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ORIGINAL ARTICLE

Three-Dimensional Evaluation of the Mandibular Lingula on Cone-Beam Computed Tomographic Images in The Turkish Population

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ABSTRACT

Objective: The purpose of this study was to provide morphometric and anatomical data for mandibular lingula (Li) in The Turkish population using three dimensional-cone beam computed tomography (3D-CBCT) images. **Methods:** CBCT images of the patients taken between July 2020 and March 2021, were retrieved from the archival records. A total of 100 Li's of 50 patients who met the criteria of this study were evaluated. The distances between the tip of the Li and ramal landmarks/occlusal plane were measured and the shape of the Li was evaluated on 3D-CBCT images. **Results:** CBCT images of the 50 patients (19 males and 31 females) with an age range of 18 to 56 years were included in this study. Significant differences were found for the measurements of right LP ($p < 0.001$), left LP ($p = 0.003$), right LOP ($p = 0.016$) and left LOP ($p = 0.007$) between genders. A significant difference was observed for LI ($p = 0.024$) between the left and right sides. Regarding the shape of the Li significant difference was found between the right and left sides ($p = 0.003$), while no significant differences were observed among genders on either both sides. **Conclusion:** This study contributes additional data to the literature about the location and morphology of the Li in Turkish subpopulation. These results provide a reference for the clinicians regarding the procedures involving mandibular ramus to perform maneuvers in safe margins.

Key words: CBCT, landmark, lingula

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INTRODUCTION

The Lingula (Li) is a bony process located in the medial sight of the ramus which was first described as 'Spix ossicle or spine' in the 1800s.[1] Li forms the orifice of the mandibular foramen and sometimes can be palpated through the mucosa. It has a preservative role on the nerve and vascular structures entering the mandibular foramen (MF) by serving as an attachment for the sphenomandibular ligament.[2–4] Variations in the morphology of the Li have been explored by many researchers.[5–7] Although different classifications exist,[6,8] the classification of the Tuli et al.[9] is the most widely used.

The Li constitutes the medial boundary of the MF and thereby has a connection with the inferior alveolar nerve and accompanying vascular structures.[10,11] Thus, Li is considered as an important anatomical reference when performing certain procedures like sagittal split/vertical ramus or inverted-L osteotomies, management of trauma and benign/malignant lesions, pre-prosthetic surgeries, and surgeries of the temporomandibular joint.[4,10–12] Furthermore, precise determination of MF is crucial for the management of inferior alveolar nerve (IAN) neuralgia, and IAN block, which is a fundamental procedure for most dental procedures in the mandible.[3] Incorrect identification of Li may lead to IAN or lingual nerve damage, to the hemorrhage or unfavorable fracture and as the failure of anesthesia.[11,12] IAN failure of has been estimated to be 10-15% and the majority of these failures was attributed to anatomical variations.[13]

Several studies have has shown that the position and shape of the Li may be affected by age, gender, ethnicity and individual factors.[4,14–17] In the Turkish adult population a limited number of studies exploring the

morphology and the location of Li on dry mandibles[3] and cone beam computed tomography (CBCT) images[4,11,12,18] have been performed previously. The aim of this research was to provide data from the Middle Black Sea Region of Turkey for the location of Li using CBCT by considering its morphology and the patients' genders and to contribute to the knowledge of clinicians in terms of performing procedures using Li as a reference anatomical landmark.

METHODS

This study was conducted in a retrospective manner on the CBCT images of the patients that were obtained at the Oral and Maxillofacial Radiology Department of Ordu University between July 1, 2020 and March 17, 2021, for various problems involving the maxillofacial region. The Clinical Research Ethics Committee of Ordu University approved this study (IRB approval no: 2021/75). All tomographic images were obtained in a standard position by using a CBCT machine (KaVo OP 3D Vision,Imaging Sciences International LLC, USA) with as low as reasonably achievable (ALARA) principles. CBCTs were taken at 90-120 kVp, 3-8 mA, and 8.9 seconds. The largest voxel size in the analyzed images was 0.3 mm and the largest FOV area was 16x13 cm. The obtained DICOM images were evaluated using OnDemand 3D Dental (OnDemand3D Technology Inc., USA) software.

