# Morphometric and Morphologic Evaluation of the Mental Foramen in Relation to Age and Sex: An Anatomic Cone Beam Computed Tomography Study

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**Objective:** The aim of this study was to assess the vertical and horizontal position, angle, and diameter of the mental foramen (MF) according to sex and age by cone beam computed tomography in a Turkish patient population.

**Methods:** Cone beam computed tomography records of 192 consecutive patients consisting of 106 women and 86 men were examined, retrospectively. The vertical and horizontal positions of MF, angle and diameter of MF, and distance from MF to the alveolar crest and the base of the mandible were evaluated with respect to sex and age groups.

**Results:** There were statistically significant differences in the distance of MF to the alveolar crest according to age groups. When we compared the right and left sides, we have only found out statistically significant differences in the angles of MF and that it was higher in the left side.

**Conclusions:** From our results, the detection of the position of MF can provide detailed information for preoperative treatment planning (for surgery and dental implant surgery procedures), especially in the mandibular premolar region.

**Key Words:** Mental foramen, cone beam computed tomography (CBCT), alveolar crest

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The inferior alveolar canal, in which the mandibular nerve and the mandibular artery travel, typically hugs the lingual aspect of the mandible until it curves labially to exit the mandible at the mental foramen (MF), which, on the labial surface of the mandible, is between the first and second premolars at the level of the roots.[1] At the MF, the main trunk of the mandibular nerve exists as the mental nerve and supplies sensory fibers to the skin overlying the mandible and the lower lip. The location of the MF and also the course of the neurovascular bundle must be identified precisely before any surgical and dental implant surgery procedures to avoid possible damages. The location of the root apices in relation to the MF must also be determined before root-canal treatment of the premolars and molars. In the literature, there are various studies that have reported variations of MF location.[2–5] In addition, morphometric studies were also carried out for MF as size and shape in the literature.[6–9]

Many methods may be used to examine the MF such as direct examinations on dry skulls and radiologic examinations established by conventional radiography or computed tomography (CT). Conventional radiographic techniques collapse a three-dimensional structure onto a two-dimensional plane. The resulting superimposition of anatomic structures complicates image interpretation and landmark identification, and this distortion and magnification may lead to errors of identification.[10] Cone beam CT (CBCT) has recently been developed as an alternative to conventional CT for dental and maxillofacial osseous diagnostic tasks. The CBCT, which was also used in the present study, allows for a shorter scanning time and a lower radiation dose than a conventional CT scan.

The CBCT is capable of providing accurate, submillimeter-resolution images in formats allowing three-dimensional visualization of the complexity of the maxillofacial region.[11] Rather than capturing an image as separate slices as in medical CT, CBCT produces a cone-shaped x-ray beam that allows an image to be captured in a single shot. The resultant volume can be reformatted to provide axial, coronal, and sagittal reconstructed images that are similar to traditional medical CT images.[12] The MF can be clearly identified on axial, panoramic, or cross-sectional images by CBCT. The course of the neurovascular bundle can be clearly traced on the cross-sectional images as it enters the mandibular foramen on the lingual surface, travels through the inferior alveolar canal, and finally exits the MF on the buccal surface.

In the literature are few studies about MF location in a Turkish population.[13,14] The aim of the present study was to assess the vertical and horizontal position, angle, and diameter of the MF according to sex and age by CBCT in a Turkish patient population.

## MATERIALS AND METHODS

### Study Design

The study was carried out on a total of 192 patients (106 women and 86 men) who retrospectively reviewed the archive records of CBCT device. The overall mean age was 32.5 years (range, 18–55 y; SD, 13.8 y). Patients who had present inferior premolar teeth were included in the study group. This study was also approved by our local institutional ethical committee.

### Imaging Procedures

The cone beam images were taken with a NewTom 3G (Quantitative Radiology, Verona, Italy) flat panel-based CBCT device. The scanner operated with a maximum output of 110 KV, 15 mAs, and 0.16-mm voxel size, and typical exposure time was

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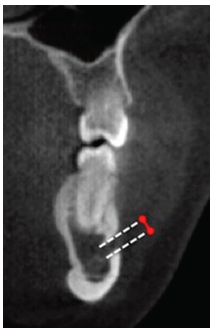

**FIGURE 1.** The cross-sectional slice shows the measurement of the vertical diameter of the MF.

5.4 seconds. Radiographic parameters were determined automatically from scout views by the NewTom FP. The horizontal plan review of MF was evaluated on the axial slices, which are slice thickness and intervals of 0.5 mm and a field of view (FOV) of 13 × 16 cm. These axial sections, taken from the records of the archive, will be parallel to the lower edge of the mandibular, where inclined reconstructions were obtained. The vertical plan review of MF was performed on the cross-sectional slices, which are slices with a thickness of 1 mm and an FOV area of 4 × 6 cm, and derived from indirect reconstructions of axial slices.

