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Original Article

Localization of Mental Foramen in Relation to Primary Molars in Children. (A Cone-Beam Computed Tomography Study)

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Abstract

The aim of the current study is to determine the location of mental foramen MF in relation to lower primary molars and its form, and to correlate this data to age, gender, and side. 19 MF on CBCT images for children under ten were analyzed. Normality was assessed using Shapiro-Wilk's test, independent and paired t-tests, and a chi-square test was used for data analysis. The study results found that MF was located in positions 3 (between the roots of the first primary molar), 4 (at the level of the distal root of the first primary molar), 6 (at the level of the mesial root of the second primary molar) and 7 (between the roots of the second primary molar), it was below the apices of primary molars in all cases, boys and > six-year-old children have significantly distal MF. Conclusions: MF in children is located apical to the roots of primary molars, in the area between the long axis of the primary molars, more distally for boys and > six-year-old children. The horizontal diameter was larger for girls and ≤ six-year-old children.

Keywords: children, mental foramen; molars, cone beam computed tomography, mental nerve block anesthesia

I. INTRODUCTION:

The mental foramen (MF) is an opening on the anterior surface of each side of the mandible, usually located in the premolars/primary molars area. Through the MF, a branch of the inferior alveolar nerve exits the mandibular canal as the mental nerve. The mental nerve on each side carries the sensory stimuli to the chin, skin and mucous membrane of the lower lip, and the pulp and supporting structure of the lower anterior teeth and premolars/primary molars. 1,2

Determining the location of MF is necessary for a lot of dental procedures such as surgeries, implant placement, root canal treatment; moreover, mental nerve block anaesthesia MNBA is a routine procedure that depends on the operator's knowledge and is not aided by radiographic data to determine the location of the MF. 3,4

Several studies have been carried out to define the size, shape and location of the MF 3,5,6; however, there is a scarcity of studies dealing with this data in the younger age group.

2-dimensional radiography was previously used to assess the location of MF, but limitations such as distortion, overlapping and inaccurate dimensions of anatomical landmarks affect the quality of the outcomes. 5

A well-proven alternate is cone-beam computed tomography CBCT, high-resolution images in frontal, sagittal, and transverse planes

allow visualization of structures with accurate location and dimension. CBCT images were proven to be more accurate than panoramic radiographs, representing the actual size of the foramen as on cadavers.3,6

There is a scarcity of studies dealing with the size and location of MF in children, Ulusoy et al. found that the horizontal and vertical lengths of MF among other linear and angular measurements on panoramic radiographs, do not provide enough data for age and gender estimations, Lim et al. found that with increasing age the location of MF moved posteriorly and inferiorly in children with Mongoloid skeletal pattern. 7,8

This study aims to determine the location of MF in relation to lower primary molars, its form, and to correlate this data to age, gender, and side.

II. MATERIALS AND METHODS

A. CBCT imaging

CBCT images from a private radiology centre were used in this study. All CBCTs were taken using NewTom 5G (QR srl, Verona, Italy). at 110 kV, 5.0 mA, 18-second exposure time. The right and left sides of each CBCT image were evaluated independently using NNT Viewer version 10.0 [Installation package 10].

B. Inclusion and exclusion criteria

CBCT images for less than ten-year-old children were included in the study. Included CBCT images should have either or both sides of the lower arch in the field of view, with the lower first and second primary molars present, with no or minimal root resorption. Images with pathologies, fractures, malformations, or abnormal teeth alignment that would affect the location or shape of the MF were excluded from the study.

C. CBCT images screening

124 CBCT images were screened for the current study, images were filtered for the targeted age group where 104 images were excluded, and only 20 images were studied. Among the 20 images, 4 did not include the lower arch, 3 had missing either or both primary molars and 2 were excluded due to pathologies that would alter the shape and location of the MF, leaving 11 images to be included in the study. Eight images have both sides eligible for analysis, and three images have only the left sides eligible for analysis due to the presence of a lesion on the right side of one image, an abnormal teeth alignment on the right side of one image. One image had only the left side in the field of view.

