

Evaluation of mental foramen localization in children by age and gender using cone-beam computed tomography

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Abstract

Aim: This retrospective study was carried out to obtain detailed data on mental foramen localization differences, which can guide dental practices such as endodontic treatments, surgical procedures, and dental anesthesia, preventing complications. Cone-beam computed tomography (CBCT) images of individuals aged 7-18 were analyzed according to gender and age.

Methodology: The CBCT images of 120 individuals who met the research criteria were divided into six groups according to age, and 240 hemimandibles were measured. The gender distribution of the patients in each group was equal. Measurements were obtained using 3D volumetric images obtained via CBCT and the RadiAnt DICOM Viewer. When examining differences between groups, the Mann-Whitney U test was used for paired groups, and the Kruskal-Wallis H test and post hoc multiple-comparison tests were used for groups of more than two.

Results: Statistically significant differences in the parameters related to mental foramen localization were determined between the gender and age groups ($p < 0.05$). No statistically significant differences were found between the right and left sides of the individuals in all measurements ($p > 0.05$). Further, the mean values of the anatomical points were determined, which can be used to guide pediatric and general dentistry practices.

Conclusion: In the present study, the mean values of the anatomical points measured were determined. Our study suggests that these values can be used as a guide in pediatric and general dentistry applications, such as local anesthesia, endodontic treatments, and surgical operations.

Keywords: mental foramen, anatomical landmark, cone-beam computed tomography, RadiAnt DICOM viewer

Introduction

Dentists should know the anatomy of the working fields. The mental foramen (MeF) and associated neurovascular structures are anatomical structures that require attention because their locations are of great importance in dental treatment planning. The mental foramen is located on the outer lateral surface of the corpus mandible, partially between its upper and lower borders, in relation to the premolar teeth (1). The mental nerve, which is the terminal branch of the inferior alveolar nerve, is responsible for the sensory innervation of the vestibular gingiva, cheek, lower lip, and chin from the mesial to the midline of the first molar (2, 3). The MeF is considered a basic anatomical landmark that facilitates local anesthesia injection, surgical incisions, implant applications, periapical surgeries, and osteotomies in this region (4, 5).

Determining the distance between the mental foramen and other anatomical structures is crucial for providing effective nerve block anesthesia during dental procedures and preventing damage to the neurovascular bundle during surgical procedures and regional anesthesia (6, 7). However, the available data on the age, sex, and lateral variations of the mental foramen in children are inadequate (8). Mental nerve damage can lead to sensory dysfunction of the lower lip, surrounding skin, and mucosa. It has been reported that paresthesia resulting from nerve damage can continue for days, weeks, or months, or may even be permanent (9, 10). Therefore, preoperative radiographs are recommended before dental procedures (11). The mental foramen may not be visible on conventional radiographs. Dimensional distortions in radiographs should be considered in the linear measurements performed in two dimensions. The position of the mental foramen, its relationship with tooth roots and bone lesions, and the distance from adjacent structures can be accurately determined and measured using three-dimensional (3D) radiographs obtained via cone-beam computed tomography (CBCT). Recent studies have suggested that CBCT imaging is the most appropriate imaging technology for determining the correct position of the mental foramen (12, 13).

Conventional radiographs used in dental practice offer only two-dimensional examination for the localization of three-dimensional anatomical structures (14). Medical computed tomography (CT), which is used for three-dimensional examination in dentistry applications, has been replaced by cone-beam computed tomography (CBCT) in recent years. CBCT applications provide many advantages, such as a shorter scanning time and lower radiation dose compared with medical CT. CBCT allows the determination of the location of anatomical points in the maxillofacial region and the evaluation of these points in the axial, coronal, and sagittal planes (15).

Digital Imaging and Communications in Medicine (DICOM) has been established by physicians as the leading standard for the management and analysis of patient image data in medical practice and clinical

research. Various free software programs, such as OsiriX Lite, RadiAnt, Ginkgo CADx, Horos, K-PACS, MAYAM, and MITO, can display, import, and export DICOM data and create volume-rendered (VR) images (16).

