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# EVALUATION OF MANDIBULAR LINGULA AND FORAMEN LOCATION USING CONE-BEAM COMPUTED TOMOGRAPHY IN LIBYAN POPULATION

**Ashraf Elmansori[1]*, Randa Farag Salih[2], Osama Othman Mohammed Ambarak[3] and Abdullatif H. Annaas[4]**

[1,3]Department of Anatomy, Faculty of Medicine, University of Benghazi, Benghazi-Libya.
[2]Department of Conservative Dentistry, Faculty of Dentistry, University of Benghazi, Benghazi- Libya.
[4]Department of Anatomy, Faculty of Medicine, Omar Al-Mukhtar University, Al-Bayda- Libya.

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***Corresponding Author**
**Ashraf Elmansori**
Department of Anatomy,
Faculty of Medicine,
University of Benghazi,
Benghazi-Libya.

## ABSTRACT

**Introduction:** Evaluation of the mandible's morphology and morphometry is important clinically because of the intimate connection between the lingula and the neurovascular pathways that enter through the mandibular foramen. The lingula is frequently employed as a significant bone landmark during inferior alveolar nerve block anesthesia and oral and maxillofacial surgical procedures. Poor anatomical knowledge can lead to several intraoperative problems, including nerve damage, fractures, and hemorrhage. Additionally, incorrect mandibular foramen localization and anatomical differences in the lingula have been linked to the failure of inferior alveolar nerve block anesthesia. **Materials and Methods:** Cone beam computed tomography (CBCT) scans were conducted on 106 Libyan patients who visited a dental clinic, consisting of 49 males and 57 females, with ages ranging from 20 to 56 years. The location of the mandibular lingula was measured. We measured the mandibular angle, anteroposterior width of the ramus, distances from the lingula to the sigmoid notch, distance from the lingula to the Gonion, and from the IOR to the lingula in 112 mandibular rami. **Results:** The comparison of mean and standard deviation between the right and left sides revealed significant differences (P < 0.01) for most parameters, except for the anteroposterior width of the ramus, which had no significant difference (P > 0.05). The comparisons between different sexes have statistically significant differences on both sides. **Conclusion:** The results of this research provide important guidelines for orthognathic surgery and IAN block anesthesia. It is possible to regard CBCT as an accurate and efficient method of measuring mandibular fine structures.

**KEYWORDS:** Lingula, Cone-beam CT, Inferior alveolar nerve, Mandibular foramen.

**Abbreviation:** ML**:** mandibular lingula; MF: mandibular foramen; CBCT: cone-beam computed tomography; IAN: inferior alveolar nerve; IANB: inferior alveolar nerve block; IOL: internal oblique line; SPSS: Statistical Package for Social Sciences.

## INTRODUCTION

The mandibular foramen is situated on the medial surface of the mandibular ramus, slightly above the center. The mandibular canal runs first obliquely downward and forward within the ramus and then horizontally forward within the body of the mandible beneath the roots of the molar teeth. Mandibular teeth, gums, and lower lips are supplied by fine branches originating from the inferior alveolar arteries and nerves. A thin, pointed bone structure termed the mandibular lingula (ML), overlaps the mandibular foramen anteromedially. The lingula is positioned higher in edentulous subjects than in teeth-bearing subjects.[1] Lingula was first described by Johannes – Baptist as ‘Spix ossicle or spine’ in 1815.[2] The lingula is a tongue-shaped bone that provides an attachment area for the sphenomandibular ligament.[3] Because of its close relation to the neurovascular pathways entering the mandibular foramen, the lingula is frequently utilized as a significant bone marker for various maxillofacial surgical procedures and inferior alveolar nerve block anesthesia. Inadequate understanding of lingula structural changes and subsequent incorrect localization of the mandibular foramen can lead to intraoperative problems such as hemorrhage, fractures, and even injury to the inferior alveolar nerve.[4,5] Failure of inferior alveolar nerve block [IANB] anesthesia has been reported to occur at a rate of up to 45%, with around 10-15% of failures related to anatomical abnormalities of the lingual.[6] That is why it is essential for dentists and surgeons to understand the shape, location, and height of the ML before performing IANBs and ramus procedures.[7] Variations in the morphology of the lingula have been explored by many researchers.[8-10] Several studies have shown that the position and shape of the lingula may be affected by age, gender, ethnicity, and individual factors.[11-13] Many studies explore the morphology and the location of lingula on dry mandibles[14] and cone beam computed tomography (CBCT).[15,16] CBCT has recently replaced dry mandibles in morphometric studies by providing high-quality and accurate three-dimensional pictures. CBCT has become more prevalent in dentistry in recent years, particularly in the field of implantology. This is because CBCT has been shown to improve many of the disadvantages of conventional medical computed tomography (CT), including high radiation dose, prolonged radiation exposure, and low-resolution ratio. The radiation dose from CBCT is only about 25% of the radiation dose from a panoramic radiograph and between 1.6 and 2.5% of the radiation dose from a conventional medical CT scan.[17,18] Consequently, the purpose of this retrospective investigation is to accurately describe the anatomical morphology of the mandibular ramus and to verify the locations of the MF and ML with respect to the surrounding landmarks using CBCT data.