## Measurements

The vertical diameter of MF measured obliquely the upper and lower cortical edge peaks of the foramen on the cross-sectional slices (Fig. 1). The horizontal diameter of MF measured obliquely the mesial and distal cortical margin peaks of the foramen on the axial slices (Fig. 2).

The opening angle of the MF was measured on the cross-sectional slices (Fig. 3). First, a line, which runs from the peak lower cortical edge of the foramen to the foramen into, is horizontally drawn. In addition, when the second line, which runs from the peak upper cortical edge of the foramen to the foramen into, is obliquely drawn, the area between the 2 lines was measured as the angular. This first line is parallel to the lower edge of the base of the mandible (Fig. 3).

For the distance from MF to the top of the alveolar crest, with a line passing from the alveolar crest peak, from peak of the upper cortical edge of foramen to this line, the landing strut (90-degree projection) was measured as the distance (Fig. 4).

For the distance from MF to the base of the mandible, with a line passing from the lower edge of the base of the mandible, from the peak of the lower cortical edge of foramen to this line, the landing strut (90-degree projection) was measured as the distance (Fig. 4).

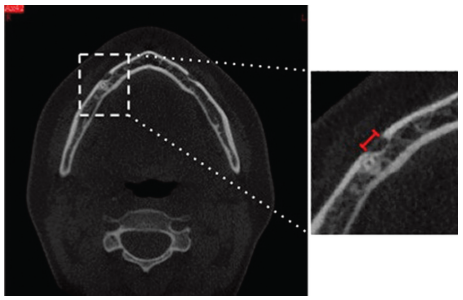

**FIGURE 2.** The axial slice shows the measurement of the horizontal diameter of the MF.

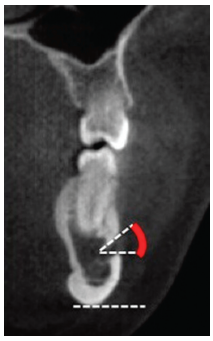

**FIGURE 3.** The cross-sectional slice shows the measurement of the opening angle of the MF.

## Statistical Analyses

Statistical analyses were conducted with the program SPSS (SPSS 20.0, Inc, Chicago, IL) for Windows. The 1-way analysis of variance test was used to determine differences in the diameter, distance to the base of the mandible and alveolar crest, and the angle of MF between age groups. The Student's *t*-test was used to determine the differences between sexes and to compare the right and left sides. $P < 0.05$ was considered to be statistically significant.

Three observers chosen by the study organizer performed the measurements and categorizations. Three observers, who are oral and maxillofacial radiologists and have experience with CBCT images for 5 years, performed the measurements and categorizations after providing calibration of each other. The 3 observers established all the parametric measurements, and the mean of the results was used to determine the reliability of the study. In addition, for the nonparametric categorizations, any conflict in decision was resolved by consensus.

# RESULTS

The diameter and distance to the base of the mandible and alveolar crest were higher in men than women, statistically in both the right and left sides (Table 1). The angle in the right side was also higher in men; however, there were no differences in the left side. There were statistically significant differences in the distance of MF to the alveolar crest according to age groups (Table 2). Thus, it was highest in patients between the ages of 21 and 40 years in both the right and left sides. Moreover, the angle of MF in the right side was highest in patients between the ages of 21 and 40 years; however, there were no differences in the left side. When we compared the right and left sides, we have only found statistically significant differences in the angles of the MF and that it was higher in the left side (Table 3). When we detected the position of MFs, it was

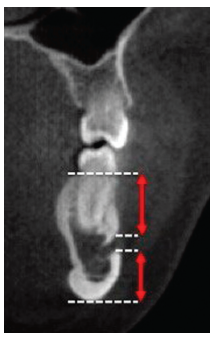

**FIGURE 4.** The cross-sectional slice shows the distance from MF to the top of the alveolar crest and the base of the mandible.

