Original Articles

ASSESSING MENTAL FORAMEN POSITION IN CLASS I, II, AND III MALOCCLUSION BY CBCT

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ABSTRACT

Background The present study aimed to determine the position of the mental foramen (MF) in CBCT images in Class I, II, and III malocclusions with different growth patterns.

Methods In this study, 150 CBCT with Class I, II, and III malocclusions were selected. Each sagittal malocclusion had 50 samples, with 25 participants with vertical growth and 25 with horizontal growth patterns. MF Shape and Position relative to the Nearest Tooth were evaluated. MF Length, height, Distance from MF to Inferior Border, Distance from MF to Bone Crest, and Mental Canal Angle were measured. A one-way analysis of variance and chi-square test evaluated the data.

Results No significant differences were observed in the shape of MF among different types of malocclusion in sagittal and type of growth pattern. Significant differences in the location of MF were observed in terms of growth pattern P=0/0028. However, there were no significant changes in the location of MF in sagittal malocclusions.

Conclusion Greater distance between the mental foramen (MF) and the inferior border of the mandible was observed in the Class II vertical growth pattern compared to Class I and Class II vertical growers.

KEYWORDS

Malocclusion; Mandibular Canal; Mental Foramen; Cone-Beam Computed Tomography.

1. INTRODUCTION

The mental foramen (MF) is a bilateral opening on the mandible's anterior surface; determining its position, shape, and size is important in dental treatments such as local anesthesia and surgical procedures. By focusing the injection around the MF, dental procedures in the mandibular area can be performed with optimal pain control and patient comfort [1]. MF is a crucial anatomical landmark used for various methods, including administering local anesthesia, placing implants, inserting miniscrew or miniplate, performing peri-apical surgeries, and carrying out osteotomies in the MF region [2]. Neurosensory disturbances affecting the chin and lower lip are commonly encountered as unintended complications during implant placements and miniscrew and mini plate placement. These complications often arise from a failure to properly identify and protect the structures of the mental foramen [3]. Multiple studies have documented both temporary and permanent sensory disturbances in the peri-oral soft tissues following the placement of mandibular implants [4-6]. In the existing literature, there is a lack of knowledge regarding the position of the mandibular foramen in different skeletal malocclusion. This research gap emphasizes the need for further investigation into the MF position in sagittal and vertical deformities. Understanding the specific characteristics and variations in MF position based on different skeletal malocclusion is crucial for appropriate treatment planning and developing practical techniques. It also contributes to a more personalised and practical approach to orthodontics,

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ensuring optimal outcomes for patients with malocclusion. This research would contribute to the existing literature by better understanding the MF position of different sagittal and vertical skeletal malocclusion. Moreover, Knowing the location of the mental foramen in each malocclusion is crucial during the insertion of mini plates and mini-screws.
High-resolution Cone-Beam Computed Tomography (CBCT) is considered the most promising and accurate technology currently available for precisely determining the position of the mental foramen quantitatively [7]. By examining CBCT images, researchers could assess the MF position and analyse any correlations between its location and different malocclusion classes.
This observational study aimed to determine and compare the size and location of the MF by using the CBCT in class I, II, and III malocclusions in horizontal and vertical growth pattern samples.