## MATERIALS AND METHODS

### Study design

This study analyzed CBCT scans from 106 Libyan patients (49 males and 57 females), retrospectively obtained from the archives of a dental clinic in Benghazi, Libya, between October 2023 and May 2024. The scans were originally performed for various diagnostic purposes. Pre-operative medical records were reviewed to collect patients' information and determine the specific clinical reasons for requesting the CBCT scans. The study included participants aged 18 to 65 years.

### Inclusion and Exclusion criteria

The subjects were included in the study if they had the following inclusion criteria: (1) Mandibular ramus CBCT data from adult patients (older than 18); and (2) the existence of molars and premolars to determine the occlusal plane. Individuals with a history of mandibular pathology or surgery and those with missing mandibular posterior teeth were not accepted.

### Radiographic evaluation

The CBCT data were acquired using the Acteon XMIND CBCT system (SOPRO Acteon group, France). The imaging parameters included a field of view of 15 × 12 cm and a voxel size of 0.200 mm. Scans were conducted at 84 kV and a current ranging from 12 to 16 mA. All images were evaluated using Acteon’s AIS Software (version 4.6.1.AIS) on a computer monitor. Measurements were overlaid and maintained in a consistent position across the entire image series. For the ML region, panoramic, axial, coronal, and sagittal radiographic slices were utilized to create a 3D reconstruction of the area of interest. The study aimed to assess the position of the mandibular foramen and its associated anatomical structures.

