Morphometric study for determining the anteroposterior position of the mental foramen in dentate human subjects

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Abstract

Background: The mental foramen (MnF) is the place where the mental nerve and mental artery exit the body of the mandible, being an important landmark for dentoalveolar surgery. Materials and Methods: For the assessment of MnF topography, we performed a direct morphometric study and two morphometric imaging studies through cone-beam computed tomography (CBCT) scans and orthopantomography (OPG). The following locations of the MnF were investigated: anterior to the first premolar, at the first premolar level, between the two premolars, at the second premolar level, between the second premolar and the 6-year molar, and at the level of the mesial root of the 6-year molar. The data obtained were statistically analyzed by chi-squared test. Results: Through direct morphometry on dentate dry human mandibles, no statistically significant differences were found for the number of MnF located between the two premolars, at the level of the second premolar and between the second premolar and the 6-year molar, depending on age and analyzed side. The number of MnF located between the second premolar and the first molar varies statistically significantly in relation to the subject’s gender but does not vary statistically significantly depending on age and side. By means of imaging morphometry through OPG, we found that the number of MnF located at the first premolar level, between the two premolars, at the second premolar level and between the second premolar and the 6-year molar varies statistically significantly in relation to the age of the patients. Using imaging morphometry trough CBCT scans, we found that the number of MnF located between the two premolars, at the second premolar level and between the second premolar and the 6-year molar varies statistically significantly according to the age of the patients. Comparing the results obtained from the three studies, we found that only according to age the number of MnF located between premolars and at the level of the second premolar varies statistically significantly. Conclusions: Wide and accurate knowledge of both the MnF topography and the key anatomical landmarks used in locating it proves to be essential and clinically relevant in dentoalveolar and endodontic surgery, and for improving anesthesia techniques.

Keywords: mental nerve, direct and imaging morphometry, OPG, CBCT, mental nerve block.

Introduction

Mental foramen (MnF) is situated on the buccal side of the mandibular body, usually in the premolar region. The MnF externalizes the mental canal and contains the mental neurovascular bundle; hence, it is important for highly effective local anesthesia and dentoalveolar and implant surgery in the posterior mandible [1–5].

MnF topography varies, thus favoring a decreased success rate in the case of mental nerve block and the occurrence of complications during different dentoalveolar surgery procedures in this area [2, 6].

The specialized literature on this topic does not convey a unified perspective when describing the topography of the MnF. The topography of the MnF presents frequent population variations and even individual variations comparatively left/right side [1, 4, 7–10].

Accurate determination of the MnF location is especially important for implant dentistry, which developed a lot over the last decade [1, 4, 11].

In-depth knowledge of the MnF topography, of the mandibular canal and of the vital neighboring structures is important for loco-regional anesthesia, in endodontics, periodontology, implant surgery and dentoalveolar surgery, i.e., in all therapeutic procedures performed on the posterior mandible [1, 12, 13].

The MnF can be identified by orthopantomography (OPG) and especially by cone-beam computed tomography (CBCT), which requires a low dose of radiation; by being able to provide structural details in the three directions of
space, the latter imaging technique has greatly improved the pre-interventional morphological analysis.

Aim

Research existing in the specialized literature describes differences in the MnF location. Consequently, in this study, we aim to show a combined morphometric determination, by direct and imaging techniques, of the topography of the MnF on Romanian population, particularly its antero-posterior location in relation to the teeth.

Materials and Methods

The topography of the MnF on the sagittal plane (in relation to the teeth) was assessed by an ex vivo morphometric study on 27 dentate mandibles from the Francisc I. Rainer Anthropology Institute of the Romanian Academy, Bucharest, the same specimens, with specified gender and age, used in a previous study concerning the topography of the mandibular foramen [8]. At the same time, we carried out two morphometric imaging studies through CBCT scans (19 from partially edentulous patients) and OPGs (21 from dentate patients) from a private dental practice. Patients’ written informed consent was obtained for using the radiographs in this research.

Results

The first study: direct morphometry on 27 dentate dry human mandibles

The distribution of the specimens with respect to gender was 18 (66.7%) females and nine (33.3%) males. The average age of the subjects was 29.5 years, with the minimum age of 20 years and the maximum age of 39 years.

Concerning MnF location, the mean obtained values on the right vs. left side were different, as shown in Table 1, which demonstrates morphological asymmetry.