2. METHODS AND MATERIALS

In this study, a comprehensive analysis was conducted on CBCT obtained from the archives of the Department of Oral and Maxillofacial Radiology at the Faculty of Dentistry, Tehran Medical Sciences, Islamic Azad University, Tehran, Iran. The survey was performed according to the guidelines of the Declaration of Helsinki. All human research was conducted by the ethical standards of the committee responsible for human experimentation (institutional and national) and with the Helsinki Declaration of 1975, revised in 2013. 150 CBCT Images, aged between 18 and 35, were collected with Class I, II, and III malocclusions with vertical and horizontal growth patterns in each sagittal malocclusion. Using the Analysis Power ANOVA one-way considering $\alpha=0.05$ and $\beta=0.2$, the minimum required sample size for each of the six subgroups under investigation is determined to be 25 samples. Therefore, 150 individuals (25 with vertical growth patterns and 25 with horizontal growth patterns in each class I, II, and III malocclusion group). Each individual has two mental foramina; therefore, considering 150 samples, 300 foramina were examined. All the patients had no specific oral diseases, surgical history, previous orthodontic treatment, previous history of trauma, and facial and neck anomalies.
Ethical approval was obtained from the IAU Local Research Ethics Committees (Number: IR.IAU.DENTAL, REC;1400.187). The skeletal malocclusion types were grouped as Class 1, Class 2 and Class 3 according to Steiner's ANB angle and wits appraisal based on lateral cephalometric radiographs (Point A: the deepest anterior point on the buccal face of the maxilla body, Point N: Nasion, Point B: the deepest anterior point on the buccal face of the mandibular body, ANB angle: the angle formed by the NA and NB planes and wits appraisal: which was measured drawing perpendiculars from points A and B on the maxilla and mandible, respectively, onto the occlusal plane).
Class 1: ANB° = 0° to 4°; 0 <Wits<-1
Class 2: ANB°> 4°; 0<Wits
Class 3: ANB°<0°; Wits < -1
Samples in each class I, II, and III groups were divided into subgroups according to vertical and horizontal growth. In the horizontal growth pattern, the SN-Gn-Go angle is less than 32 degrees (32>SN-Gn-Go). In the vertical growth pattern, the Go-Gn-SN angle is greater than 32 degrees (Go-Gn-SN>32).
There were 100 images of individuals with Class I malocclusion, with 25 individuals having a vertical growth pattern and 25 having a horizontal growth pattern. For Class II malocclusion, there were 50 images, with 25 individuals having a vertical growth pattern and 25 individuals having a horizontal growth pattern. Similarly, there were 50 images for Class III malocclusion, with 25 individuals with a vertical growth pattern and 25 with a horizontal growth pattern. Using CBCT images, measurements were performed on both the left and right sides. MF Shape and MF Position relative to the Nearest Tooth were evaluated. MF Length, Height, Distance from MF to Inferior Border, Distance from MF to Bone Crest, and Mental Canal Angle were measured.
The measurements were recorded as follows:
• Mental Foramen Shape: In CBCT images, the shape of the mental foramen was categorised as oval or round.
• Mental Foramen Position relative to the Nearest Tooth: In CBCT images, the position of the mental foramen was recorded in one of four locations: below the first premolars, below the second premolars, between the first and second premolars, and between the second premolars and first molars.
• Mental Foramen Length: The widest part of the mental foramen in millimetres.
• Mental Foramen Height: The tallest height of the mental foramen in millimetres.
• Distance to Inferior Border: The distance from the lowest point of the foramen to the inferior border of the mandible in millimetres.
• Distance to Bone Crest: The distance from the highest point of the foramen to the bone crest in millimetres.
• Mental Canal Angle with Buccal Surface of Mandible: The angle between the longitudinal axis of the mental canal and the superior part of the buccal cortical bone, measured in degrees.
To assess the reliability of the measurements in the study, 20 CBCT images were randomly selected, and the measurements were repeated after one week. The results of the intraclass correlation coefficient (ICC) test showed no statistically significant difference between the two measurement sessions (ICC = 0.756)
The data were analysed using the statistical software SPSS (version 25.0). The mean and standard deviation

of MF Length, Height, Distance from MF to Inferior Border, Distance from MF to Bone Crest, and Mental Canal Angle were measured for each Class I, II, and III malocclusions, as well as based on horizontal and vertical growth patterns. The calculations and results regarding different malocclusions were evaluated using a one-way analysis of variance (ANOVA). The frequency of the MF shape and its position relative to the nearest tooth were analysed using the chi-square test. To assess the reliability of research measurements, 20 CBCT scans were randomly selected, and the measurements were repeated after two weeks. The coefficient correlation intraclass (ICC) test results showed a non-significant statistical difference (ICC = 0.756) between the two measurement occasions.

3. RESULTS

Of 300 images, 144 cases (48.0%) were related to women, and 156 patients (52.0%) were related to men. The average age of the samples was 26.91 years, with a standard deviation of 5.33 years.

