Original Article

Localization of the mandibular foramen of 8-18 years old children and youths with cone-beam computed tomography

Mustafa Altunsoy[1]*, Osman Sami Aglarci[2], Evren Ok[3], Bilge Gulsum Nur[1], Enes Gungor[4], Mehmet Colak[4]
Departments of [1]Pediatric Dentistry, [2]Oral and Maxillofacial Radiology, and [3]Endodontology, Faculty of Dentistry, Sifa University, Izmir, [4]Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Dicle University, Diyarbakir, Turkey

ABSTRACT

The aim of this study was to determine the location of mandibular foramen (MF) of 8-18 years old Turkish individuals by analyzing cone-beam computed tomography (CBCT) images. CBCT images of 63 females and 64 males with an age range of 8-18 years were examined. The distance of the MF to the anterior border of the ramus (A), posterior border of the ramus (P), inferior point of the mandibular incisura (MI), superior point of the curvature of the mandibular notch (MN), and the straight line of the cusps of the mandibular permanent molars (O) were measured and recorded. Data were analyzed by one-way analysis of variance (ANOVA), the Bonferroni test, independent *t*-test, and Student's *t*-test at a significance level of $P < 0.05$. The MN-MF, MI-MF, A-MF, and MN-MF values of females aged 9, 13, 14, and 18 were statistically higher than those of males aged 9, 13, 14, and 18 ($P < 0.05$). There were no significant differences in the O-MF values or A-MF values among the age groups ($P > 0.05$); however, the P-MF, MI-MF, and MN-MF values increased with age ($P < 0.05$). This study concluded that the location of the MF is just posterior to the middle of the ramus, 2.5-3.6 mm above the occlusal plane of the molars. The P-MF, MI-MF, and MN-MF values increase with age.

Key words: Anatomic Landmarks, Cone-beam Computed Tomography, Mandibular Nerve

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INTRODUCTION

The comfort of many dental treatments depends on achieving excellent local anesthesia. Pain-free treatment provides comfort to the patient, as well as helping the operator. Since such treatment can be performed in a calm and unhurried manner. Deep and efficient anesthesia is of considerable importance for pediatric dentistry, endodontics, and surgery. However, many dentists have experienced local anesthetic failure. One of the causes of such failure is the different location of anatomic structures.[1] Anesthetic techniques vary for the jaws. It is easy to provide anesthesia in the maxilla, but in the mandible, some difficulties may be encountered.[2] The most frequent technique failure in anesthesia of the inferior alveolar block involves the inappropriate setting of the needle due to the inaccurate location of anatomic structures in mandibular foramen (MF).[3] Therefore, knowledge of the position of the MF is extremely important in clinical dentistry, medicine or health sciences to anesthetize the hard and soft tissues in the mandible.[4] Incorrect estimation of its location might explain unsuccessful anesthesia of the inferior alveolar nerve.[3]

The MF cannot be palpated clinically; therefore, there are specific landmarks used to determine its location. The external and internal oblique ridges, the anterior border of the ramus, and the occlusal plane are examples of landmarks that can be used to determine the position of the MF.[5] The position of the MF has been determined in several studies.[2-4] The methods used in these studies were different and including examination of dried human mandibles[2,4,6,7] as well as analysis of panoromic and cephalometric radiographs.[5]

***Address for correspondence**
Dr. Mustafa Altunsoy, Department of Pediatric Dentistry, Faculty of Dentistry, Sifa University, Izmir 35100, Turkey.
E-mail: dtaltunsoy@gmail.com

Cone-beam computed tomography (CBCT) scanning has been used in dentistry since 1990.[8] It uses a cone-shaped beam of radiation to acquire data in a single 360° rotation, which reveals the internal structure of an object. In comparison with conventional CT imaging, CBCT exhibits improved accuracy, higher resolution, lower scan time, and lower radiation doses.[9] CBCT scanning was used for diagnosis and identification of the location of anatomic structures in several studies.[10,11] However, to our knowledge, no data are available in the literature on the determination of location of MF using CBCT. Therefore, the aim of this retrospective study was to determine the location of the MF of 8-18 years old Turkish individuals by analyzing CBCT images.

MATERIALS AND METHODS

This retrospective study was composed of CBCT images from 127 children and youths that diagnosed at the Dicle University, Department of Oral and Maxillofacial Radiology between May 2009 and April 2012. All patients were from the South-Eastern region of Turkey. Only good quality CBCT images were analyzed. CBCT images of 63 females and 64 males with an age range of 8-18 years were examined. The right and left MFs of each patient were analyzed and hence the study consisted of 254 images of MF. Each patient's name, age, and gender were recorded and the subjects were divided into 11 age-groups.

