ORIGINAL RESEARCH

Quantitative and Mathematical Analysis of Mental Foramen along with Its Correlation with Sex and Age Using Cone-beam Computed Tomography

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Abstract

Aim and objective: The aim of the present study was to perform quantitative and mathematical analysis of mental foramen (MF) along with its correlation with study subject's sex and age using three-dimensional imaging like cone-beam computed tomography (CBCT).

Materials and methods: The CBCT scan images stored in the database were used in this study. Two-hundred sixty-seven scans were selected. They were divided into four different age-groups. These age-groups were 16–23 years, 24–38 years, 39–55 years, and more than 56 years. Each age-group was further divided into two subgroups. One subgroup was of males, while the other subgroup was of females. Following this, there was evaluation of all CBCT-scanned images considering certain parameters like position of MF, size of MF, distance X, distance Y, and distance Z.

Results: The MF was located generally apically to the premolar and molar. It was more commonly located between the first premolar and second premolar among females, while in males, it was mostly located along the long axis of the second premolar. In most of the age-groups, the MF was located between the long axis of the first premolar and second premolar. The average distance of MF from the apex of first premolar was 5.01 mm. Further, the average size of MF and its distance from the base of the mandible were greater in males as compared with females. When all these measurements were compared in different age-groups, the difference was not statistically significant.

Conclusion: The average distance of MF from the apex of the first premolar was 5.01 mm. The average size of MF and its distance from the base of the mandible were greater in males as compared with females. When the measurements were compared in different age-groups, then the difference was not statistically significant.

Clinical significance: MF is an important structure in the mandible because it acts as an important landmark in the anesthetic procedure; therefore, there was a need to carry out detailed quantitative and mathematical analysis for MF.

Keywords: CBCT, Mental foramen, Quantitative measurements.

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Introduction

The mandible consists of many important structures; one of them is mandibular canal, through which branches of mandibular nerve pass through. The mandibular canal opens through an opening, which is called mental foramen (MF). The knowledge about the exact position of MF is very important because local anesthesia in several surgical procedures like implant surgery and periodontal flap surgery is administered at the area near to the MF and in many dental procedures like root canal treatment and others in the oral cavity; it would be within the premolar and mandibular anterior regions. Exact information about the location of MF and adequate anesthesia can be achieved in a single attempt. Moreover, the added advantage is that there will be fewer traumas to the important anatomical structures.[1,2]

MF is generally located according to the position of the first premolar and second premolar regions, but several variations have been observed in its location. The variation can be in the horizontal plane as well in the vertical plane according to the position of the premolars and molars. These variations have been studied in various studies.[3,4] It is necessary to study these variations in the position of MF because it will reduce the chances of failure of mental nerve block and prevent undue extra attempts for mental nerve block. These extra attempts for mental nerve block can cause trauma to the important structures of the oral cavity. Another important aspect is that, among the patients who have lost their premolars and molars, locating the position of MF becomes very difficult. Therefore, other anatomical landmarks should also be studied to locate the exact position of MF among such patients, and there is a severe scarcity of studies in this regard.[5,6]

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In order to avoid the hardships because of variations in the position of MF, there is a need for an extensive quantitative and mathematical analysis of the location of MF. This method would be able to give improved information, which could help in proper anesthesia administration by mental nerve block. Recently, a lot of interest has been shown in carrying out the quantitative and mathematical analysis of the MF.[7,8] This analysis includes the measurement of the distance of MF from different anatomical structures like the premolars and molars to make a generalized condition for locating the position of MF. Recently, some studies have been conducted in this regard where such quantitative and mathematical analysis has been performed using two-dimensional imaging techniques like panoramic radiography, intraoral periapical radiography, and lateral radiographs. Elongation and shortening of the images is an important disadvantage of these two-dimensional imaging techniques. Moreover, the method used for carrying out measurements was not standard. In order to rule out these drawbacks of two-dimensional imaging, there is an introduction of advanced three-dimensional imaging techniques.[9,10] Cone-beam computed tomography that is commonly denoted by the term CBCT is one of such techniques. There is no elongation and shortening of the images in this technique. Besides, it is equipped with advanced software, which provides accurate measurements. Another important consideration is that there have been some studies conducted for studying various variations in the location of MF but very few studies have been conducted in which study subject's age and sex have been correlated with the position of MF.[11]

Therefore, this study was conducted to perform extensive quantitative and mathematical analysis of MF along with its correlation with study subject's sex and age using three-dimensional imaging like CBCT.