The chi-square test showed no significant differences in the shape of MF between the horizontal and vertical growth patterns. However, significant differences were observed in the position of MF among different growth patterns (p=0.028), where the position between the first and second premolars was greater in the vertical growth pattern, and the position below the second premolar was greater in the horizontal growth pattern. (Table 1) The chi-square test also showed that no significant differences were found in the shape and position of MF among different types of malocclusion in CBCT images. (Table2)

Table 1. The abundance of shape and position of MF based on horizontal and vertical growth pattern.

Growth pattern		Vertical	Horizontal	P value
Shape	Circular	(%56/7) 85	(%48/0) 72	0/1
	Oval	(%43/3) 65	(%52/0) 78	
Position	Below is the first premolar	(%2/7) 4	(%0/7) 1	0/028
	Below the second premolar	(%42/7) 64	(%55/3) 83	
	Between premolars	(%54/0) 81	(%41/3) 62	
	Below are the first premolar and first molar	(%0/7) 1	(%2/7)4	

Table 2. The abundance of shape and position of MF based on sagittal malocclusion.

Growth pattern		Class I	Class II	Class III	P Value
Shape	Circular	(%57) 57	(%52) 52	(%48) 48	0/4
	Oval	(%43/) 43	(%48) 48	(%52) 52	
Position	Below is the first premolar	(%2) 2	(%2) 2	(%1) 1	0/5
	Below the second premolar	(%41) 41	(%54) 54	(%52) 52	
	Between premolars	(%56) 56	(%42) 42	(%45) 45	
	Below are the first premolar and first molar	(%1) 1	(%2) 2	(%2) 2	

One-way ANOVA test revealed significant differences in the length and height of MF, distance to the mandibular border, and distance to the bone crest among different types of malocclusion ($p < 0.001$). However, the angle of the mental canal did not show significant differences among different types of malocclusion. Based on these findings, the length and height of MF were greater in patients with Class I malocclusion compared to the other two groups, the distance to the mandibular border was greater in individuals with Class II malocclusion, and the distance to the bone crest was greater in individuals with Class I malocclusion. (Table 3)

Table 3. The variables' mean and standard deviation based on the malocclusion type.

	Class I	Class II	Class III	P Value
Mental Foramen Length	5/32±0/88	2/98±0/66	2/70±0/61	<001
Mental Foramen Height	5/56±0/78	2/90±0/73	2/66±0/61	<001
Distance to Inferior Border	10/74±0/57	14/76±1/43	10/44±0/90	<001
Distance to Bone Crest	14/15±2/33	10/06±1/28	11/05±1/55	<001
Mental Canal Angle	42±14	46±16	44±12	0/1

As seen in Table 4, the Student's t-test showed no significant differences in the length and height of the MF between the two growth patterns. However, the distance from MF to the inferior border ($p<0.001$), distance to the crest of the bone ($p<0.001$), and mental canal angle ($p=0.008$) were significantly greater in individuals with a vertical growth pattern compared to those with a horizontal growth pattern.

Table 4. The mean and standard deviation of the variables based on the growth pattern.

	Vertical	Horizontal	P Value
Mental Foramen Length	3/71±1/24	3/62±1/52	0/6
Mental Foramen Height	3/80±1/42	3/61±1/56	0/3
Distance to Inferior Border	12/46±2/60	11/50±1/65	<001
Distance to Bone Crest	12/85±2/58	10/67±1/84	<001
Mental Canal Angle	48±14	44±14	<008

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Tables 5 and 6 present the mean and standard deviation of the variables under investigation based on the classification of malocclusion types in CBCT images of individuals aged 18-35 with vertical and horizontal growth patterns, respectively. According to the results of the ANOVA test, in individuals with horizontal and vertical growth patterns, significant differences were observed in terms of the length and height of the MF, distance to the inferior border, and distance to the crest of the bone in different types of malocclusion (all p < 0.001).

Table 5. The mean and standard deviation of the variables based on the type of malocclusion in the vertical growth pattern.

	Class I	Class II	Class III	P Value
Mental Foramen Length	5/13±0/79	3/21±0/69	2/80±0/64	<001
Mental Foramen Height	5/52±0/82	3/17±0/69	2/72±0/63	<001
Distance to Inferior Border	10/82±0/59	15/96±0/63	10/59±1/0	<001
Distance to Bone Crest	16/27±0/76	16/27±0/76	16/27±0/76	<001
Mental Canal Angle	48±16	49±14	47±13	0/7

Table 6. The mean and standard deviation of the variables based on the type of malocclusion in the horizontal growth pattern.