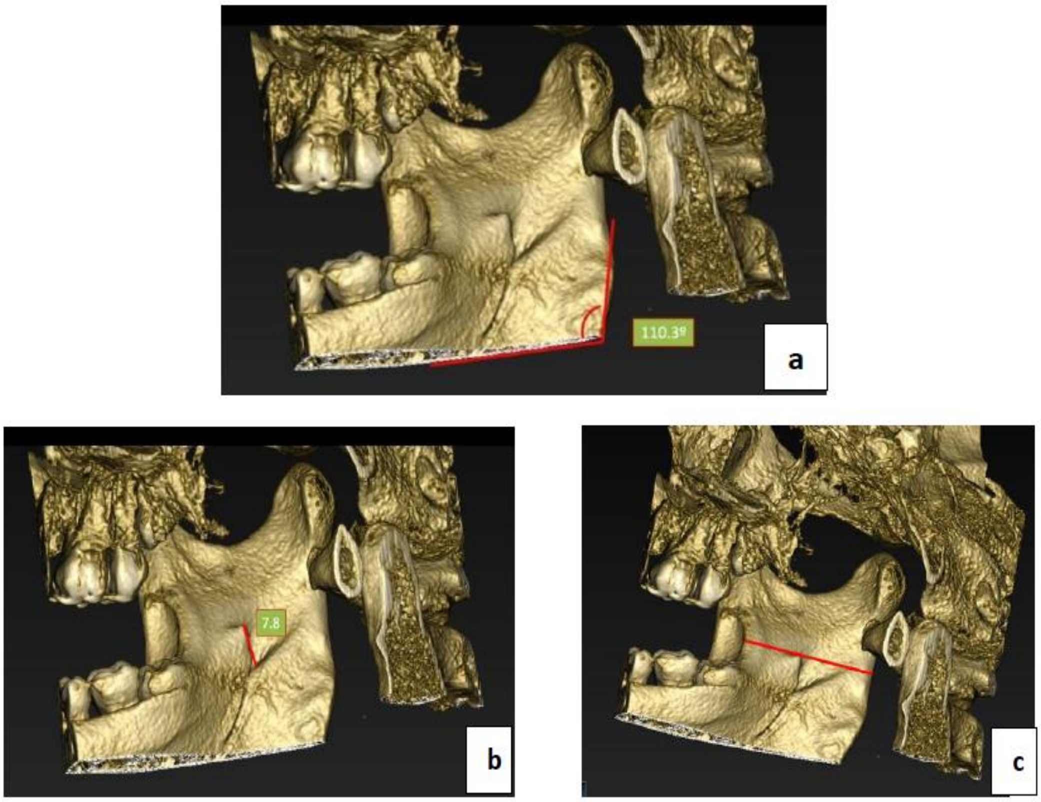
**Measurements**

The following parameters were analyzed to determine the location of the mandibular foramen (MF):

The parameters include 7 parameters (Rt & Lt sides) = 14 parameters

1. Right & Left MA (Mandibular angle).
2. Right & Left L-F (Distance between the lingula & mandibular foramen).
3. Right & Left A-P (Antero-posterior width of the ramus).
4. Right & Left ML- IOL (Distance from the lingula to the internal oblique line).
5. Right & Left ML- SG (Distance from the lingula to the sigmoid notch).
6. Right & Left ML- GN (Distance from the lingula to the Gonion).
7. Right & Left ML- M2 (Distance from the lingula to the CEJ of the second molar).

Comparison of these parameters on both sides and also, between male & female subjects were performed.