RadiAnt DICOM Viewer 5.5.0 (64-bit) (Medixant Company, Poznan, Poland) allows users to open studies from CD/DVD, flash memory, local and network folders, and PACS locations. This software enables 3D examinations by generating volumetric data from images acquired in different planes. It allows cutting a 3D volumetric image using the program's "scalpel" feature, measuring length with the "length" feature, and measuring angle with the "angle" feature. It has been used in many studies in dentistry and medical science. Different imaging methods that can be processed in the RadiAnt DICOM Viewer include digital radiography, mammography, CT, CBCT, magnetic resonance, positron emission tomography, ultrasonography, digital angiography, endoscopy, and microscopy (17, 18).

The aim of this study was to retrospectively examine and evaluate changes in mental foramen localization using cone-beam computed tomography (CBCT) images according to sex and age to prevent complications during endodontic treatment, surgical procedures, and dental anesthesia applications.

Materials and Methods

This study was approved by the Dicle University Faculty of Dentistry Local Ethics Committee (Decision no: 2019/28). The archives of the Faculty of Dentistry, Department of Oral and Maxillofacial Radiology were retrospectively scanned. One hundred and twenty randomly selected tomography images of patients who applied for various purposes between 2018 and 2019 were included in the study. The voxel size of the CBCT images was 0.3 mm. The evaluation was performed on 240 hemimandibles using these images. CBCT images were acquired using a three-dimensional imaging device (i-CAT®, Model 17-19, Imaging Sciences International, Hatfield, PA, USA). The images were saved on a computer in the DICOM format for analysis using RadiAnt DICOM Viewer 5.5.0 software.

In the present study, patients with developmental disorders, systemic or metabolic bone disease, projection errors or artifacts, pathologies such as cysts and tumors in the mandible, osteomyelitis in the mandible, and mandibular fractures were excluded from the study. High-quality CBCT scans were included in this study.

In order to examine the tomographic images of patients aged 7-18 years who met the inclusion criteria, the images were divided into six groups (7-8 years (10 girls + 10 boys) / 9-10 years (10 girls + 10 boys) / Ages 11-12 (10 girls + 10 boys) / 13-14 years (10 girls + 10 boys) / 15-16 years / 17-18 years (10 girls + 10 boys) were divided equally by gender in each group.

Measurements related to the mental foramen were made on the 3D volumetric image obtained using the

Radiant DICOM Viewer program from the CBCT images. The measurement of the parameters was evaluated by a single observer (H.K.B.) in the right and left regions. In our study, no intervention was performed on the patients, including re-examination, and the study was completed retrospectively.

CBCT images recorded in DICOM format were transferred to the RadiAnt DICOM Viewer (5.5.0) software to examine the mental foramen (Fig. 1).

With RadiAnt DICOM Viewer (5.5.0), multiplanar reconstruction of images in DICOM format and 3D volumetric images can be obtained (Fig. 2).

Instead of measuring the distance of the mental foramen to the determined anatomical points on the 3D volumetric image obtained in the entire image, the "scalpel" feature of the program was used to perform it only on the mandible (Fig. 3).

On the three-dimensional volumetric image obtained by transferring CBCT images saved in DICOM format to the RadiAnt DICOM Viewer (5.5.0) program for analysis, the distance from the anterior border of the mental foramen to the symphysis (MeF-SM) and the distance from the posterior border of the mental foramen to the posterior border of the ramus (MeF-RA) were measured parallel to the horizontal line known as the plane on which the mandible sits (Figs. 4, 5).



Figure 3. Cutting with the "scalpel" feature of the program on the 3D volumetric image obtained using the RadiAnt DICOM Viewer.

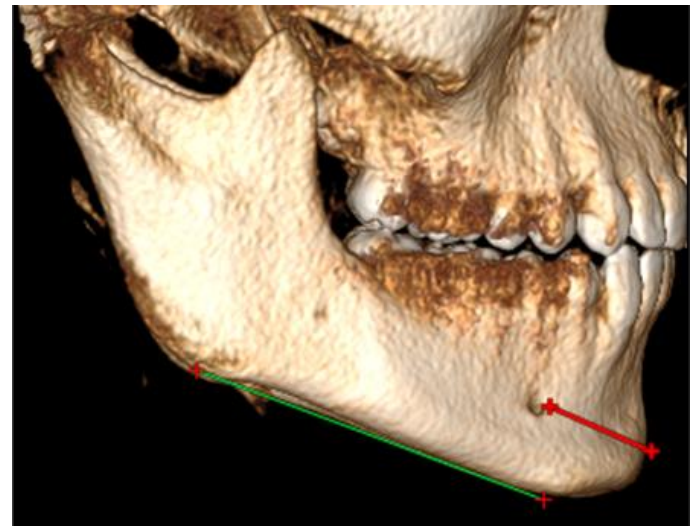


Figure 4. Measurement of the distance from the anterior border of the mental foramen to the symphysis.

