to ML. Hence, further research is needed in this aspect to support the results.

Conclusion

The lingula has been a main anatomic landmark to guide surgeons. This study was carried out in two aspects, one is clinical (since the ML is in close proximity to the MF), and the other is forensic. Identification of the ML is very essential to preventing complications like hemorrhage and neurological damage. The observed results between age and gender require further research to support this ML as an anthropological marker.

Hence, Multi-center trials are required regarding the forensic aspect of ML.

Ethical approval

This study was approved by the Institutional Ethical committee MADC/IEC-I/53/2022.

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Conflict of Interest

Authors declare no conflict of interest.

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