	Class I	Class II	Class III	P Value
Mental Foramen Length	5/51±0/93	2/74±0/55	2/61±0/58	<001
Mental Foramen Height	5/60±0/75	2/63±0/67	2/60±0/58	<001
Distance to Inferior Border	10/66±0/54	13/56±0/89	10/28±0/78	<001
Distance to Bone Crest	12/03±1/11	8/94±0/66	11/02±1/89	<001
Mental Canal Angle	48±11	43±17	41±11	0/03

The MF distance to the mandible's inferior border was 15/96± 0/63 in class II vertical growth pattern, higher than in class I and II vertical growers. Also, the same distance was 13/56± 0/89, more significant than in class I and II horizontal growers.

4. DISCUSSION

In this study, CBCT images of individuals with Class I, II, and III malocclusion were selected. The images' sagittal dimension measured the MF's length, height, and shape. In the coronal dimension, the distance from the MF to the crest of the bone, the distance from the MF to the inferior border of the bone, and the mental canal's angle with the mandible's occlusal plane were measured. In the axial dimension, the position of the MF relative to the nearest tooth was assessed. According to the research findings, the size of the variables was significantly greater in males than in females. Furthermore, the position and shape of the MF were consistent across different malocclusions. Still, the length, height, distance to the inferior border, and distance to the crest of the bone showed differences among malocclusion types.

The mental foramen is one of the critical anatomical landmarks of the mandible that has received significant attention. Some studies have evaluated its position, shape, and distance from other anatomical landmarks and adjacent tooth roots. From a clinical perspective, local anesthesia during dental treatments and the safety of surgical procedures in this area are influenced by the clinician's knowledge of the mental foramen's position. The mental foramen also plays a role in interpreting anatomical landmarks in forensic medicine. In the present study, the mental foramen (MF) position was observed below the second premolar in 49.0% of cases and between the first and second premolars in 47.7% of cases. Significant differences were also noted in terms of the patients' growth patterns, where the position between the first and second premolars was more critical in the vertical growth pattern compared to the horizontal growth pattern, and the part below the second premolar was more significant in the horizontal growth pattern compared to the vertical growth pattern. On the other hand, no significant differences were found in the position of MF among patients with Class I, Class II, and Class III malocclusions.

According to the present study's findings, the shape of MF was round in 52.3% of cases and oval in 47.7%. On the other hand, no significant differences were observed in the shape of MF based on the growth pattern or in the three groups of malocclusions. However, in the vertical growth pattern group, the frequency of round-shaped MF was slightly higher in individuals with Class III malocclusion compared to other malocclusions, and the frequency of oval-shaped MF was somewhat higher in individuals with Class II malocclusion compared to other malocclusions. In the horizontal growth pattern group, the frequency of round-shaped MF was higher in individuals with Class I malocclusion, and the frequency of oval-shaped MF was higher in individuals with Class III malocclusion compared to other malocclusions.

In this study, no significant differences were found in terms of the length and height of MF between vertical and horizontal growth patterns. However, the distance from MF to the inferior border (mean of 12.46 mm versus 11.50 mm) and from MF to the crest of the bone (mean of 12.25 mm versus 10.67 mm) differed significantly between vertical and horizontal growth patterns. Additionally, the angle of the mental canal (mean of 42 degrees versus 44 degrees) was significantly greater in individuals with vertical growth compared to those with horizontal growth. Overall, in the combined images of both groups, the distance from MF to the inferior border was approximately 11.92 mm, and the distance from MF to the crest of the bone was approximately 11.76 mm.

Some studies have observed that mental foramen (MF) is most commonly located between the mandible's first and second premolar teeth [8, 9].