The CBCT images were obtained using a CBCT scanner (I-CAT Vision TM Imaging Science International, Hatfield, USA, 2008) at 120 kVp and 18.54 mA, with an exposure time of 8-9 s. The voxel size of the images was 0.3 mm. An experienced radiologist acquired the images according to the manufacturer's instructions.

A maxillofacial radiologist assessed all the images. The location of the MF was investigated radiographically by CBCT [Figure 1] and the following measurements were recorded:

1. The shortest distance between the anterior border (A) and MF;
2. The shortest distance between the posterior border (P) and MF;
3. The shortest distance between the inferior point of the mandibular incisura (MI) and MF;
4. The shortest distance between the most superior point of the curvature of the notch (mandibular notch [MN]) and MF; and
5. The distance between the straight line of the cusps of the mandibular permanent molars (O) and MF [Figure 2].

All measurements were registered in millimeters. Data were analyzed by one-way ANOVA, the Bonferroni test, independent *t*-test, and Student's *t*-test at a significance level of $P < 0.05$. All statistical analyses were performed using SPSS (version 17.0; SPSS Inc., Chicago, IL, USA) software.

RESULTS

There were no significant differences in measurements between the right and left side of the mandible; therefore two values of the distance of landmarks to the MF were obtained from each patient [Table 1]. The means and distribution of ages, as well as distances from the examined landmarks to the MF with the standard deviations are summarized in Table 2. Females with aged 9, 13, 14, and 18 exhibited statistically higher values of MN-MF, MI-MF, A-MF, and MN-MF than males in the same age groups ($P < 0.05$); however, other measurements did not vary significantly by gender ($P > 0.05$) [Table 2]. The statistical comparison of the

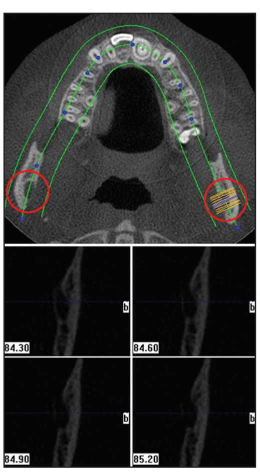

Figure 1: Location of the mandibular foramen with axial view on cone-beam computed tomography image

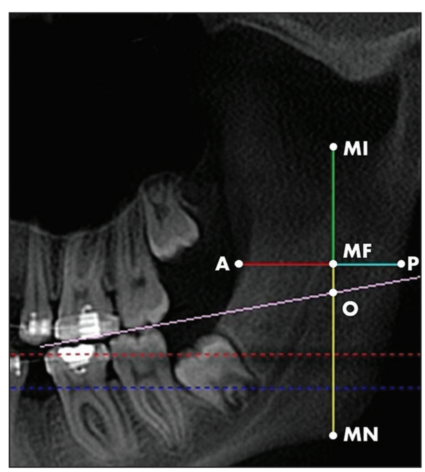

Figure 2: Images of landmarks used in the present study. A: Anterior border of the ramus; P: Posterior border of the ramus; mandibular incisura: Inferior point of the mandibular incisura; mandibular notch: The most superior point of the curvature of the notch; O: The straight line of the cusps of the mandibular permanent molars

values of the age groups is presented in Table 3. There were no significant differences in the O-MF values and among A-MF values according to the age groups ($P > 0.05$); however, the P-MF, MI-MF, and MN-MF values increased with age ($P < 0.05$) [Table 3].

DISCUSSION

Awareness of the position of the MF is of great importance for many procedures in dentistry. Its definitive location enables more effective anesthesia. Pain-free treatment provides comfort to the patient, and helps the operator to carry out such treatment in a calm and unhurried manner.[12,13] The MF cannot be palpated clinically; therefore, there are specific landmarks to determine its location such as the external and internal oblique ridges, the anterior border of the ramus, and the occlusal plane. These are used to determine the placement of the needle for the inferior alveolar nerve block.[5] In the literature, studies on determining the location of MF were performed with dried human skulls,[4-7] panoramic radiographs,[5-14] cephalometric radiographs[5] and conventional tomography.[14]

Studies for determining the localization of the MF have commonly been carried out using panoramic radiographs;[5-14] however, they have some disadvantages, such as image magnification, loss of definition, and less accurate diagnostic value.[12-15] Thus, deviations can be shown when it comes determining the location of the MF. Lindh *et al.*[14] measured the distances between the superior border of the canal and the alveolar crest and

Table 1: Comparison of the measurements between the right and left side of the mandible mean (SD) (mm)