The CBCT images of the individuals over the age of 18 and the CBCT images that covered entirety of mandibular ramus region, were included in the study. CBCT images of the patients with the craniofacial syndromes or osseous disease of the cranio-facial region; have with pathological lesions or previous surgeries involving the mandibular ramus region; whose mandibular incisor and/or second molar teeth were missing and whose CBCT images with included artifact or poor image quality were excluded. A total of 100 Li's of 50 patients who met the criteria of this study were evaluated.

The position of the Li was determined by measuring the distances between the tip of the Li and the ramal landmarks on both sides of the mandible, as follows:

1. The shortest distance between Li and the internal oblique ridge (LI)
2. The distance between Li and the deepest point of the sigmoid notch (LS)
3. The shortest distance between Li and the external oblique ridge (LE)
4. The shortest distance between Li and the ramus posterior border (LP)
5. The vertical distance between Li and the occlusal plane (LOP)

Three-dimensional images of the software were used for distance measurements of LI, LS, LE and

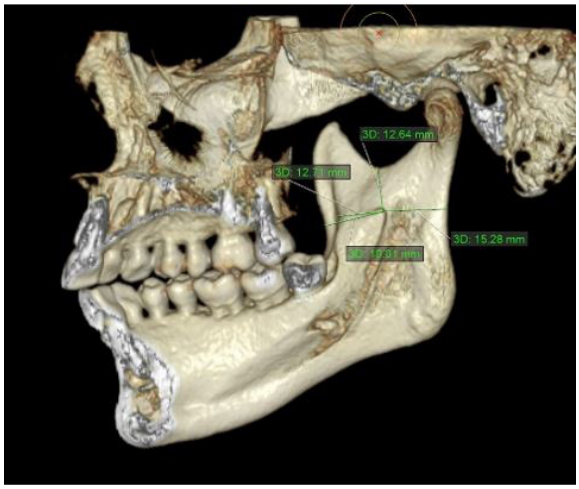

Figure 1. Measurement of the distances between the tip of the Li and ramal landmarks.

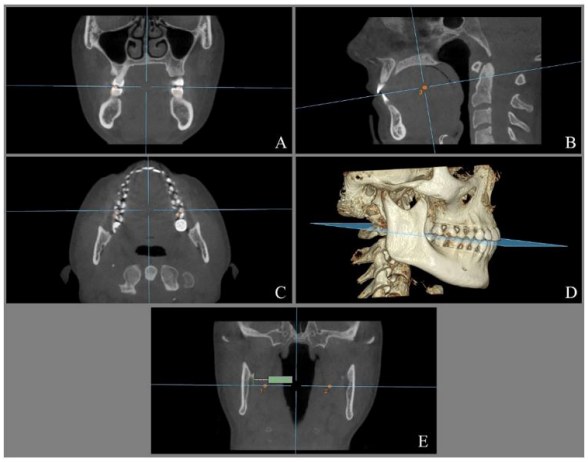

Figure 2. A) Coronal. **B**) Sagital. **C**) Axial. **D**) 3D images show set up of the occlusal plane. **E**) Measurement of the distance from the tip of the lingula to the occlusal plane.

LP. Firstly, the medial aspect of the ramus of the mandible was visualized using the plane function in 3D Tools. The most superior and posterior point of Li was determined as the tip of the Li on this aspect. The shortest distance from the tip of the Li to the internal oblique ridge, the deepest point of the sigmoid notch, the external oblique ridge and the posterior border of ramus was measured with a 3D ruler. (Figure 1).

LOP: The occlusal plane (OP) was determined as the plane combining the mesiobuccal cusp tips of the mandibular second molars and midpoint of the tip of the mandibular central incisors as described previously.[17] LOP was measured in the 3D MPR coronal section with a 2D ruler (Figure 2).