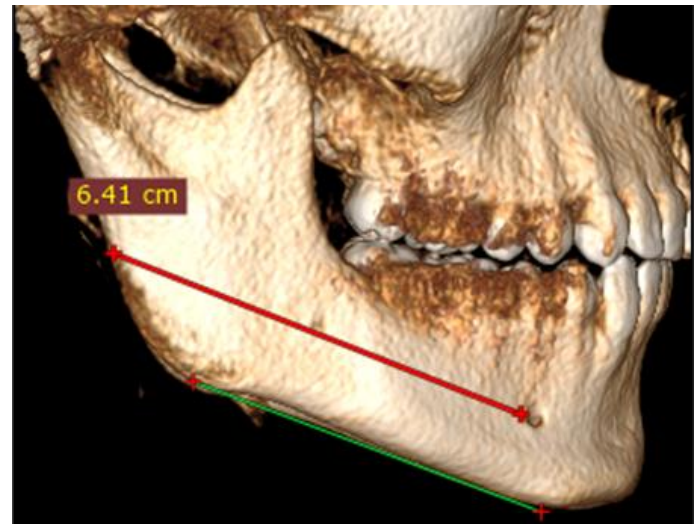


Figure 5. Measurement of the distance from the posterior border of the mental foramen to the posterior border of the ramus.

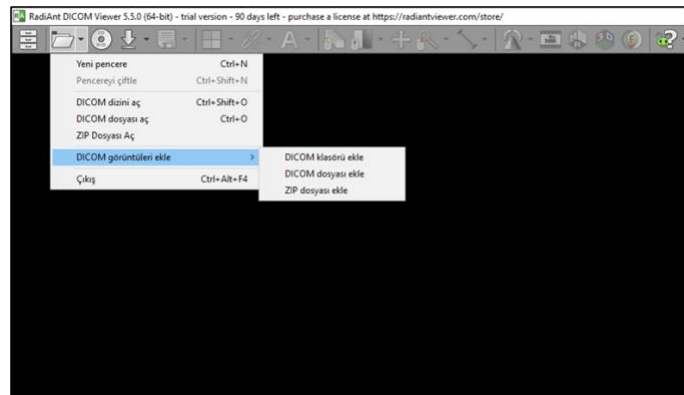


Figure 1. Transferring images in DICOM format to RadiAnt DICOM Viewer (5.5.0).



Figure 2. Obtaining multiplanar reconstruction and 3D volumetric image from CBCT data with RadiAnt DICOM Viewer

Statistical Analysis

Analyses were performed using the SPSS software (version 21.0; IBM Corp., Armonk, NY, USA).

Shapiro-Wilk's test was used due to the number of units while investigating the normal distribution of the variables. The significance level was set at 0.05; $p < 0.05$ indicated that the variables did not follow a normal distribution, and $p > 0.05$ indicated that the variables followed a normal distribution. While examining differences between the groups, Mann-Whitney U tests were used for paired groups and Kruskal-Wallis H tests for more than two groups, since the variables did not follow a normal distribution.

In the case of significant differences in the Kruskal-Wallis H test, the groups with differences were determined using the Post-Hoc Multiple Comparison test.

Results

In the present study, a statistically significant increase was observed in the age-related MeF-SM distance value between the six study groups on the right and left sides of the individual ($p < 0.05$) (Table 1).

When the multiple comparison test was performed on the MeF-RA distance values between the groups, the MeF-RA value of Group 1 on the right was found to be significantly lower than that of Groups 3, 4, 5, and 6. The MeF-RA value of Group 3 on the right side was significantly lower than that of Group 5. On the left, the MeF-RA value of Group 1 was significantly lower than that of Groups 3, 4, 5, and 6. The MeF-RA value of Group 2 was significantly lower than that of Groups 4, 5, and 6. ($p < 0.05$) (Table 1). There was no statistically significant difference when MeF-SM measurements were compared between individuals' right and left sides ($p > 0.05$) (Table 2).