Al-Mahalawy et al. [1] conducted a study that demonstrated the most common position of the mental foramen (MF) to be below the apex of the second premolar in both male and female patients. Similarly, Aoun et al. reported that MF was predominantly in line with the second mandibular premolar on both sides. [10] On the other hand, MF in the Indian population, North American Caucasian population, and Nigerian adults were primarily located between the roots of the first and second premolars [9,11-13]. It is well-documented that the position of the mental foramen (MF) can vary among different racial and ethnic groups. Studies in dental anthropology and craniofacial research have highlighted these variations. Factors such as craniofacial morphology, genetic factors, and evolutionary differences contribute to the differences observed in the position of MF across populations [1].

Based on the shape of the mental foramen, Verma et al. found that most of the MF was round, followed by an oval in the Indian population. [9] Conversely, Sheikhi et al. [14] found that the oval shape of the mental foramen was twice as familiar as the round shape; the findings of Sheikhi et al. were by Gershenson et al. [15]. Some results of the previous study were not used in the present study because of the difference in the race and group of the population selected. Most previous studies have been conducted using two-dimensional imaging techniques, such as panoramic images, rather than 3-D imaging techniques, like cone-beam computed tomography (CBCT)

5. CONCLUSION

The results of the current study aimed at determining the position of MF in CBCT images in Class I, Class II, and Class III malocclusions with different growth patterns are as follows:

- No significant differences were found in the shape of MF among different types of malocclusions.
- There were no significant changes in MF's location in sagittal malocclusions.
- The position of MF was located below the second premolars in 55.3% of cases in horizontal growth patterns and between the first and second premolars in 54.0% of vertical cases, with significant differences observed based on the growth pattern ($p = 0.028$).
- The length and height of MF were more significant in individuals with Class I malocclusion in comparison with class II and III ($p < 0.001$). The distance from MF to the inferior border was more significant in individuals with Class II malocclusion in regards to other sagittal malocclusions ($p < 0.001$), and the distance from MF to the crest of the bone was more significant in individuals with Class I malocclusion in comparison with class II and III malocclusion ($p < 0.001$).
- No significant differences were found in the length and height of MF based on the growth patterns. However, the distance from MF to the inferior border ($p < 0.001$), the distance from MF to the crest of the bone ($p < 0.001$), and the angle of the mental canal in vertical growth patterns were more significant than in horizontal growth patterns ($p = 0.002$).
- The distance of MF to the inferior border of the mandible was more significant in class II vertical growth patterns about class I and class II vertical growers. The same distance in class II horizontal growers was higher than in class I and II horizontal growers.

AUTHOR CONTRIBUTIONS

AJ was the major contributor to writing the manuscript, study design, and corresponding author. **LN** was responsible for statistical consulting and editing the final draft. **KM** was responsible for radiological consultant and data generation. **NN** was involved in data gathering and methodology. **RF** was responsible for the literature review and drafting, and **VG** and **LP** were responsible for the literature review, data interpretation, and critical revisions. All the authors have read and approved the final version of the manuscript.

COMPETING INTERESTS

The authors declare that they have no competing interests in this study.

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Questions

1. Which one is correct?

❑a. The shape of the Mental Foramen is round in 52.3% of cases and oval in 47.7%;
❑b. The shape of the Mental Foramen was oval in 52.3% of cases and round in 47.7%;
❑c. The shape of the Mental Foramen was oval in 45% of cases and round in 35%;
❑d. The shape of the Mental Foramen was oval in 35% of cases and round in %.

2. The position of Mental foramen in the Indian population, North American Caucasian population, and Nigerian adults were primarily located :

❑a. Between the roots of the first and second premolars;
❑b. Between the roots of the first and second molars;
❑c. Between the roots of the canine and first premolars;
❑d. Below the canine.

3. Which factors contribute to the differences observed in the position of MF across populations?

❑a. Craniofacial morphology;
❑b. Genetic factors;
❑c. Evolutionary differences ;
❑d. All of them.

4. Which one is correct?

❑a. In the present study, the mental foramen position was observed below the second premolar in 49.0% of cases and between the first and second premolars in 47.7% of cases.;
❑b. In the present study, the mental foramen position was observed below the second premolar in 60.0% of cases and between the first and second premolars in 40.% of cases;
❑c. In the present study, the mental foramen position was observed below the second premolar in 40.0% of cases and between the first and second premolars in 60.% of cases;
❑d. None of them.