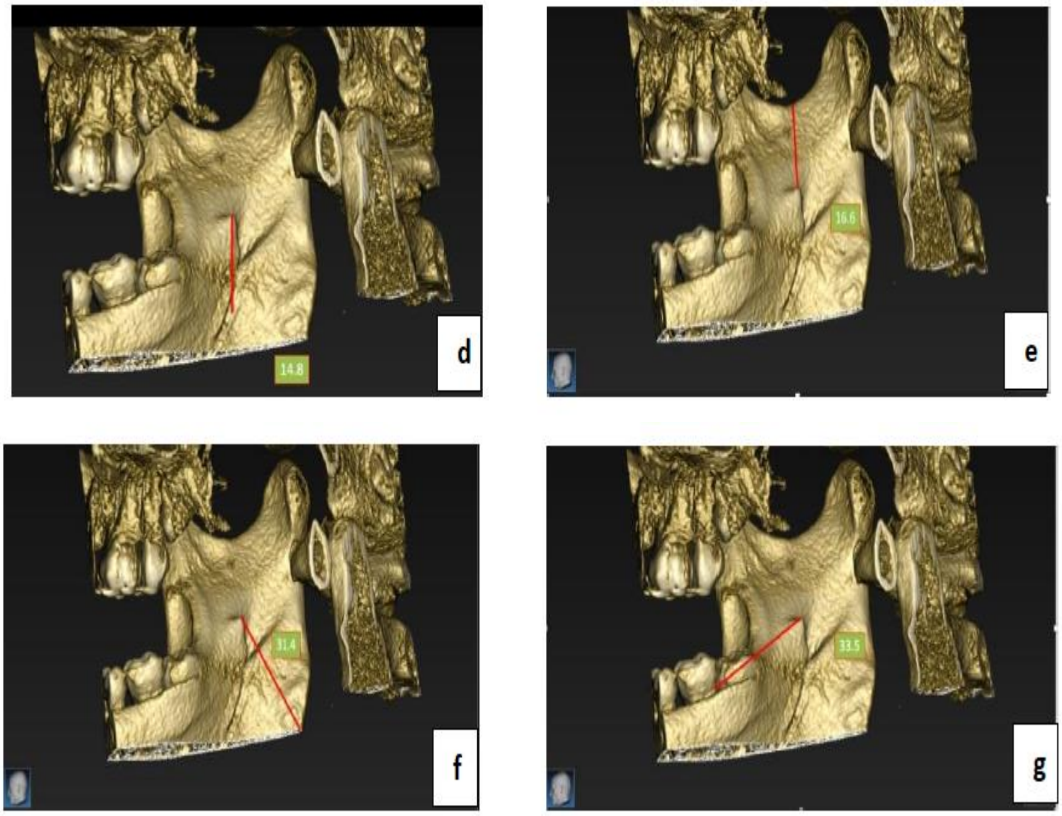



**Figure 1: (a) CBCT shows the measurement of the MA, (b) the distance between the ML & MF (c) Antero-posterior width of the ramus (d) ML- IL. (e) ML- SG distance (f) ML-GN distance (g) ML- distance M2.**

**Statistical analysis:** The data collected were processed, calculated, and analyzed using SPSS software (version 26). Measurements were taken to determine the position of the mandibular foramen (MF) and its distance from various anatomical landmarks on the mandible. Differences between genders and comparisons between the right and left sides were assessed using one-way ANOVA. A P-value of less than 0.05 was considered statistically significant.

**Compliance with ethical standards:** All procedures conducted in this study involving human participants adhered to the ethical guidelines set by the research ethics committee in Benghazi, Libya. As this study was retrospective in nature, formal consent from participants was not required.

**Study period:** The research was carried out over a period of five months, starting in October 2023 and concluding in May 2024.

## RESULTS

Measurements of distances from various mandibular landmarks for all subjects were calculated and are presented in Table 1. The samples were categorized by sex. The mean and standard deviation of different parameters were analyzed for males and females, and the results are displayed in Table 2. Comparisons between sexes showed statistically significant differences on both sides (Table 3).

Comparisons of mean and standard deviation between the right and left sides revealed statistically significant differences ($P < 0.01$) for most parameters, except for the antero-posterior width of the ramus, which showed no significant difference ($P > 0.05$). The mean mandibular angle was 124.5° in males and 113.25° in females, with a statistically significant gender-based difference ($P < 0.001$). At the ML level, the anteroposterior width of the ramus was significantly greater in males (35.99 ± 3.26 mm) compared to females (29.14 ± 2.59 mm) ($P < 0.001$). The distance of the ML from the CEJ of the second molar was statistically greater in females (33.7 ± 3.76 mm) than in males (27.14 ± 3.21 mm) ($P < 0.001$). A significant gender difference was also observed in the distance of the ML from the gonion ($P < 0.001$), with males having a greater distance. Additionally, significant gender variation was found in the distance between ML and MF, with males measuring 12.5 ± 2.26 mm and females measuring 8.89 ± 2.11 mm.

**Table 1: Measurement of the different parameters on the right and left sides among all subjects *(Asterisk= means statistically significant).***

| Measurement | All sample | | P-value |
|---|---|---|---|
| | Right side (mm) | Left side (mm) | |
| Mandibular angle (MA) | 121.2+7.1 | 115.7+11.6 | <0.001* |
| Distance between the lingula & mandibular foramen (L-F). | 11.4+2.5 | 9.7+2.9 | <0.001* |
| Antero-posterior width of the ramus (A-P) | 32.6+4.4 | 31.9+4.4 | 0.224 |
| The lingula to the internal oblique line (ML- IL) | 15.19+3.2 | 13.07+2.8 | <0.001* |
| Lingula to the sigmoid notch (ML-SG) | 16.63+3.53 | 14.98+2.6 | <0.001* |
| Lingula to the Gonion (ML- GN) | 32.5+4.5 | 28.18+4.83 | <0.001* |
| Lingula to the CEJ of the second molar | 32.13+4.5 | 29.2+4.6 | <0.001* |