Table 1. The mean (mean), minimum (min), maximum (max), and standard deviation (ss) values of the distance from the anterior border of the mental foramen to the symphysis (MeF-SM) measurements in age groups on the right and left sides.

Groups (right side)	n	Mean (mm)	Min. (mm)	Max. (mm)	ss	H*	p*
Group 1 (7-8 years)	20	15.39	13.8	16.7	0.9	75.343	0.001
Group 2 (9-10 years)	20	16	13.2	19.3	1.49		
Group 3 (11-12 years)	20	18.86	17.3	22.5	1.18		
Group 4 (13-14 years)	20	21.59	18.8	26.4	2.3		
Group 5 (15-16 years)	20	21.19	18.9	26.6	2.52		
Group 6 (17-18 years)	20	20	17.7	21.5	2.06		
Total	120	20.86	13.8	26.6	2.25	(1-3/ 1-4/ 1-5/ 1-6/ 2-4/ 2-5 2-6/ 3-5)*	
Groups (left side)	n	Mean (mm)	Min. (mm)	Max. (mm)	ss	H*	p*
Group 1 (7-8 years)	20	15.69	13.2	16.9	1.2	75.197	0.001
Group 2 (9-10 years)	20	16	13	18.3	1.3		
Group 3 (11-12 years)	20	19.6	17.3	22	1.08		
Group 4 (13-14 years)	20	20.59	18.8	25.4	1.09		
Group 5 (15-16 years)	20	19.9	18.9	25.9	1.05		
Group 6 (17-18 years)	20	20	17.7	21.5	1.15		
Total	120	20.79	13.2	25.9	1.87	(1-3/ 1-4/ 1-5/ 1-6/ 2-4/ 2-5/ 2-6)*	

*Findings were obtained using the Kruskal-Wallis H and multiple comparison tests.

Table 2. Findings of the evaluation of the distance from the anterior border of the mental foramen to the symphysis (MeF-SM) measurements between individuals' right and left sides using the Mann-Whitney U test, including the mean, minimum (min), maximum (max), and standard deviation (ss) values.

Side	n	Mean (mm)	Min. (mm)	Max. (mm)	ss	z	P
Right side	120	20.86	13.8	26.6	2.25	-0.071	0.944
Left side	120	20.79	13.2	25.9	1.87		
Total	240	20.83	13.2	26.3	2.06		

When the MeF-SM distance values of the sexes were compared, statistically significant results were found in favor of males ($p<0.05$) (Table 3).

There was a statistically significant increase in the age-related MeF-RA distance value between the six study groups on the right and left sides of the individual ($p<0.05$) (Table 4).

When multiple comparison tests were performed on the MeF-RA distance values between the groups, the MeF-RA value of Group 1 on the right side was significantly lower than those of Groups 3-6. ($p<0.05$).

The MeF-RA values of Groups 2 and 3, according to Groups 5 and 6; the MeF-RA value of Group 4 was significantly lower than that of Group 6 ($p<0.05$). On the

left side, the MeF-RA value of Group 1 was significantly lower than those of Groups 3-6 ($p<0.05$). The MeF-RA values of Groups 2 and 3 were significantly lower than those of Groups 5 and 6. The MeF-RA value of Group 4 was significantly lower than that of Group 6 ($p<0.05$) (Table 4).

When the MeF-RA distance measurements were compared between individuals' right and left sides, no statistically significant difference was observed ($p>0.05$) (Table 5).

When the MeF-RA distance values between the sexes were compared, statistically significant results were found in favor of males ($p<0.05$) (Table 6).

Table 3. Findings of the evaluation of the distance from the anterior border of the mental foramen to the symphysis (MeF-SM) measurements between genders using the Mann-Whitney U test, including the mean, minimum (min), maximum (max), and standard deviation (ss) values.