**TABLE 1.** The Right and Left and Vertical and Horizontal Position, Angle, and Diameter of MF According to Sex

| | Female | | Male | | | |
|---|---|---|---|---|---|---|
| | n | Mean (SD) | n | Mean (SD) | *t* | *P* |
| Right MF, basis distance | 106 | 12.17 (1.15) | 86 | 13.70 (1.56) | 7.785 | 0.000* |
| Left MF, basis distance | 106 | 12.37 (1.62) | 86 | 14.09 (1.77) | 6.998 | 0.000* |
| Right MF, crest distance | 106 | 11.19 (2.64) | 86 | 12.68 (2.67) | 3.873 | 0.000* |
| Left MF, crest distance | 106 | 11.25 (2.88) | 86 | 13.10 (3.10) | 4.263 | 0.000* |
| Right MF, horizontal diameter | 106 | 3.57 (0.99) | 86 | 4.14 (1.04) | 3.898 | 0.000* |
| Left MF, horizontal diameter | 106 | 3.60 (1.01) | 86 | 4.05 (0.91) | 3.239 | 0.001† |
| Right MF, vertical diameter | 106 | 3.12 (0.60) | 86 | 3.51 (0.69) | 4.175 | 0.000* |
| Left MF, vertical diameter | 106 | 3.19 (0.90) | 86 | 3.57 (0.77) | 3.099 | 0.002† |
| Right MF, angle | 106 | 54.66 (12.48) | 86 | 51.14 (8.90) | 2.197 | 0.029‡ |
| Left MF, angle | 106 | 58.07 (12.73) | 86 | 58.15 (13.40) | 0.043 | 0.966 |

*$P < 0.0001$; †$P < 0.005$; ‡$P < 0.05$.

observed that MFs were usually located between the first and second premolars, below the level of their root apices.

## DISCUSSION

The diagnostic and therapeutic procedures in dentistry, maxillofacial, and orthognathic surgery applications, especially in the planning of the placement of the implant, intraoperative and postoperative success and protection are of great importance for the detection of the MF. The location of the MF in the horizontal and vertical planes shows variability. In the horizontal plane, it is aligned with the long axis of a tooth or found to be in the area between the first and second premolars.[15]

Fishel et al[15] investigated vertical MF position and reported that, in the first premolar area of patients, the MF was situated coronal to the apex in 38.6% of cases, at the apex in 15.4% of cases, and apical to the apex in 46.0% of cases. The MF location, in relation to the second premolar, was coronal to the apex in 24.5% of cases, at the apex in 13.9% of cases, and apical to the apex in 61.6% of cases. When we studied the horizontal (buccolingually) and vertical (occluso-apically) positions of MFs, we observed that MFs were usually located between the first and second premolars, below the level of their root apices. It can be concluded that the foramen's location is not constant in the horizontal or vertical planes. Furthermore, the finding that it may be coronal to the apex of the root needs to be considered when performing immediate placement of dental implants in sockets.

Our results indicated that the mean (SD) horizontal diameter was 3.83 (1.04) mm and the mean (SD) vertical diameter was 3.29 (0.66) mm on the right side. On the left, these were 3.80 (0.99) and 3.36 (0.87) mm, respectively. These findings support those of previous reports. Yosue and Brooks[7] noted that the mean diameter of the MF was 3.5 mm, Solar et al[8] found a mean width of 5 mm, and Neiva et al[9] found a mean MF height of 3.47 mm (range, 2.5–5.5 mm) and a mean width of 3.59 mm (range, 2–5.5 mm).

In a Turkish population smaller than that in our study, Oguz and Bozkir[13] found the horizontal dimension of the MF to be 2.93 mm on the right side and 3.14 mm on the left side; the vertical dimension was 2.38 mm on the right side and 2.64 mm on the left side. In addition, in another Turkish population the same as in our results, Kalender et al[14] found that the vertical and horizontal sizes of the MF were 3.7 mm (range, 1.0–7.0 mm) and 3.4 mm (range, 0.8–7 mm), respectively.

When some studies in the literature are analyzed for shape, they declared that MF has an oval father than a round shape.[6,16] According to the mean horizontal and vertical diameters, the values of obtained from the study, we can say that MF exhibited an oval shape on both sides as well (Table 3).

There are few research studies viewing from the base of the mandible to the height of MF on the mandible, and the literature has reported that this mean distance was 14 to 15 mm.[17] When the MF is difficult to detect radiologically, when alveolar crests are extremely reabsorbed, or when an angled implant will be placed on a mandatory region of MF, the base of the mandible distance is more important in these cases. Neiva et al[9] reported this distance as 12.0 mm. This study detected that the distance ranging from MF to the base of the mandible was 12.86 mm on the right side and 13.13 mm on the left side. According to some studies in the literature, the