Materials and Methods

The current study was a retrospective study. It was carried out at Patna Dental College and Hospital, Patna, Bihar. This study was started once the ethical committee gave its permission. CBCT scans stored in the database from December 2018 to December 2020 were included in this study. The inclusion criteria for the selection of CBCT scans were good quality and CBCT scans of subjects of age more than 15 years. The exclusion criteria were radiographic signs of poor bone formation, pathology in the area of interest, impacted teeth, and absence of the first and second mandibular premolars.

The procedure and methods used for the analysis of CBCT images were the same for each CBCT scan image. The software used for acquiring all images was i-CAT (Imaging Sciences International, USA). The size of the voxel was 0.25 mm, while the gray scale was 12 bit. The analysis of all CBCT images was carried out with the help of software named Xoran (USA). The analysis of all CBCT images was carried out by the same investigator who was kept completely unaware of the details of the study. This was done to maintain consistency in the analysis.

The CBCT-scanned images selected for the study were divided into four different age-groups. These age-groups were 16–23 years, 24–38 years, 39–55 years, and more than 56 years. Each age-group was further divided into two subgroups. One subgroup was of males, while the other subgroup was of females. Then, there was evaluation of all CBCT-scanned images mainly considering certain parameters. These parameters included position of MF, size of MF, distance X, distance Y, and distance Z.

Evaluation of the horizontal position of the MF was done in this manner. There was selection of six locations for analysis of the horizontal position of the MF in the sagittal section of the CBCT scan. These positions were position I, position II, position III, position IV, position V, and position VI. Position I referred to the location that was anteriorly placed to the long axis of the lower first premolar. Position II referred to the location corresponding to the long axis of the lower first premolar. Position III referred to the position between the long axis of the lower first premolar and second premolar.

Position IV referred to the horizontal location corresponding to the long axis of the second premolar. Position V referred to the location between the long axis of the lower second premolar and lower first molar. Finally, position VI referred to the long axis of the mesial root of the lower first molar.

Now, the distance "X" was calculated as the distance measured between the apex of the lower first premolar and the highest point of the MF. Distance "Y" was calculated as the distance measured between the alveolar crest and the maximum highest point of the MF. Distance "Z" was calculated as the distance between the lower border of the mandible and the lower border of MF. Two additional measurements were carried out along with this localization of position. One was measurement in vertical direction between the cortical borders of MF. This was considered as the height of MF (H). The other measurement was horizontal measurement between the cortical borders of the MF. It was considered as the length of MF (L) (Figs 1 and 2). The measurements were carried

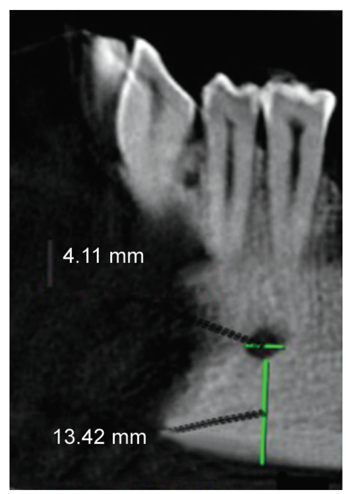

Fig. 1: CBCT scan image showing internal length of MF and distance between the lower border of MF and lower border of the mandible

Fig. 2: CBCT 3D reconstruction image showing the distance between the upper border of MF and the alveolar crest

out in all the CBCT scans selected in the study by the same oral and maxillofacial radiologist, and possible difference in measurement values was tried to discover out between different age-groups and different sexes.