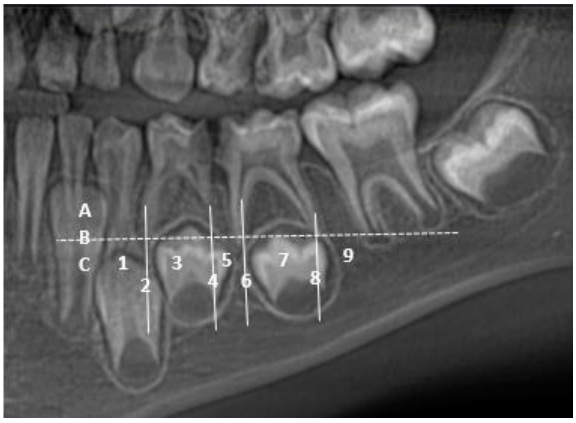
D. Mental foramen location

After eligible CBCT images were extracted, a modification of the Tebo and Telford classification was used to determine the horizontal location HL of MF in relation to mandibular teeth 9, table 1, figure 1. Then the MF on each image was located vertically in relation to the apices of primary teeth where location A: MF is located higher than the level of primary teeth root apices, location B: MF is located at the level of primary teeth root apices, and location C: MF is located at a lower level than the primary teeth root apices 10 (figure 1). The HL and vertical location VL of MF were analyzed to find associations with gender, age or side.

Table 1: Classification of horizontal locations of the mental foramen.

Location	Mental foramen is located……
1	mesial to the first primary molar
2	at the level of the mesial root of the first primary molar
3	between the mesial and distal roots of the first primary molar
4	at the level of the distal root of the first primary molar
5	between the first and the second primary molars
6	at the level of the mesial root of the second primary molar
7	between the mesial and distal roots of the second primary molar
8	at the level of the distal root of the second primary molar
9	distal to second primary molar

Figure 1: classification of the location of the horizontal dimension and vertical dimension of mental foramen.



E. Mental foramen dimensions and form

The horizontal diameter HD was measured on the axial scans (figure 2), while the vertical diameter VD of MF was measured on the cross-sectional CBCT images (figure 3). The ratio between horizontal and vertical diameters (HD: VD) was calculated to classify MF into: form I (oval-horizontal) where HD:VD > 1.24, form II (oval-vertical) where HD:VD < 0.76, and, form III (round) where $0.76 \leq HD:VD \geq 1.24$ 11, 12. The HD, VD and form of MF were analyzed to find associations with gender, age or side.

Figure 2: measurement of the horizontal diameter of the mental foramen on the axial CBCT image.

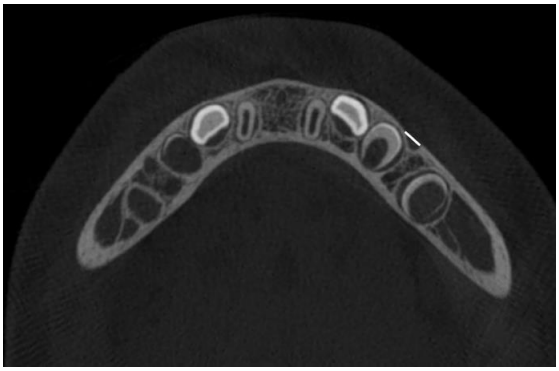
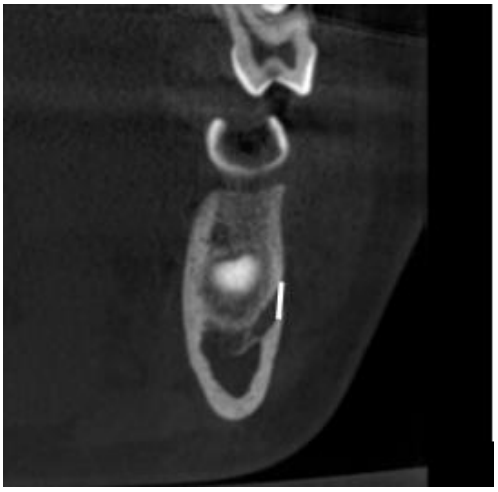


Figure 3: measurement of the vertical diameter of the mental foramen on the cross-sectional CBCT image



III. RESULTS

A. Reliability and statistical analysis:

Each of the 19 MF on CBCT images was examined three times. A calibration session was conducted to review the MF location classifications, and the illustration in figure 1 was used as a reference. For the dimensions of

the MF, calibration of the measuring procedure was done using CBCT images not included in the study. First, the author (M.A.) assessed the location and dimensions, and an independent radiologist (M.O.) reanalyzed the images. Then, the author (M.A.) reperformed the analysis in a different order of images after 3 weeks. It was agreed that the difference in location identification would be discussed and reevaluated, and the average of the three measurements was considered for the final data analysis.