Gender	*n*	A-MF		P-MF		MI-MF		MN-MF		O-MF		Significant of right-left
		Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	
Female	63	15.7 (2.2)	15.8 (2.3)	11.8 (2.0)	12.0 (1.8)	17.3 (2.5)	17.3 (2.2)	23.2 (2.9)	23.3 (2.9)	2.6 (1.0)	2.4 (1.0)	P>0.05
Male	64	16.2 (2.3)	16.4 (2.1)	12.1 (2.2)	12.2 (2.2)	18.4 (3.3)	17.7 (2.8)	24.4 (4.8)	24.4 (4.7)	2.58 (1.1)	2.6 (1.1)	P>0.05

A: Anterior border of the ramus, P: Posterior border of the ramus, MI: Inferior point of the MI, MN: The most superior point of the curvature of the notch, O: The straight line of the cusps of the mandibular permanent molars. SD: Standard deviation, MF: Mandibular foramen, MI: Mandibular incisura, MN: Mandibular notch

Table 2: Mean and SDs of distances from each landmark to the mandibular foramen mean (SD) (mm)

Age	*n* (%)	A-MF		P-MF		MI-MF		MN-MF		O-MF	
		Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
8	38 (15.0)	15.7 (2.1)	16.3 (1.6)	11.2 (1.3)	10.9 (1.2)	15.6 (1.2)	15.7 (2.2)	21.0 (2.0)	20.6 (2.3)	2.3 (0.9)	2.5 (1.0)
9	34 (13.4)	17.1 (1.4)	16.2 (2.2)	10.6 (1.5)	10.9 (1.7)	16.9 (2.2)	16.9 (2.5)	18.8 (1.2)	22.3 (2.2)	2.8 (0.8)	2.2 (1.0)
10	22 (8.7)	15.6 (1.9)	15.8 (2.7)	11.7 (1.1)	11.5 (1.6)	15.4 (1.2)	16.9 (1.9)	19.6 (1.5)	21.1 (1.9)	2.2 (0.9)	2.3 (0.9)
11	20 (7.9)	15.7 (2.9)	16.2 (2.7)	12.5 (2.8)	11.3 (0.7)	17.4 (2.0)	16.2 (1.9)	23.8 (2.9)	21.9 (1.6)	2.2 (0.8)	1.9 (1.2)
12	20 (7.9)	16.4 (1.3)	15.1 (3.0)	12.3 (1.5)	11.6 (2.0)	19.9 (2.5)	18.3 (2.6)	23.4 (1.9)	23.5 (4.1)	1.9 (0.8)	2.7 (1.8)
13	20 (7.9)	15.2 (1.7)	15.4 (2.2)	12.2 (1.8)	13.8 (2.8)	17.1 (1.6)	20.7 (2.6)	23.1 (2.5)	24.4 (2.4)	2.7 (0.7)	2.9 (1.3)
14	20 (7.9)	15.8 (2.4)	18.4 (1.7)	12.4 (1.9)	14.6 (1.3)	18.4 (1.7)	19.8 (3.3)	24.7 (1.2)	24.8 (3.4)	2.9 (1.1)	3.6 (1.0)
15	20 (7.9)	16.2 (3.2)	16.3 (1.3)	13.1 (2.2)	13.7 (1.5)	17.1 (2.5)	19.1 (2.1)	24.3 (2.2)	25.1 (3.7)	2.6 (1.4)	2.5 (0.5)
16	20 (7.9)	15.4 (2.2)	18.7 (0.6)	11.6 (1.9)	12.6 (0.5)	17.6 (2.9)	21.1 (1.0)	24.9 (2.3)	21.4 (0.6)	2.7 (1.0)	2.7 (2.1)
17	20 (7.9)	14.6 (1.6)	15.7 (1.8)	11.9 (1.8)	13.1 (2.8)	17.2 (1.3)	19.1 (2.9)	27.6 (1.1)	30.4 (4.6)	2.6 (0.4)	3.0 (0.6)
18	20 (7.9)	16.2 (2.5)	17.2 (1.9)	12.3 (2.3)	13.1 (1.8)	19.7 (1.1)	19.9 (3.6)	25.2 (1.7)	31.5 (2.9)	3.2 (0.8)	2.5 (1.0)

A: Anterior border of the ramus, P: Posterior border of the ramus, MI: Inferior point of the MI, MN: The most superior point of the curvature of the notch, O: The straight line of the cusps of the mandibular permanent molars. SD: Standard deviation, MF: Mandibular foramen, MI: Mandibular incisura, MN: Mandibular notch