Shape of the Li: The shape of the Li was evaluated by to Tuli et al.[9] as assimilated, truncated, nodular, and triangular. The triangular Li has a wide base with a pointed apex, truncated Li has a quadrangular top, nodular Li was nodular and of variable sizes, except for

its apex, and completely incorporated Li were evaluated as assimilated. The shape evaluation of the mandibular Li was performed according to the 3D images of the software.

The same researcher carried out all distance measurements twice by one week apart. The mean values of two measurements were analyzed. If the differences were more than 1mm differences existed, the measurement were performed again, and the two values having lower differences was used. The evaluation of the shape of the Li was carried out by two researchers one week apart.

Data analysis

IBM SPSS Statistics for Windows software version 23.0 (IBM Corp, Armonk, NY) the used for statistical analyses. Normality of the data was evaluated using the Kolmogorov-Smirnov test. Comparisons of the measurements between males and females were performed with an independent samples t-test or Mann-Whitney U test as appropriate. Comparisons of the measurements between right and left sides were performed with paired samples t-test or Wilcoxon test as appropriate. To compare age and the shape of the Li across genders, Mann-Whitney U test and Chi-Square tests were used. Correlation between the age and LOP was determined by Spearman correlation. For the interrater reliability evaluation the Kappa coefficient was used for the categorical data, and for the intrarater reliability evaluation the intraclass correlation coefficient (ICC) was used for continuous data. Data were expressed as the mean ± standard deviation and minimum–maximum. All tests were two-tailed and were based on a 0.05 significance level.

RESULTS

CBCT scans of the 50 patients (19 males and 31 females) with an age range of 18 to 56 years were included in this study. Descriptive statistics are shown in Table 1.

Table 1. Demographic data of the patients.

Gender	n	Age		p
		Mean±SD	Min–Max	
Male	19	29.11±10.69	18–51	0.352*
Female	31	32.48±11.84	18–56	
Total	50	31.20±11.42	18–56	

*: Mann Whitney- U test, SD: Standard deviation

Regarding gender, no significant differences were found in terms of the measurements LE, LI, and LS for both right and left sides ($p > 0.05$). Significant differences were found for the measurements of the right LP ($p < 0.001$), left LP ($p = 0.003$), right LOP (0.016) and left LOP ($p = 0.007$) between genders. In terms of the total LE, LI, LS, LP and LOP measurements (average of the right and left side measurements) significant differences were found only for LP ($p < 0.001$) and LOP ($p = 0.002$) measurements between males and females (Table 2). The comparisons of the measurements on left and right sides showed no significant differences for LE, LS, LP or LOP measurements except LI ($p = 0.024$) (Table 3). No significant correlations were observed between LOP and age on the right ($p = 0.283$, $r=0.155$) or left ($p = 0.897$, $r=0.019$) sides.

Regarding the shape of the Lis, the difference between the right and left sides was found to be significant ($p = 0.003$). No significant differences were observed among genders in terms of the shape of Li in right ($p = 0.916$) and left ($p = 0.512$) sides (Table 4, Figure 3).

For the shape evaluation interrater reliability was found for between 0.634-0.831 for the left and right-side evaluations. Also, for intrarater reliability regarding the measurements of left and right LE, LI, LS, and LP was found between 0.960-0.985.

Table 2. Comparisons of the measurements among genders.