For the determination of the MF HL and VL, all readings for the three assessments were identical. For the measurements of the MF dimensions, the intraclass correlation coefficient (ICC) was calculated to assess intra-observer reliability and inter-observer reliability, they were 0.991 (0.972:0.996) and 0.973 (0.945:0.987) respectively denoting excellent reliability.

Categorical data (frequency and percentage) was analyzed using a chi-square test followed by pairwise comparisons utilizing multiple z-tests with Bonferroni correction. Numerical data were presented as mean and standard deviation (SD) values. Shapiro-Wilk's test was used to test for normality. Data were normally distributed and analyzed using independent and paired t-tests for independent and repeated measures. The significance level was set at $p<0.05$ within all tests. Statistical analysis was performed with R statistical analysis software version 4.1.3 for Windows. 13

The study was conducted on 11 CBCT images, 9 (81.8%) boys and 2 (18.2%) girls. 4 (36.4%) ≤ six-year-old and 7 (63.6%) > six-year-old. Out of the 11 CBCT images, only eight have both right and left sides suitable for analysis and the remaining three have only the left side suitable for analysis making the whole sample size 19 MF, 11 on the left side and eight on the right side.

B. Mental foramen location

The HL of MF was confined to only 4 out of 9 predicted locations, 3,4,6 and 7. Descriptive data for the HL of MF on the right, left and both sides are presented in table 2. There is a significant association with gender, as boys have significantly higher percentages of positions 6 and 7 than girls ($p=0.011$). There was also a significant association with age with > six-year-old children having a significantly higher percentage of position 7. Associations with the HL of MF are presented in table 3. VL of MF was at location 3 (below the apices of primary molars) in all cases.

C. Mental foramen dimensions and form

The mean HD for MF in all images was (3.03±0.98), and the mean VD was (2.93±0.52), 68.4% of the analyzed MF in this study were round. Descriptive data for the dimensions and form of MF on right, left and both sides are presented in table 4. There is a significant association between HD and gender ($p=0.009$) and age ($p=0.001$), with girls and ≤ six-year-old having larger HD. Other associations were not statistically significant ($p>0.05$), tables 5 and 6.

Table 2: Horizontal location of mental foramen

Location		Right side	Left side	Both sides
1	***n***	0	0	0
	%	0	0	0
2	***n***	0	0	0
	%	0	0	0
3	***n***	1	2	3
	%	12.5	18.2	15.8
4	***n***	2	1	3
	%	25.0	9.1	15.8
5	***n***	0	0	0
	%	0	0	0
6	***n***	3	6	9
	%	37.5	54.5	47.4
7	***n***	2	2	4
	%	25.0	18.2	21.1
8	***n***	0	0	0
	%	0.0%	0.0%	0.0%
9	***n***	0	0	0
	%	0.0%	0.0%	0.0%

Table 3: Associations with mental foramen horizontal position

Parameter	Value		Horizontal position				Statistic	p-value
			3	**4**	**6**	**7**		
Gender	***Boy***	***n***	1^{A}	1^{A}	9^{A}	4^{A}	10.89	0.011*
		%	33.3%	33.3%	100.0%	100.0%		
	Girl	***n***	2^{A}	2^{A}	0^{B}	0^{B}		
		%	66.7%	66.7%	0.0%	0.0%		
Age	***≤ six-year-old***	***n***	3^{A}	3^{A}	2^{A}	0^{A}	12.62	0.002*
		%	100.0%	100.0%	22.2%	0.0%		
	> six-year-old	***n***	0^{A}	0^{A}	7^{A}	4^{B}		
		%	0.0%	0.0%	77.8%	100.0%		
Side	***Right***	***n***	1^{A}	2^{A}	3^{A}	2^{A}	1.22	0.910
		%	33.3%	66.7%	33.3%	50.0%		
	Left	***n***	2^{A}	1^{A}	6^{A}	2^{A}		
		%	66.7%	33.3%	66.7%	50.0%		

Table 4: Dimensions and form of the mental foramen.