Gender	n	Mean (mm)	Min. (mm)	Max. (mm)	ss	z	p
Male	120	20.96	14	26.6	1.98	-2.329	0.02
Female	120	20	13.2	19	2.08		
Total	240	20.83	13.2	26.6	2.06		

MeF-SM: distance from the anterior border of the mental foramen to the symphysis

Table 4. The mean, minimum (min), maximum (max), and standard deviation (sd) values of the MeF-RA distance in the age groups on the right and left sides.

Groups (right side)	n	Mean (mm)	Min. (mm)	Max. (mm)	ss	H*	p*
Group 1 (7-8 years)	20	52.18	48.5	54.8	2.02	93.529	0.001
Group 2 (9-10 years)	20	57.42	55	61.5	1.69		
Group 3 (11-12 years)	20	59.68	56.4	62.5	1.77		
Group 4 (13-14 years)	20	60.78	56.4	67	3.23		
Group 5 (15-16 years)	20	64.76	60.6	69.6	2.9		
Group 6 (17-18 years)	20	66.7	60.7	72	3.48		
Total	120	59.25	48.5	72	5.42	(1-3/ 1-4/ 1-5/ 1-6/ 2-5/ 2-6/ 3-5/ 3-6/ 4-6)*	
Groups (left side)	n	Mean (mm)	Min. (mm)	Max. (mm)	ss	H*	p*
Group 1 (7-8 years)	20	51.71	47.3	54.9	1.84	92.967	0.001
Group 2 (9-10 years)	20	57.51	55.9	59.7	1.37		
Group 3 (11-12 years)	20	59.04	56.6	62	1.61		
Group 4 (13-14 years)	20	60.73	56	66.9	3.38		
Group 5 (15-16 years)	20	64.52	60.3	69.5	2.76		
Grup 6 (17-18 years)	20	66.12	60.4	72.1	3.54		
Total	120	58.94	47.3	72.1	5.37	(1-3/ 1-4/ 1-5/ 1-6/ 2-5/ 2-6 3-5/ 3-6/ 4-6)*	

* Findings were obtained using the Kruskal-Wallis H test and multiple comparison tests.

Table 5. Findings of the evaluation of MeF-RA measurements between the right and left sides of the individual using the Mann-Whitney U Test. Mean (mean), minimum (min), maximum (max), and standard deviation (ss) value.

Side	n	Mean (mm)	Min. (mm)	Max. (mm)	ss	z	p
Right side	120	59.25	48.5	72	5.42	-0.403	0.687
Left side	120	58.94	47.3	72.1	5.37		
Total	240	59.1	47.3	72.1	5.39		

Table 6. Findings of the evaluation of MeF-RA measurements between the sexes using the Mann-Whitney U test. Mean (mean), minimum (min), maximum (max), and standard deviation (ss) value.

Gender	n	Mean (mm)	Min.(mm)	Max. (mm)	ss	z	p
Male	120	60.76	49.8	72.1	5.8	-4.69	0.001
Female	120	58.43	47.3	66.7	4.36		
Total	240	59.1	47.3	72.1	5.39		

Discussion

The mental foramen is an important anatomical structure that should be considered during dental procedures. Determination of the distances of this structure to certain anatomical points helps prevent damage to the inferior alveolar nerve and its branches during various operations, such as local anesthesia, endodontic treatments, impacted tooth extraction, cyst and tumor excision, placement of miniscrews for orthodontic anchorage purposes, and the application of osteosynthesis plates and screws in trauma cases (19, 20).

Various measurement methods have been used in dry bone, cadaver, and radiographic studies to determine the localization of mandibular anatomical structures. However, such studies in pediatric groups are limited (8, 21). In studies involving dry bones, sex and age assessments could not be made accurately. Panoramic radiography provides a general field of view in dental practice. However, as stated in many studies, they have some disadvantages, such as the possibility of examining only two dimensions in detecting anatomical points and the occurrence of magnification and superimposition in images (22, 23).

Computed tomography (CT), a 3D imaging method, has been used in dentistry for many years. In the last 10 years, it has been replaced by cone-beam computed tomography (CBCT). Compared with CT, CBCT has important advantages, such as lower radiation doses and shorter imaging times. Furthermore, CBCT allows the localization of anatomical points in the maxillofacial region and the evaluation of these points in the axial, coronal, and sagittal planes (15). Recent studies have

suggested that CBCT imaging is the most appropriate imaging technology for determining the correct position of anatomical points (12, 13).