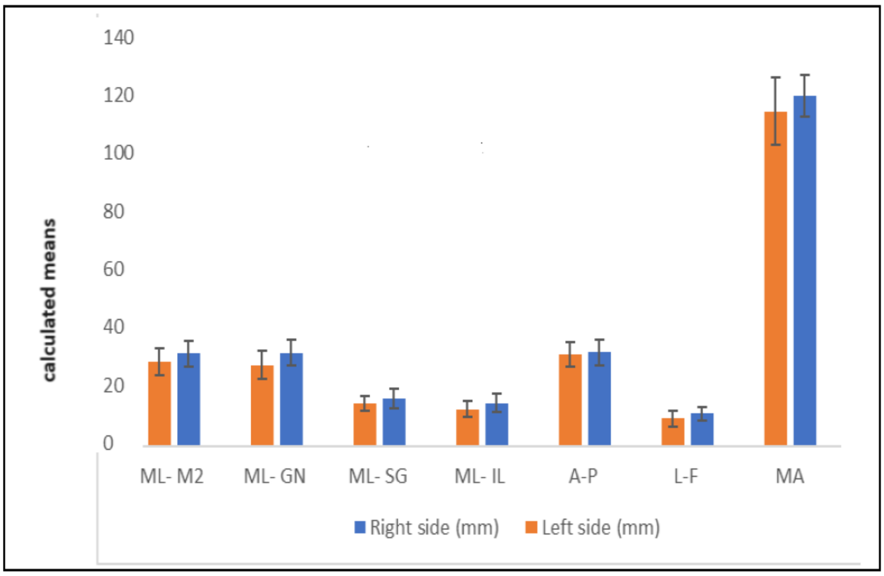



**Chart 1: Comparison of the means of different parameters on both sides.**

**Table 2: Comparison of the different parameters between male & female mandibles *(Asterisk= means statistically significant)*.**

| Measurement | All sample | | P value |
|---|---|---|---|
| | Male | female | |
| Mandibular angle | 124.5+4.7 | 113.25+10.36 | <0.001* |
| Distance between the lingula & mandibular foramen. | 12.5+2.26 | 8.89+2.11 | <0.001* |
| Antero-posterior width of the ramus | 35.99+3.26 | 29.14+2.59 | <0.001* |
| The lingula to the internal oblique line | 16.16+2.5 | 12.3+2.6 | <0.001* |
| Lingula to the sigmoid notch | 13.9+2.28 | 17.4+2.9 | <0.001* |
| Lingula to the Gonion | 33.5+5.06 | 27.6+3.3 | <0.001* |
| Lingula to the CEJ of the second molar | 27.14+3.21 | 33.7+3.76 | <0.001* |

**Table 3: Comparison of the different parameters between male and female on the right and left sides *(Asterisk= means statistically significant)*.**

| Measurement | Right side | | P value | Left side | | P value |
|---|---|---|---|---|---|---|
| | Male | Female | | Male | Female | |
| Mandibular angle | 127.5+4.2 | 115.7+3.9 | <0.001 | 121.6+3.14 | 110.7+13.7 | <0.001* |
| Distance between the lingula & mandibular foramen). | 13.1+2.15 | 10+1.8 | <0.001 | 12+2.26 | 7.7+1.6 | <0.001* |
| Antero-posterior width of the ramus | 36.1+3.4 | 29.6+2.7 | <0.001 | 35.7+3.1 | 28.6+2.28 | <0.001* |
| The lingula to the internal oblique line | 17.3+2.3 | 13.3+2.6 | <0.001 | 15+2.1 | 11.4+2.2 | <0.001* |
| Lingula to the | 14.3+2.4 | 18.6+3.1 | <0.001 | 13.4+2 | 16.2+2.3 | <0.001* |

| | | | | | | |
|---|---|---|---|---|---|---|
| sigmoid notch | | | | | | |
| Lingula to the Gonion | 35.9+4.3 | 29.6+1.7 | <0.001 | 31.1+4.5 | 25.6+3.4 | <0.001* |
| Lingula to the CEJ of the second molar | 28.7+2.8 | 35+3.7 | <0.001 | 25.4+2.6 | 32.3+3.3 | <0.001* |

## DISCUSSION

Precise identification of the ML and MF is essential for numerous orthognathic surgical procedures to avoid intraoperative complications, including bleeding or injury to the important adjacent vital structures.