Parameter			Right side	Left side	Both sides
Horizontal diameter	***Mean±SD***		2.94±0.91	3.09±1.07	3.03±0.98
Vertical diameter			2.89±0.35	2.95±0.63	2.93±0.52
Mental foramen form	***I (oval-horizontal)***	***n***	1	2	3
		%	12.5%	18.2%	15.8%
	II (oval-vertical)	***n***	2	1	3
		%	25%	9.1%	15.8%
	III (round)	***n***	5	8	13
		%	62.5%	72.7%	68.4%

Table 5: Associations with horizontal and vertical dimensions

Parameter			Mean±SD	Statistic	p-value
Horizontal diameter	***Gender***	***Boys***	2.74±0.84	2.93	0.009*
		Girl	4.10±0.75		
	Age	***≤ six-year-old***	3.80±0.81	3.92	0.001*
		> six-year-old	2.46±0.67		
	Side	***Right***	2.94±0.91	0.33	0.748
		Left	3.09±1.07		
Vertical diameter	***Gender***	***Boy***	2.83±0.50	1.57	0.135
		Girl	3.28±0.53		
	Age	***≤ six-year-old***	3.19±0.56	2.02	0.060
		> six-year-old	2.74±0.41		
	Side	***Right***	2.89±0.35	0.27	0.790
		Left	2.95±0.63		

*Significant ($p<0.05$)

Table 6: Associations with mental foramen form

Parameter	Value		Mental foramen shape			Statistic	p-value
			I (oval-horizontal)	II (oval-vertical)	III (round)		
Gender	***Boy***	*n*	1	3	11	4.81	0.192
		%	33.3%	100.0%	84.6%		
	Girl	*n*	2	0	2		
		%	66.7%	0.0%	15.4%		
Age	***≤ six-year-old***	*n*	3	0	5	6.38	0.057
		%	100.0%	0.0%	38.5%		
	> six-year-old	*n*	0	3	8		
		%	0.0%	100.0%	61.5%		
Side	***Right***	*n*	1	2	5	0.91	0.796
		%	33.3%	66.7%	38.5%		
	Left	*n*	2	1	8		
		%	66.7%	33.3%	61.5%		

Different superscript letters indicate a statistically significant difference within the same parameter and horizontal row; *significant ($p<0.05$)

IV. DISCUSSION:

The exact location of MF in children is still unclear; there is a scarcity of studies locating MF in children. This study aims to locate MF in relation to primary molars using CBCT images, collect some data about the size and form of MF and associate these findings to age, gender and side. This study is retrospective, collecting data from preexisting CBCT images, and no child was exposed to hazardous radiation for the sake of the study.

The HL of MF on the mandible in relation to the primary molars was classified according to a modification to Tebo and Telford classification 9, the results of this study showed that the HL of MF was limited to four positions, 3 (between the mesial and distal roots of the first primary molar), 4 (at the level of the distal root of the first primary molar), 6 (at the level of the mesial root of the second primary molar) and 7 (between the mesial and distal roots of the second primary molar); in all cases, MF was related to the middle and distal part of the first primary molar and the mesial and middle part of the second primary molar.

To compare these results to previous studies, we considered the location of the first primary molar will correspond to the location of the first premolar, and the location of the second primary molar will correspond to the location of the second premolar. Therefore, the results of this study were in line with previous studies where the MF was located mostly between the first and second premolars 14, Between the first and second premolar and in line with the second premolar. 10,15,16

In this study, MF in boys is significantly located more in positions 6 (at the level of the mesial

root of the second primary molar) and 7 (between the mesial and distal roots of the second primary molar) than in girls (p=0.011). Also, > six-year-old children have a significantly higher percentage of position 7 (between the mesial and distal roots of the second primary molar). This means that MF is located more posteriorly for > six-year-old children.