Measurements (mm)	Side	Mean	SD	Minimum	Maximum	p
LE						
Female	R	17.26	2.26	11.24	22.44	0.409*
Male		16.75	1.78	13.69	19.67	
Female	L	17.10	2.67	9.36	22.54	0.930*
Male		17.16	1.81	14.33	20.62	
Female	A	17.18	2.35	10.30	22.49	0.720*
Male		16.96	1.71	14.33	20.14	
LI						
Female	R	12.22	2.02	7.36	16.25	0.203*
Male		12.91	1.43	9.65	14.90	
Female	L	11.82	2.39	6.62	17.83	0.247*
Male		12.57	1.78	8.24	15.73	
Female	A	12.22	2.02	7.36	16.25	0.208*
Male		12.91	1.43	9.65	14.90	
LS						
Female	R	16.47	2.36	10.50	20.32	0.112*
Male		17.66	2.81	11.78	22.25	
Female	L	16.98	2.62	12.30	23.72	0.338*
Male		17.76	3.02	10.15	23.83	
Female	A	16.72	2.37	11.78	21.61	0.189*
Male		17.71	2.83	10.97	22.51	
LP						
Female	R	14.82	1.52	11.82	17.24	**<0.001***
Male		16.72	1.52	13.62	20.35	
Female	L	14.83	1.54	11.30	18.67	**0.003***
Male		16.27	1.60	13.58	18.98	
Female	A	14.83	1.41	11.65	17.37	**<0.001***
Male		16.49	1.41	14.10	19.33	
LOP						
Female	R	8.63	2.38	3.07	15.15	**0.016¥**
Male		11.16	3.60	6.54	17.84	
Female	L	8.55	2.45	3.35	14.17	**0.007¥**
Male		11.07	3.03	7.23	16.72	
Female	A	8.59	2.38	3.21	14.60	**0.002***
Male		11.12	3.10	7.23	17.28	

*: Independent t test, ¥: Mann Whitney- U test, SD: Standard deviation, R: Right, L: Left, A: Average

Table 3. Right and left side comparisons of the measurements (N = 50).

Measurements (mm)	Side	N	Mean	SD	Minimum	Maximum	*p*
LE	**R**	50	17.07	2.09	11.24	22.44	0.798*
	L		17.12	2.36	9.36	22.54	
	A		17.09	2.11	10.30	22.49	
LI	**R**	50	12.48	1.83	7.36	16.25	**0.024***
	L		12.10	2.19	6.62	17.83	
	A		12.29	1.93	7.37	16.28	
LS	**R**	50	16.92	2.58	10.50	22.25	0.104*
	L		17.28	2.78	10.15	23.83	
	A		17.10	2.57	10.97	22.51	
LP	**R**	50	15.54	1.77	11.82	20.35	0.356*
	L		15.38	1.70	11.30	18.98	
	A		15.46	1.62	11.65	19.33	
LOP	**R**	50	9.59	3.13	3.07	17.84	0.604¥
	L		9.51	2.93	3.35	16.72	
	A		9.55	2.92	3.21	17.28	

*: Paired t test, ¥: Wilcoxon test, SD: Standard deviation, R: Right, L: Left, A: Average

Table 4. Right and left side comparisons of the measurements.

Shape	Bilateral		Unilateral				Total		
			Right		Left				
	Female	Male	Female	Male	Female	Male	Female	Male	Both
Nodular	5	2	7	6	4	3	21	13	34
Triangular	4	2	2	4	2	3	12	11	23
Assimilated	9	3	2	2	6	5	26	13	39
Truncated	1	0	1	0	0	1	3	1	4
Total	38	14	16	8	18	6	62	38	100