After the collection of all the data, statistical analysis was carried out with the help of Fisher's exact test and Chi-square test. The Statistical Package for the Social Sciences (SPSS) (version 22, SPSS Inc., Chicago, Illinois) was used for carrying out statistical analysis.

Results

The number of CBCT scans of males was 142, while the number of females was 125. The number of CBCT scans in the age-group of 16–23 years was 24, it was 43 in 24–38 years age-group, it was 120 in 39–55 years age-group, while the number of CBCT scans in the age-group of more than 56 years was 80 (Table 1). It was found that maximum male CBCT scans (48.1%) consisted of MF in position III, while male CBCT scans (36.5%) were found to have position IV of the MF. On the contrary, maximum female CBCT scans (53.3%) were found to have position IV of MF.

When the distribution of position of MF in different age-groups was analyzed, then it was observed that maximum CBCT scans belonging to the age-group of 16–23 years, 24–38 years, and more than 56 years were found to have MF in the position III, while maximum CBCT scans belonging to age-group of 39–55 years were found to have MF in position IV (Table 1).

When the distance "X" was measured and the measurements were analyzed among different sexes and different age-groups, then it was found that the average value of all CBCT scans was 5.01 mm. There was no statistical difference in the measurement of distance X in the male and female groups. The average value in males was 5.02 mm, while it was 5.04 mm in females. The difference was not statistically significant when the comparison was made among different age-groups. Maximum distance was found in the 24–38 years age-group (Table 2).

When the measurements of distance "Y" were analyzed, then the total average was 12.04 mm. When the different sexes and age-groups were compared, then no significant difference was found (Table 3). When the measurements of distance "Z" were analyzed, then the average distance was found out to be 13.42 mm. The difference was statistically significant when the

Table 1: Data showing distribution of mental foramen positions for the sample by sex and age

	Sexes		*Age-groups*			
Position studied	*Male, n (%)*	*Female, n (%)*	*16–23 years, n (%)*	*24–38 years, n (%)*	*39–55 years, n (%)*	*>56 years, n (%)*
I	1 (0.9)	1 (0.1)	0 (0.0)	0 (0.0)	2 (1.3)	0 (0.0)
II	13 (9.6)	7 (5.2)	2 (11.3)	5 (12.1)	14 (12.0)	2 (6.3)
III	68 (48.1)	47 (38.4)	11 (45.0)	22 (51.5)	42 (35.2)	43 (53.7)
IV	52 (36.5)	66 (53.3)	10 (42.6)	15 (36.2)	54 (44.6)	29 (35.7)
V	6 (4.3)	3 (3.0)	1 (1.1)	1 (0.2)	8 (6.8)	2 (2.5)
VI	2 (0.6)	1 (0.1)	0 (0.0)	0 (0.0)	1 (0.1)	1 (2.0)
Total	142 (100.0)	125 (100.0)	24	43	120	80

Table 2: Evaluation of measurements of distance X

Studied groups	*Minimum value*	*First quartile value*	*Median value*	*Average value*	*Third quartile value*	*Maximum value*	*Standard deviation observed*	*p value*
All	1.50	4.12	4.83	5.01	6.39	12.82	2.13	
Female	1.45	4.14	4.87	5.04	6.49	12.81	2.21	0.78
Male	1.32	3.52	4.44	5.02	6.67	11.27	2.53	
16–23 years	1.48	3.43	4.83	4.63	5.86	8.42	1.87	0.32
24–38 years	3.16	3.88	5.59	5.47	6.53	8.77	1.89	
39–55 years	1.43	3.51	4.62	4.81	6.67	10.53	2.39	
>56 years	1.63	2.84	4.32	4.85	6.12	12.65	2.74	