Overall, most commonly, the MnF was located between PM1 and PM2 and at PM2 level in equal percentages, 48.15% of cases, hence in a total percentage of 96.3%. More rarely (3.7%), the MnF was found in another location (Table 1).

The results obtained on the MnF anteroposterior location in relation to the teeth, by direct morphometry in the 27 dry dentate mandibles were statistically analyzed by chi-squared test (Table 2).

The following MnF locations (as shown in Figure 1) were investigated on both sides of the mandibles:
1 – anterior to the first premolar (PM1);
2 – at the level of the first premolar;
3 – between the two premolars;
4 – at the level of the second premolar (PM2);
5 – between the second premolar and the first molar (M1);
6 – at the level of the mesial root of the first molar.

For panoramic orthopantomography, a PLANMECA ProMax 2D was used, with the following technical parameters: 68 kV, 10.0 mA, about 15.8 seconds X-ray exposure time, and approximately 13 μSV the effective radiation dose. Radiographically obtained data were processed with ROMEXIS 4.6 software (Figure 2).

For the CBCT, a NewTom VG1 Evo imaging unit was used, with the technical specifications: 1–20 mA, 110 kV, 3.5–4.3 seconds X-ray exposure time range, 18 seconds scanning time, and 100 μSV effective dose, used in a previous study [8]. Data obtained were analyzed on a computer with New Net Technologies (NNT) ver. 11 software [8]. The measurements expressed in millimeters, on mandibular sections, are at a scale of 1:1 (Figure 3).

The results of the measurements were statistically analyzed using χ² (chi-squared) test in Stata/MP13 software package. The statistical significance level was set at \( p \leq 0.05 \).

Table 1 – The results for the MnF locations on dentate dry mandibles

| Analyzed landmarks | N₁  | N₂  | %   |
|-------------------|-----|-----|-----|
| Anterior to the first premolar | 27  | 0   | 0   |
| At the first premolar level | 27  | 0   | 0   |
| Between premolars | 27  | 11  | 40.7|
| At the second premolar level | 27  | 15  | 55.6|
| Between the second premolar and the first molar | 27  | 1   | 3.7 |
| At the mesial root of the first molar level | 27  | 0   | 0   |

Left side

| Analyzed landmarks | N₁  | N₂  | %   |
|-------------------|-----|-----|-----|
| Anterior to the first premolar | 27  | 0   | 0   |
| At the first premolar level | 27  | 0   | 0   |
| Between premolars | 27  | 15  | 55.6|
| At the second premolar level | 27  | 11  | 40.7|
| Between the second premolar and the first molar | 27  | 1   | 3.7 |
| At the mesial root of the first molar level | 27  | 0   | 0   |

MnF: Mental foramen; N₁: No. of subjects; N₂: No. of findings.
morphometry through CBCT scans on dentate human mandibles, showed morphological asymmetry (Table 5).

| Table 3 – The results for the MnF locations by OPG examination in dentate patients |
| --- |
| Right side – all patients |
| Analyzed landmarks | \(N_1\) | \(N_2\) | % |
| Anterior to the first premolar | 21 | 0 | 0 |
| At the first premolar level | 21 | 1 | 4.8 |
| Between premolars | 21 | 9 | 42.9 |
| At the second premolar level | 21 | 9 | 42.9 |
| Between the second premolar and the first molar | 21 | 2 | 9.5 |
| At the mesial root of the first molar level | 21 | 0 | 0 |
| Left side – all patients |
| Analyzed landmarks | \(N_1\) | \(N_2\) | % |
| Anterior to the first premolar | 21 | 0 | 0 |
| At the first premolar level | 21 | 1 | 4.8 |
| Between premolars | 21 | 10 | 47.6 |
| At the second premolar level | 21 | 9 | 42.9 |
| Between the second premolar and the first molar | 21 | 1 | 4.8 |
| At the mesial root of the first molar level | 21 | 0 | 0 |

MnF: Mental foramen; \(N_1\): No. of subjects; \(N_2\): No. of findings; OPG: Orthopantomography.