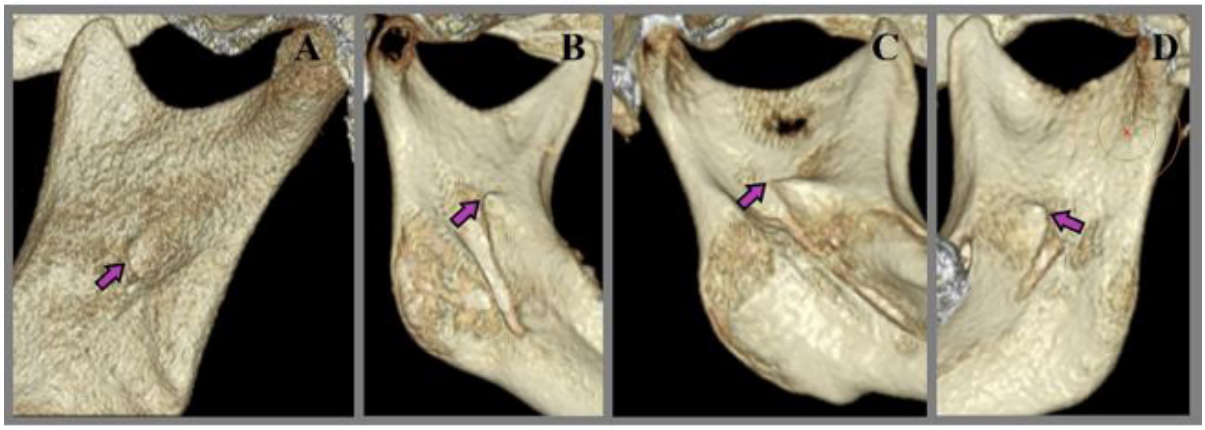

Figure 3. Shapes of the lingula; assimilated (A), nodular (B), triangular (C) and truncated (D).

DISCUSSION

In this study, we aimed to explore the location and morphology of the Li in the Turkish adult population. In previous studies, the location and morphology of the Li have been explored by dry skulls,[3,15,19] plain radiography[5,19] or CBCT images.[4,16,18] Dry mandibles as a research material require higher costs and

provide limited data regarding age and gender.[17] Plain radiographs on the other hand may show distortion and magnification.[16] CBCT is a more convenient, accurate method and enables precise measurements with high resolution.[16,17] CBCT also has advantages like the requirement of a low amount of radiation, short exposure time and lower cost involved.[12,20] Thus, in this study we used 3D CBCT to perform the measurements of the distances and evaluation of the morphology of the Li.

The morphology of the Li has been found to vary across populations. In the study of Ahn et al. on CBCT images of the Korean population, the most frequent type of the Li was the nodular (32.8%).[16] It is followed by the triangular (31%), truncated (25.9%) and the assimilated (10.3%) types. They observed that in males the triangular shape was the most frequent while found the nodular type was the most common in females. In another study which compared dry mandibles and panoramic radiography of the Thai population, the most common shape of Li was found to be the truncated (47.22%) type, followed by nodular (22.92%), triangular (16.66%) and the assimilated (13.19%) types. The authors found bilateral shape more frequent and more common in males.[19] In the study of Murlimanju et al. on Indian subject's dry mandible, the most frequent shape was triangular (29.9%) and nodular (29.9%), these followed by truncated (27.6%), and assimilated (12.6%) types.[1] The shape of the Li was found symmetrical in 61.2% of the subjects evaluated. The authors also observed that triangular type was most common in males, while the nodular type was the most common in females. In the study of Lopes et al. on Brazilian population, it was reported that the most frequent was a triangular type (41.3%).[21] The truncated (36.3%), assimilated (11.9%), and nodular (10.5%) types followed respectively. They also observed that the majority of the shapes were symmetrical.

Studies on the Turkish population also showed variable results. In the study of Ozalp et al. on 50 dry adult mandibles it was found that the most frequently encountered shape of Li was the triangular type (42%), followed by nodular (30%) and truncated (28%) types and most of the shapes were observed as being symmetrical.[3] The authors did not observe an assimilated type in their study population. Sekerci et al. found on CBCT images of 412 patients that the most common shape was the nodular (51.2%), and this was followed by truncated (32%), triangular (14.1%) and the assimilated types (2.7%).[11] The authors found bilateral shapes (79.4%) more often than a unilateral shapes and did not observe gender difference in terms of the distribution of the shapes. In another study conducted by Senel et al. on CBCT images the most common shape was the nodular types (32.5%).[12] This followed by the assimilated type (26.2%), triangular types (22.2%) and the truncated (19%) types. In 76% of the images evaluated symmetrical shape was observed. They observed nodular shape more often in females and assimilated in males. In the study of Akçay et al. selected CBCT images of Class I - III patients to evaluate, and was is found that most common shape of Li was nodular (45%) followed by truncated (21.7%) triangular (20%) and assimilated (13.3%) types.[4] In the present study, different from the majority of other studies, the most common type was assimilated (39 %), and this was followed by nodular (34%), triangular (23%) and truncated (4%) types. Triangular shape which is the most easily identified during ramus surgeries[15] was found to be less frequent in this study similar to the other studies on the Turkish population.[4,11,12] In concordance with the published data we also observed bilateral shapes more than unilateral ones. Regarding gender, we found assimilated type is more frequent among females, whereas both assimilated and nodular type is seen more frequent among males.