Table 3: Evaluation of measurements of distance Y

Studied groups	*Minimum value*	*First quartile value*	*Median value*	*Average value*	*Third quartile value*	*Maximum value*	*Standard deviation observed*	*p value*
All	5.01	9.95	11.35	12.04	13.49	18.41	1.88	
Female	5.01	9.78	11.50	12.05	13.43	16.66	1.88	0.74
Male	7.25	10.06	11.27	12.48	13.37	18.63	1.88	
16–23 years	8.98	10.89	12.18	12.88	14.18	15.69	1.48	0.53
24–38 years	6.54	9.28	11.25	12.22	13.37	15.74	1.77	
39–55 years	5.76	9.76	11.29	12.28	13.71	16.66	2.17	
>56 years	5.01	10.02	11.36	12.26	13.43	18.63	2.24	

comparison was made among different sexes with measurement greater in males (14.24 mm) than females (12.76 mm). The difference was not statistically significant when comparison was made among different age-groups (Table 4). When the internal height of the MF was analyzed, then the average value in all CBCT scans was 4.22 mm. When the measurements were compared in different sexes, then the difference was statistically significant with more distance measurements in males as compared with females. When the measurements were compared in different age-groups, then the difference was not statistically significant (Table 5). When the measurements of length of the MF were compared in different sexes and age-groups, then the difference was not statistically significant. The average value was 4.11 mm (Table 6).

Discussion

In the present study, it was found out that the MF was located generally apically to the premolar and molar. It was more commonly located between the first premolar and second premolar in females, while in males, it was mostly located along the long axis of the second premolar. In most of the age-groups, MF was located between the long axis of the first premolar and second premolar. The average distance of MF from the apex of the first premolar was 5.01 mm. Further, the average internal height of MF and its distance from the base of the mandible were greater in males as compared with females. When the measurements were compared in different age-groups, then the difference was not statistically significant.

Von et al., Carruth et al., and Kalender et al. conducted similar studies and found that the height of MF was greater in males as compared with females. The results of the current study were similar to the results obtained from those studies.[12–14] The numerical values of height and length of MF obtained in the studies conducted by Von et al. and Kalender et al. were similar to the values obtained in the present study. It was found in the studies conducted by Von et al., Carruth et al., and Kalender et al. that the difference in the size of MF among different age-groups was not statistically significant[12–14]; similar findings were obtained in the current study.

In this current study, the distance between the apex of the first premolar and the upper border of MF was designated as

Table 4: Evaluation of measurements of distance Z

Studied groups	*Minimum value*	*First quartile value*	*Median value*	*Average value*	*Third quartile value*	*Maximum value*	*Standard deviation observed*	*p value*
All	9.41	12.18	12.31	13.42	13.51	17.15	1.55	
Female	9.42	11.07	12.02	12.76	13.10	17.37	1.47	0.01
Male	11.19	12.03	13.26	14.24	14.28	17.36	1.46	
16–23 years	10.82	11.95	12.41	12.79	13.53	15.83	1.24	0.72
24–38 years	10.44	12.27	13.41	13.41	14.28	16.44	1.37	
39–55 years	9.61	12.34	13.25	13.41	14.63	17.37	1.85	
>56 years	10.62	12.11	13.51	13.57	14.84	17.37	1.83	

Table 5: Evaluation of height measurements of mental foramen

Studied groups	*Minimum value*	*First quartile value*	*Median value*	*Average value*	*Third quartile value*	*Maximum value*	*Standard deviation observed*	*p value*
All	2.38	3.44	2.11	4.22	4.33	6.66	0.89	
Female	2.84	3.42	3.94	3.88	4.17	6.23	0.72	0.03
Male	2.38	3.83	4.36	4.92	4.85	6.44	0.87	
16–23 years	3.41	3.62	4.51	4.23	5.43	6.34	2.13	0.11
24–38 years	2.84	3.52	4.27	4.18	4.84	6.67	1.94	
39–55 years	2.18	3.42	3.52	3.88	4.44	6.32	0.58	
>56 years	2.75	3.41	2.11	4.16	4.37	5.82	0.51	