| Table 4 – Analysis by chi-squared test of the measurements carried out on OPG in dentate patients |
| --- |
| Chi-squared test – all patients, examination by OPG |
| Analyzed landmarks | \(N_1\) | \(N_2\) | Side | Gender | Age |
| Anterior to the first premolar | 21 | 42 | – | – | – |
| At the first premolar level | 21 | 42 | 1.00 | 0.167 | 0.003 |
| Between premolars | 21 | 42 | 0.757 | 0.226 | 0.016 |
| At the second premolar level | 21 | 42 | 1.00 | 0.721 | 0.009 |
| Between the second premolar and the first molar | 21 | 42 | 0.549 | 0.607 | 0.023 |
| At the mesial root of the first molar level | 21 | 42 | – | – | – |

\(N_1\): No. of patients; \(N_2\): No. of findings; OPG: Orthopantomography.

| Table 5 – The results for the MnF locations by CBCT examination in dentate patients |
| --- |
| The results of the measurements by CBCT [%] |
| Right side – all patients |
| Analyzed landmarks | \(N_1\) | \(N_2\) | % |
| Anterior to the first premolar | 19 | 0 | 0 |
| At the first premolar level | 19 | 1 | 5.3 |
| Between premolars | 19 | 9 | 47.4 |
| At the second premolar level | 19 | 8 | 42.1 |
| Between the second premolar and the first molar | 19 | 1 | 5.3 |
| At the mesial root of the first molar level | 19 | 0 | 0 |
| Left side – all patients |
| Analyzed landmarks | \(N_1\) | \(N_2\) | % |
| Anterior to the first premolar | 19 | 0 | 0 |
| At the first premolar level | 19 | 2 | 10.5 |
| Between premolars | 19 | 7 | 36.8 |
| At the second premolar level | 19 | 7 | 36.8 |
| Between the second premolar and the first molar | 19 | 3 | 15.8 |
| At the mesial root of the first molar level | 19 | 0 | 0 |

CBCT: Cone-beam computed tomography; MnF: Mental foramen; \(N_1\): No. of subjects; \(N_2\): No. of findings.
Similar to the previous study, we found greater variability regarding the MnF topography. Most commonly, the MnF was located between PM1 and PM2 in 16 (42.10%) from the total of 38 studied sides, and at PM2 level in 15 (39.45%) from the total of 38 studied sides. These main locations represent a total percentage of 81.55% of the cases. The MnF was less commonly situated between PM2 and M1 (10.55%), and at PM1 level (7.9%).

The results obtained on the MnF anteroposterior location in relation to the teeth, by imaging morphometry through CBCT scans, in the 19 dentate patients were compared by side, gender and age through chi-squared test (Table 6). The number of MnF located between PM1 and PM2, at PM2 level, between PM2 and M1 varies statistically significantly depending on age (p<0.05). There were no statistically significant differences for all locations of the MnF mentioned in Table 6, in relation to the analyzed side and the patients’ gender (p>0.05).

Table 6 – Analysis by chi-squared test of the measurements carried out on CBCT in dentate patients

| Analyzed landmarks | N1  | N2  | Side | Gender | Age |
|--------------------|-----|-----|------|--------|-----|
| Anterior to the first premolar | 19   | 38  |       |        |     |
| At the first premolar level | 19   | 38  | 0.547 | 0.748  | 0.787 |
| Between premolars | 19   | 38  | 0.511 | 0.624  | 0.023 |
| At the second premolar level | 19   | 38  | 0.740 | 0.832  | 0.033 |
| Between the second premolar and the first molar | 19   | 38  | 0.290 | 0.832  | 0.045 |
| At the mesial root of the first molar level | 19   | 38  |       |        |     |

CBCT: Cone-beam computed tomography; N1: No. of subjects; N2: No. of findings.

Analysis of the results as a whole

Analyzing the results for the 67 subjects by the chi-squared test, no statistically significant differences regarding the MnF locations mentioned in Table 7 were found for the study, for the right side vs. the left side and according to gender (p>0.05). The number of MnF located at PM1 level and between PM2 and M1 does not vary statistically significantly depending on age (p>0.05). The number of MnF located between PM1 and PM2, and at PM2 level varies statistically significantly depending on age (p<0.05).

Table 7 – Analysis by chi-squared test of the results as a whole

| Analyzed landmarks | N1  | N2  | Study | Side | Gender | Age |
|--------------------|-----|-----|-------|------|--------|-----|
| Anterior to the first premolar | 67   | 134 |       |      |        |     |
| At the first premolar level | 67   | 134 | 0.132 | 0.649 | 0.123  | 0.590 |
| Between premolars | 67   | 134 | 0.848 | 0.603 | 0.262  | 0.016 |
| At the second premolar level | 67   | 134 | 0.699 | 0.384 | 0.807  | 0.011 |
| Between the second premolar and the first molar | 67   | 134 | 0.433 | 0.730 | 0.563  | 0.111 |
| At the mesial root of the first molar level | 67   | 134 |       |      |        |     |

Chi-squared test – all patients, examination by CBCT

N: No. of subjects; N2: No. of findings.