Table 3: Comparison of the each measurement according to the age groups

Age	A-MF	P-MF	MI-MF	MN-MF	O-MF
8	–	13, 14, 15, 18	12, 14, 16, 17, 18	13, 14, 15, 16, 17, 18	–
9	–	13, 14, 15, 17, 18		14, 15, 16, 17, 18	–
10	–	–	12, 13, 14, 17, 18	11, 12, 13, 14, 15, 16, 17, 18	–
11	–	–	18	10, 17, 18	–
12	–	–	8, 10	8, 10, 17, 18	–
13	–	9	8, 10	8, 10, 17, 18	–
14	–	8, 9	8, 10	8, 9, 10, 17, 18	–
15	–	8, 9	–	8, 9, 10, 17, 18	–
16	–		–	8, 9, 10, 17, 18	–
17	–	9	8	8, 9, 10, 11, 12, 13, 14, 15, 16, 18	–
18	–	8, 9	8, 9, 10	8, 9, 10, 11, 12, 13, 14, 15, 16, 17	–

Each age with the same line ages is statistically different means ($P < 0.05$). SD: Standard deviation, MF: Mandibular foramen, MI: Mandibular incisura, MN: Mandibular notch between the mandibular base and the inferior border of the canal, and the height of the canal; they concluded that tomography gave more accurate values than panoramic techniques. A study Afsar *et al.*[5] have reported that there were differences between panoramic and cephalometric radiograph measurement; therefore, in this study, we used CBCT images to determine the distance from the MF to specific landmarks.

Afsar *et al.*[5] studied panoramic radiographs and reported that no significant differences between male and female values for the distances measured from the MF to the landmarks; however, the general trend was that distances in males were greater than or equal to those observed in female subjects, which is in agreement with our findings.

Afsar *et al.*[5] also reported that position of the MF in relation to the landmarks does not change with age; their study including subjects under 40 years of age. Our study subjects were children and youth with an age range of 8-18. There were no significant differences among the O-MF values and among the A-MF values according to the age groups; however the *P*-MF, MI-MF, and MN-MF values increased with age.

Nicholson[2] examined 80 dried adult skulls and reported that the position of the MF was highly variable in different skulls as well as that the location of MF anteroposteriorly also varied. Afsar *et al.*,[5] Hetson *et al.*,[6] and Oguz and Bozkir[7] reported that the MF was located just posterior to the middle of the ramus; Hayward *et al.*[4] and Bremer[16] reported that the MF was located in the third quadrant of the ramus; and Weiss[17] reported that the MF was located at the midpoint of the ramus. In this study, we found that MF was located anteroposteriorly, just posterior to the middle of the ramus, which agrees with the findings of Afsar *et al.*,[5] Hetson *et al.*,[6] and Oguz and Bozkir.[7]

The molar occlusal plane may help to locate the MF. Marzola[18] has reported that the needle should be located 1 cm above the occlusal plane. Hwang *et al.*[19] have reported that the location of the MF is 4.2 mm above the occlusal plane in adults; however, Nicholson[2] and Afsar *et al.*[5] found that the MF was below the occlusal plane. Marzola[18] also reported that the MF was located on the occlusal plane of the molars and suggested that the needle set should be inclined an angle of five degrees in the anteroposterior direction to the occlusal plane of molars. In contrast, Hwang *et al.*[19] found that the MF was located 4.12 mm below the occlusal plane at the age of 3 years and subsequently moved upward with age. By the age of nine, it had reached approximately the same level as the occlusal plane. The foramen continued to move upward to 4.16 mm above the occlusal plane in the adult patients. In this study, it was found that the location of the MF is 2.5-3.6 mm was above the occlusal plane of the molars and there were no statistically changes in the location of the MF with age.

In the previous studies, the distances of the MI-MF and MN-MF values were reported to be approximately 21 and 19 mm,[3] 16 and 33 mm,[5] 22.2 and 30.7 mm,[7] respectively. In this study, the MI-MF and MN-MF values varied according to different age groups and ranged from 15.4 mm to 21.1 mm and 18.8 mm to 31.5 mm, respectively. With increasing age, the vertical measurement of the sagittal size of the structures of the mandible increase; therefore, the distance from the MF to the landmarks can vary, as shown in this study and previous studies. Thus, it is difficult to say that there is a specific value for any distance or ratio of the MF and this value can vary in different populations. These variances may be based on differences in population and/or measurement techniques. Based on the obtained results, the location of the MF is just posterior to the middle of the ramus, 2.5-3.6 mm above the occlusal plane of the molars. The P-MF, MI-MF, and MN-MF values increase with age.

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