This came in agreement with Lim et al. found that with increasing age, the location of MF moved posteriorly and inferiorly in children with Mongoloid skeletal patterns. Balcioglu et al. reported a distal shift of MF with mandibular growth, possibly due to the mesial drifting of teeth and growth. 8,17

For the vertical location, in all cases, the MF was below the level of primary molar apices; this was consistent with the results of several studies carried out on adults, wherein in the majority of cases, the position of MF was at a lower level than the apices of premolars. 76% in Sekerci et al. 10, 93.2% in Alam et al. 18 and 78% in Al-Khateeb et al. 19

For the dimensions of MF; the mean HD for all MF was (3.03±0.98), and the mean VD was (2.93±0.52). These measurements were comparable to previous studies; Oguz et al. reported a mean HD of 2.93±0.28 and 3.14±0.11 on the right and left sides, respectively, and a mean VD of .38±0.28 and 2.64±0.28 on the right and left sides respectively in a Turkish population 20. Chung et al. reported a mean HD of 2.4 mm 21. Udhaya et al. reported a mean HD of 2.72 ± 0.65 22. Apinhasmit et al. reported a mean HD of 2.72 ± 0.65 23. However, Rakhi Rastogi et al. reported a higher mean HD of 4.57 ± 0.19 and 4.61 ± 0.17 on the right and left sides, respectively, and a mean VD of 3.58 mm ± 0.17 and 3.55 mm ± 0.18 on the right and left sides respectively 24.

There was a significant association between HD and gender (p=0.009) and age (p=0.001), with girls and > than six-year-old children having larger HD. In Zmyslowska-Polakowska et al. mean HD on the right side was significantly higher in males 14. In Gungor et al. 15, Zhang et al. 11, and Kalender et al. 16, HD and VD were both larger in males.

Regarding the form of the MF, more than 2/3 of the MF in the study were round, that was the case on the right side, on the left side and in total. This was agreeing with Sankar et al. who found a majority of round MF on dry mandibles of the Indian population 25. In Sekerci et al. study on a Turkish population round and oval forms of MF were close (43% and 42%) 10. The results of the current study disagreed with Udhaya et al. and Voljevica et al. who both found 83% oval MF in adult dry mandibles from the South Indian population and Bosnia and Herzegovina respectively 22,26. Zhang et al. found 67% oval-horizontal MF versus 33% round MF on CBCT images of 12-75-year-old 11. Zmyslowska-Polakowska et al. found the oval horizontal the most common in the adult Polish population as analyzed on CBCT images 14.

This study aimed to collect some missing data regarding the location and dimensions of MF in children; however, there are some limitations to the study; being, to my knowledge, the first to target this age group, there was not much data for the same age group to compare the results of the current study to some parameters such as the distance between MF and anatomical landmarks such as the mandible's alveolar crest or lower border have not been assessed. The sample size in this study was limited due to the limited indications that would necessitate CBCTs for the lower arch in this age group 27. Also, there were no available CBCT images with soft tissue profiles to measure the distance between the point of insertion and the MF, which would have aided in determining the depth of the insertion for MNBA. Hopefully, more studies to be carried out in the future, with larger sample sizes and longitudinal study designs, to study the change in location or dimensions of MF with the increase of age.

V. CONCLUSION:

From the results of the given study, one can conclude that the mental foramen in children is located apical to the roots of primary molars, in the area between the long axis of the first primary molar and the long axis of the second primary molar, the MF was located more distally for boys and > six-year-old children. The needle insertion for a mental nerve block anaesthesia should be related to the distal half of the first primary molar and shifted to the mesial half of the second primary molars for boys and > six-year-old children. The mental foramen is primarily round in form for the tested sample, and the horizontal diameter was larger for girls and ≤ six-year-old children.

Conflict of interest:

No conflict of interest.

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Ethics: This study protocol was approved by the Fayoum University Supreme Committee for Scientific Research Ethics approval number: (EC 2208) and registered on clinicaltrials.gov with ID: NCT056631.

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