Discussions

No similar study could be found in the specialized literature we accessed, that was able to present such a complex analysis of the MnF topography by two methods of imaging morphometry, OPG and CBCT, in addition to direct morphometry.

The measurements were performed by the same person, thus eliminating possible errors.

The studies analyzed as a whole show that the most frequent location of the MnF (45.15%) was between PM1 and PM2, in 61 from the total of 134 registered observations, followed by the position at PM2 level (43.50%), in 59 from the total of 134 registered observations. Separate analysis in men vs. women shows that the most frequent location of the MnF in men was at PM2 level (45.46%), in 28 from the total of 62 registered observations, while in women, the most frequent location was between the two premolars (48.41%), in 32 from the total of 72 registered observations.

The results obtained in the three studies were close in value in terms of the order of frequency of MnF location and demonstrate the existence of left/right symmetry on location of MnF in relation to the sagittal plane by direct morphometry; the same is valid in female patients for CBCT imaging morphometry, only for MnF locations between PM1 and PM2, and at PM2 level. These results show some similarities with other studies in the literature, but also reveal many differences.

Analyzing the MnF topography in relation to the sagittal plane on dry dentate human mandibles from Turkish population, Oguz & Bozkir (2002) [1, 14] showed the following frequent locations: at PM2 level (55.8%), and between PM1 and PM2 (44.10%), with significant differences between the left and right sides. Such results differ from those we presented in this study.

Ngeow & Yuzawati (2003) [1, 15] studied the MnF topography on Malaysian population by panoramic radiographs and showed that in relation to the sagittal plane, the most common location was at PM2 level (69.20%), and between PM1 and PM2 (19.60%), with bilateral symmetry in 67.70% of cases. Again, the results differ from ours.

Kim et al. (2006) [1, 16] evaluated the MnF anteroposterior topography on Korean population, both clinically and by panoramic radiographs, and described the following locations: at PM2 level (64.3%), between PM1 and PM2 (26.8%), and at PM1 level (8.9%). These findings are different from ours.

Al-Khateeb et al. (2007) [17] studied the MnF topography on the sagittal plane by OPG on Jordanian population and showed that its most common horizontal location was between PM1 and PM2, a result close to that presented in this study.

Most of the accessed studies that evaluated the topography of the MnF in relation to the sagittal reference plane were carried out on Indian and Iranian populations.

In a study of dry dentate human mandibles from the population of Bangladesh, Hoque et al. (2013) [1, 18] presented the following locations for the MnF: between PM1 and PM2 (42.45%), at PM2 level (35.9%), and behind PM2 (21.65%), with bilateral symmetry. These results are relatively close to those presented in this study.
By OPG evaluation of Indian population, Parnami et al. (2015) [9] illustrated the following anteroposterior locations for the MnF: at PM2 level 61.0%, and between PM1 and PM2 28.7%. The results are different from those obtained by us.

By standardized OPG evaluation of Asian population, Gada & Nagda (2014) [1, 19] described that the common anteroposterior locations for the MnF were: between PM1 and PM2 63.0%, and at PM2 level 20.67%. Symmetry between left and right side was found. These results are different from our study.

By OPG evaluation on Indian population, Verma et al. (2015) [20] showed that, on sagittal plane, the MnF was situated at PM2 level (43.33%), and between PM1 and PM2 in 35.41% of cases, with some left-right asymmetry. The results are different from those obtained in this study.

In a retrospective CBCT study on South Indian population, Chappidi et al. (2019) [21] showed that, in sagittal plane, the MnF presents the following locations: between PM1 and PM2 (62%), at PM2 level (34%), at the PM1 level (1.6%), and between PM2 and M1 (1.4%). These results are similar to ours; however, the percentages differ, being greater than the ones obtained by us for the location between the two premolars and smaller for the locations at PM1 level, at PM2 level and between PM2 and M1.