**TABLE 2.** The Right and Left and Vertical and Horizontal Position, Angle, and Diameter of MF According to Age

| | 0–20 y | | 21–40 y | | 40 y and Older | | |
|---|---|---|---|---|---|---|---|
| | n | Mean (SD) | n | Mean (SD) | n | Mean (SD) | *P* |
| Right MF, basis distance | 70 | 12.55 (1.77) | 56 | 12.98 (1.33) | 66 | 13.08 (1.42) | 0.105 |
| Left MF, basis distance | 70 | 12.73 (2.06) | 56 | 13.29 (1.48) | 66 | 13.44 (1.95) | 0.070 |
| Right MF, crest distance | 70 | 11.00 (1.99) | 56 | 12.66 (2.65) | 66 | 12.08 (3.25) | 0.002* |
| Left MF, crest distance | 70 | 10.85 (2.06) | 56 | 13.80 (3.25) | 66 | 11.92 (3.29) | 0.000† |
| Right MF, horizontal diameter | 70 | 3.73 (1.00) | 56 | 3.92 (1.55) | 66 | 3.86 (0.99) | 0.572 |
| Left MF, horizontal diameter | 70 | 3.75 (1.08) | 56 | 3.76 (1.02) | 66 | 3.88 (0.87) | 0.729 |
| Right MF, vertical diameter | 70 | 3.34 (0.70) | 56 | 3.35 (0.59) | 66 | 3.20 (0.68) | 0.374 |
| Left MF, vertical diameter | 70 | 3.38 (0.95) | 56 | 3.35 (0.88) | 66 | 3.35 (0.76) | 0.978 |
| Right MF, angle | 70 | 53.92 (10.80) | 56 | 55.38 (11.14) | 66 | 50.25 (11.04) | 0.029‡ |
| Left MF, angle | 70 | 58.04 (11.55) | 56 | 58.11 (15.16) | 66 | 58.16 (12.67) | 0.999 |

*$P < 0.005$; †$P < 0.0001$; ‡$P < 0.05$.

**TABLE 3.** The Right and Left Distributions of the Vertical and Horizontal Position, Angle, and Diameter of MF

| | Right | | Left | | | |
|---|---|---|---|---|---|---|
| | n | Mean (SD) | n | Mean (SD) | *t* | *P* |
| Basis distance | 192 | 12.86 (1.55) | 192 | 13.13 (1.89) | 1.595 | 0.111 |
| Crest distance | 192 | 11.86 (2.75) | 192 | 12.08 (3.12) | 0.740 | 0.460 |
| Horizontal diameter | 192 | 3.83 (1.04) | 192 | 3.80 (0.99) | 0.288 | 0.774 |
| Vertical diameter | 192 | 3.29 (0.66) | 192 | 3.36 (0.87) | 0.805 | 0.422 |
| Angle | 192 | 53.08 (11.13) | 192 | 58.10 (13.00) | 4.064 | 0.000* |

*$P < 0.0001$.

mean height ranging from MF to the top of the alveolar crest was reported as 3.47 mm.[9] According to the results obtained from the study, we discovered this height to have a mean (SD) of 11.86 (2.75) mm on the right side and 12.08 (3.12) mm on the left side.

In the literature, few studies examined the opening angle of the MF for mandible, and this angle was reported to be from 11 to 77 degrees to changing slopes.[8] According to the results of the study, this angle was observed to have a mean (SD) of 53.08 (11.13) degrees on the right side and 58.10 (13.00) degrees on the left side. The opening angle of MF is quite important for surgical procedures applied in that region. For example, the diameter and length of the dental implants may vary depending on the angle. Short or narrow implants may need to be used, or the entrance may need to be moved through the lingual surface, where the opening angle of the MF is greater, that is, the foramen opens higher than the level of the mandibular canal.

In the present study, dental CBCT imaging was used to evaluate the MF. Dental CBCT has been recommended for the imaging of anatomic landmarks before surgical procedures. The effective dose (International Commission on Radiological Protection 2007) from a standard dental protocol scan using a traditional CT was 1.5 to 12.3 times greater than comparable medium-FOV dental CBCT (eg, NewTom FP) scans.[18] Thus, as conventional CT devices were compared with CBCT, which differ from those of low scan time and radiation dose, and compared with panoramic radiographs, the actual sizes of angle and distance measurements were determined without causing any superimposition. So, CBCT is a useful tool for morphometric and morphologic examinations of the maxillofacial hard tissues as well as anatomic landmarks and also MF.

In the literature, there is no study that bilaterally evaluates the sizes of the MF, the opening angle of the MF, and the height from the base of the mandible and alveolar crest to MF. In this study, the MF was radiologically evaluated in relation to age and sex in Turkish patients. In the distances related to the MF, there was an emergence of a high rate in men than women especially in patients between the ages of 20 and 40 years. This state may be related to the longer continuance of development of the bones of men.

In conclusion, the detection of the MF position can provide detailed information for preoperative treatment planning (for surgery and dental implant surgery procedures), especially in the mandibular premolar region.

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