Table 6: Evaluation of length measurements of mental foramen

Studied groups	*Minimum value*	*First quartile value*	*Median value*	*Average value*	*Third quartile value*	*Maximum value*	*Standard deviation observed*	*p value*
All	2.41	3.42	4.27	4.11	4.55	6.66	0.77	
Female	2.84	3.50	4.11	4.27	4.47	6.42	0.76	0.26
Male	2.42	3.51	4.31	4.41	5.23	6.72	0.77	
16–23 years	3.11	3.25	4.26	4.27	4.42	8.67	1.34	0.31
24–38 years	2.24	4.11	4.37	4.367	3.11	6.43	1.23	
39–55 years	2.32	3.43	4.24	4.38	4.55	6.32	0.76	
>56 years	3.11	3.42	4.21	4.18	4.33*	6.22	0.91	

distance X. The average value of X was found out to be 5.01 mm in this study; however, there were no statistically different results obtained when values of distance X were compared in different sexes and different age-groups in our study. The results were in accordance with the results obtained from the research carried out by Von et al., Carruth et al., and Kalender et al.[12–14]

In this present study, the apex of the lower first premolar was selected as the landmark for measuring distance "X" because it is an important landmark for the administration of the mental nerve block.[15,16] So from our study, it can be clinically implicated that dental clinicians should administer anesthetic agent at an apical distance of 5.01 mm from the apex of the lower first premolar at a position between the long axis of the lower first premolar in males and along the long axis of the lower second premolar in males. This will further prevent trauma to the important nearby neurovascular bundles.[17]

In this current study, the distance between the upper border of MF and the alveolar crest was designated by the distance "Y". In the present study, there was no significant difference in the values of distance "Y" in different sexes and different age-groups. This finding was similar to the finding obtained from the studies carried out by Li et al., Hashiba et al., and Moiseiwitsch.[18–20] But the values of distance "Y" obtained in these studies were different from those obtained in the current study. The reason attributed to this difference may be due to the variation in the amount of alveolar bone loss in different populations.[18–20]

The distance between the lower border of the mandible and the lower border of MF was designated as distance "Z". In the present study, it was found that there was statistically significant difference among different sexes with the values of "Z" greater in males as compared with females. However, there was no significant difference when the comparison was made among different age-groups. Similar findings have been observed in the studies conducted by Gupta et al.[21]

MF is an important structure in the mandible because it acts as an important landmark in the anesthetic procedure. But there are a lot of variations due to which there can be failure of mental nerve block and unnecessary trauma to the important neurovascular bundles. Therefore, there was a need to carry out detailed quantitative and mathematical analysis for MF including several parameters like location, age-groups, sexes, distance from the premolar apex, distance from the base of the mandible, and height and length of the MF.[22] Very few studies have been conducted, which have focused on all these parameters. Therefore, this study was conducted to carry out quantitative and mathematical analysis of MF along with its correlation with study subject's sex and age using three-dimensional imaging like CBCT. Moreover, we have used CBCT imaging in this study, which provides accurate information about various measurements. Previous studies have used conventional two-dimensional imaging, which did not provide accurate information as a result of elongations and superimpositions.[23]

From the present study, it can be clinically implicated that dental clinicians should administer anesthetic agent at an apical distance of 5.01 mm from the apex of the lower first premolar at a position between the long axis of the lower first premolar in males and along the long axis of the lower second premolar in males. This will further prevent trauma to the important nearby neurovascular bundles.

The limitation of this study was that it was an *in vitro* study, which may have difference in results because the results were not compared with the actual *in vivo* condition. Actual localization of MF through surgical exploration should also have been included in the study. The values obtained from CBCT scans should have been compared with these values for better results.

Conclusion

The average distance of MF from the root apex of the first premolar was 5.01 mm, and the average size of MF and its distance from the base of the mandible were greater in males as compared with females.

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