RadiAnt DICOM Viewer 5.5.0 (64-bit) is a software for processing and viewing medical images in DICOM format. It has been used in many studies in dentistry and medical science (17, 18). The RadiAnt DICOM Viewer 5.5.0 (64-bit) program, which enables 3D examinations by creating volume information from images in different planes, allows users to make cuts on the 3D volumetric images and perform length and angle measurements.

Various guide points can be used to determine the localization of the mental foramen. In the present study, the distance of the mental foramen to two different reference points (MeF-SM and MeF-RA) was measured. The distances of the mental foramen to the symphysis and posterior surface of the ramus were determined using 3D volumetric images obtained using the RadiAnt DICOM Viewer program.

Kökten et al. (24) reported an average MeF-SM value of 25.73 mm and an average MeF-RA value of 65.80 mm in their study on adult dry mandibles. In contrast, Gupta et al. (25) reported a mean MeF-SM value of 29.12 mm and an MeF-RA value of 76.16 mm using the same method.

Sheikhi et al. (26) found the mean MeF-SM value to be 27.77 mm in their study using CBCT in adults. Afkhami et al. (6) reported the MeF-SM value of 25.58 mm in their study, in which they evaluated individuals aged 18-40 years using panoramic radiography. Apinhasmit et al. (27), Prabodha et al. (28), Budhiraja et al. (29), and Udhaya et al. (30), who examined MeF-related measurements in the dry mandible, found the MeF-RA values to be 68.88, 65.38, 65.94, and 64.21 mm, respectively.

In the present study, the mean MeF-SM value was 20.83 mm, and the MeF-RA value was 59.1 mm. In the literature review, only one study was found that evaluated the MeF-SM value in pediatric age groups (31). In this study, the MeF-SM value was reported to be 21.5 mm on average, similar to our study. Kökten et al.(24), Gupta et al.(25), Sheikhi et al.(26), Apinhasmit et al. (27), Prabodha et al. (28), Budhiraja et al. (29) The difference between the MeF-RA and MeF-SM distance values determined by Udhaya et al. (30) and the values determined in our study; We suggest that it is due to the ethnic diversity of the population, the age groups studied and the use of different measurement methods.

Dotto et al. (32) reported that there may be some changes in the position of the mental foramen with age in their study with panoramic radiography in individuals aged 10-12 years. Smartt et al. (33) reported that the total size of the mandible increases significantly during pubertal growth spurt between the ages of 11-17, and significant changes occur in mandibular height with puberty. Since our study group was in the growth and development period, in the comparison of all MeF measurements between age groups, a statistically significant positive correlation was found, in line with the studies of Dotto et al. and Smartt et al.

Gungor et al. (7), Sheikhi et al. (26), Haktanir et al. (34), and Chandra et al. (35) reported significant statistical differences in favor of males between gender groups in their measurements of distance to MeF.

In the present study, Gungor et al. (7), Sheikhi et al. (26), Haktanir et al. (34), and Chandra et al. (35) reported statistically significant differences between gender groups, favoring males, in distance measurements to MeF. Studies indicating that males generally have stronger muscles and more bite force than females suggest that more bone deposition is observed along the lower border of the mandible in males than in females (36, 37). We believe that sex hormones, habits, diet, and masticatory muscle strength may affect bone development in both sexes.

Sheikhi et al. (26), and Haktanir et al. (34) did not report a statistically significant difference between the measurements related to MeF along the right and left sides of individuals. Compared with the MeF measurements on the right and left sides of participants in our study, Sheikhi et al. (26) and Haktanir et al. (34) found no statistically significant difference.

Conclusion

In the present study, the mean values of the measured anatomical points were determined. We suggest that these values can be used as a guide in pediatric and general dentistry applications, such as local anesthesia, endodontic treatments, and surgical operations. Since these anatomical points may differ among individuals, the authors propose that the use of 3D imaging methods will be beneficial before invasive surgical procedures.

Disclosures

Ethical Approval: Ethics committee approval for this study was obtained from the Non-Interventional Clinical Research Ethics Committee of the Dicle University Faculty of Dentistry, in accordance with the World Medical Association Declaration of Helsinki, with approval number 2019/28.

Peer-review: Externally peer-reviewed.

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