Additionally, the IAN block is a frequent technique used in restorative dentistry and oral surgery procedures in the mandibular region. However, this technique is associated with a high degree of failure up to 20%.[19]

The anatomical description of the mandibular ramus remains somewhat controversial, particularly regarding the ML and MF. To ensure surgical success, it is essential to understand how to accurately localize the mandibular foramen based on nearby mandibular landmarks. This knowledge should be taken into account during the preoperative evaluation in the craniofacial field. Recent anatomical studies on the location of the mandibular foramen have primarily been conducted using dried mandible specimens.[6, 11, 20, 21] The findings of these researches may be immediately obtained, as the assessment of the dried mandible is quite accurate. However, comparing the values could be difficult as data on the age and sex of the dry mandibles are limited. Furthermore, a dry mandible is costly and difficult to find. Computers have lately made it possible to measure a wide range of anatomical measures. This is due to the development of software that uses computed tomography (CT) scans of a patient to create 3D reconstructions and analyses. Compared to dry mandible data, CT data are less expensive and convenient. In this study, a 3D model of the mandible was created using the patient's CBCT images and the position of the MF and ML relative to the adjacent landmarks were measured and analyzed. In craniofacial surgery, the mandibular angle is recognized as an important marker in the assessing the shape of the face.[22] In previous work, Hetson et al.[23] used a precisely engineered photographic method to evaluate the mandibular angle on 317 hemisected dry human mandibles and discovered that the mean mandibular angle was 123°. Following the measurement of sixty panoramic radiographs, Pirgousis et al.[24] found no statistically significant difference in the mean mandibular angle between males and females, measuring 123.43° for men and 123.6° for women. These results were inconsistent with the findings of the current investigation. The mean mandibular angle was 124.5° in males and 113.25° in females and there was a statistically significant difference in the mandibular angle based on gender (P<0.001).

When performing a horizontal osteotomy in the mandible, the distance from the MF must be precisely measured to avoid injuring the mandibular nerve. This safe distance can be calculated from the ML and should be at least 5 mm from the MF (4).

These distances were measured previously in many studies; however, the results were variables. While the MF was found midway between the sigmoid notch and the inferior border of the mandible in one study,[25] it was found to be more posteriorly in another.[26]

In the current study, at the ML level, the distance between the ML & MF, anteroposterior width of the ramus, and the ML to the internal oblique line were significantly greater in males than in females. These findings were in harmony with previous studies.[25] On the other hand, when it came to the ML to the sigmoid notch & ML to the CEJ of the second molar, these measurements were significantly greater in females than in males.

According to the study's findings, the males had considerably greater ML to the mandibular angle distances than females did, in terms of sex differences. The results of earlier research using CBCT and conventional radiography confirm this conclusion.[6] The mean distance from the ML to the IOL was 16.16+2.5 mm in males and 12.3+2.6 4.68±1.44 mm in females and there was a statistically significant difference based on gender (P<0.001). Consistently, this distance was higher than the results of Ennes and Medeiros.[6]

The relation of the MF to the mandibular plane is an important landmark that is routinely used to achieve successful IAN block anesthesia. Nicholson reported that in most cases, the MFs were below the occlusal plane, and only in less than a quarter of the cases, they are observed at the occlusal plane.[26] However, in our sample, we referred the ML to the CEJ of the second mandibular molar and the distances were 28.7+2 in males and 35+3 in females which have statically significant differences. These data give a clue on the position of the inferior alveolar nerve in orthognathic surgeries involving the mandibular ramus, such as mandibular angle reduction.

## CONCLUSION

Prior to dental procedures, it is essential to identify anatomical landmarks of the mandibular ramus, and the locations of these landmarks can vary depending on a person's gender, age, and ethnicity. Before undergoing surgery, a thorough CBCT examination of the anatomical structures is essential to avoid difficulties and preserve the neurovascular structures. In most of the measurements, males showed greater values than females. These findings give clinicians a point of reference for mandibular ramus procedures so they may execute manipulations with safe margins. It should be noted that CBCT's determination of the position of the ML prior to surgical treatments is greatly helpful.

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