The position of Li significantly varies among races, genders, skeletal patterns and poses a critical role in terms of several procedures in the mandible.[11] Among them sagittal split osteotomy is one of the most prevalent procedures where the location of horizontal osteotomy should be arranged above the Li.[18] It is suggested that a 5mm distance from vital structures should be maintained during osteotomy and to provide enough vascularity the posterior segment needs to be at least 6 mm. It is also important to determine the exact location of Li in order to perform the efficient IAN block.[15] Therefore providing data regarding the location of the Li can serve as a reference for clinicians, since the Li cannot be seen directly.[22]

In our study, the vertical distance LS was found to be 17.10 mm. Variable results more and less similar to our results were reported by the studies conducted on Thai[15] (mean 16.6 mm), Brazilian[6] (16.64 mm right, 16.31 mm left side), Indian[2] (17.83 mm right 18.50 mm left), Turkish[4,12] (mean 18.1 mm; 18.21 mm), and Korean[20] (15.7 mm male, 15.5 mm female) populations. Females showed lower values of LS in our study in concordance with the studies of Jansisyanont et al.[15], Akçay et al.[4], Sekerci et al.[11] while similar values among genders were found by of Zhou et al.[20]

The location of the Li mostly seen above the OP, but rarely it is observed at or below.[20] Jansisyanont et al. found that in 117/146 subjects Li was above OP with a mean of 4.5 mm and in 29/146 of the subjects located below OP with higher values reported in females.[15] In the study of Jang et al. LOP distance was found 8.93 mm on the right side- 8.76 mm on the left side and significantly higher in males.[17] In another study conducted by Zhou et al., it is reported that 98.3 % of the Li were located 6mm above the OP while one was at the and one was below the OP.[20] On Turkish population, Akçay et al. found that Li was located 9.01 mm above OP.[4] They observed higher values in class III patients and class I males than females. In the present study

regarding all measurements, the Li was positioned above the OP and LOP distance was found to be 9.55 mm and significantly higher in males.

Regarding the anteroposterior location of the Li, special attention should be paid to performing vertical osteotomy in patients who have LP distance less than 15 mm.[15] Additionally, because of the lingual nerve positioned anterior to the Li, closer to the Li to ramus anterior border, the risk of damage to the lingual nerve was greater, especially for third-molar operations.[14] We found that LE 17.09 mm, LI 12.29 mm, and LP 15.46 mm. LE distance was found to be higher in females while LP higher in males. In the study by Jansisyanont et al. on the Thai population higher values were found for Li to ramus anterior border (ABM) (20.6 mm) and for LP (18 mm).[15] Slightly higher values when compared to this study were also reported by Senel et al. (Li-ABM 18.5 mm and LP 16.9 mm) for Turkish population.[12] Similar results regarding LI (12.66 mm) and LP (15.22 mm) values and higher results regarding LE (19.21 mm) were reported by Hsu et al. for the Chinese population.[22] They also reported observing higher values in males compared to females. In an Indian population sample also Samanta and Kharb observed higher Li-ABM distance (20 mm) and similar LP distance (15 mm).[14]

Although the small sample size is a limitation, this study contributes additional data to the literature about the location and morphology of the Li in the Turkish subpopulation. The results of this study when compared with published studies showed that the morphology and location of the Li show considerable variations originating from the several parameters, including ethnicity, gender skeletal pattern as well as the differences among the designs and evaluation methods of the studies.

CONCLUSION

Our results suggest that the inferior alveolar nerve block can be performed by inserting the needle 17.09 mm to the anterior border and 9.55 mm above the OP. Males showed higher values than females in the majority of the measurements and distribution of the shape of Li showed no gender differences. These results provide a reference for the clinicians for the procedures involving mandibular ramus to perform maneuvers in safe margins. It should also be be mentioned that determining the position of the Li before surgical procedures with CBCT may be useful when considering the case-specific anatomic variations.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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