Khalid et al. (2019) [22] radiographically evaluated the MnF topography in relation to the sagittal plane on Indian population and showed that it is located at PM1 level (45.71%), at PM2 level (38.57%), and between PM1 and PM2 (8.57%); it was not visible in 7.14% of cases. The results are different from those obtained in our study.

Haghanifar & Rokouei (2009) [1, 23] assessed Iranian population by OPG and showed that the MnF was frequently located between PM1 and PM2 (47.20%), and at PM2 level (46.0%), with a symmetry of 85.7%. These results are very close to those presented in this study.

Khajoastepour et al. (2015) [24] assessed the MnF by CBCT on Iranian population and showed the following anteroposterior positions: at PM2 level (49.4%), and between PM1 and PM2 in 33.2% of cases, with slight left/right and women/men asymmetry. The results are comparable to those obtained by us for male subjects.

By CBCT evaluation of Iranian population, Sheikhi et al. (2015) [25] determined that the most frequent locations of the MnF were: between PM1 and PM2, and at PM2 level. The results are comparable to those obtained by us only in terms of frequency, since percentage values were not presented.

Xie et al. (2021) [26] evaluated the MnF topography on Chinese population and demonstrated that it was located at PM1 level in 20% of the cases, at PM2 level in 75% of the cases, and at M1 level in 5% of the cases.

Fabian (2007) [1, 27] studied the anteroposterior position of MnF in Tanzanian population and presented the following locations: at PM2 level (45.0%), between PM2 and M1 (35.0%), between PM1 and PM2 (12.0%), and at M1 level (8.0%), with a right-left symmetry in 78.0% of cases. These results are very different from those presented in our study.

Chkoura & El Wady (2013) [28] evaluated the MnF topography in relation to the sagittal plane on Moroccan population by OPGs and showed the following percentage values for MnF locations: at PM2 level (62.70%), and between PM1 and PM2 (30.0%). These results are different from those in this study.

A unique study on MnF evaluation by ultrasonography, conducted by Laher et al. (2016) on population of South Africa [1, 29], presented for the black population, that MnF was situated between PM1 and PM2 (51.0%), and for the Caucasians between PM1 and PM2 (48.0%), and at PM2 level (36.0%). Caucasian population results are similar to those obtained by us in terms of frequency, but the percentages differ: they are greater than the ones obtained by us for the location between the two premolars and smaller for the location at PM2 level.

In a retrospective study on Egyptian population, Shalash et al. (2020) [30] studied the MnF topography on sagittal plane by CBCT and showed that it is located at PM2 level (55.8%), between PM1 and PM2 (26.35%), between PM2 and M1 (11.35%), at PM1 level (4.95%), and at M1 level (1.55%). These results are similar to ours, but the percentages differ, being smaller than the ones obtained by us for the location between the two premolars and greater for all the other locations.

By CBCT evaluation on Belarus population, Kabak et al. (2017) [1, 31] presented the following locations on the sagittal plane for the MnF: between PM1 and PM2 (57.70%), and at PM2 level (33.80%). Symmetry between the left and right side was 64.10%. These results are similar to ours in frequency, but the percentages differ, being greater than the ones obtained by us for the location between the two premolars and smaller for the location at PM2 level.

Santini & Alayan (2012) [32], in a study concerning the topography of the MnF, illustrated that on Indian and European populations the most common location was between PM1 and PM2, just as it happened in our study, on the Romanian population.

Zmysłowska-Polakowska et al. (2019) [33] evaluated MnF topography on sagittal plane in Polish population and showed that it is most frequently located between PM1 and PM2, followed by the location at PM2 level, an observation similar to ours.

In a retrospective review study on OPG and CBCT, Jasim (2020) [34] analyzed the MnF topography and showed that it was located at PM2 level in the percentage of 49.99%, and between PM1 and PM2 in the percentage of 42.30%. These results are comparable to those obtained by us for male subjects.

Pelé et al. (2021) [35] analyzed the MnF anteroposterior topography and illustrated that it was located mostly between PM1 and PM2 (from 50.4% to 61.95%) or at PM2 level (from 50.3% to 57.9%). Then, it was situated between PM2 and M1 (16.7% to 19.4%) or at M1 level (from 6.7% to 10.7%) and exceptionally in front of PM1 or between M1 and M2 (second molar).

According to the accessed references, in the Caucasian population the MnF was frequently located between the premolars and at the level of the second premolar; for Asians (Mongols, Chinese and South Koreans) it was frequently located at the second premolar level and anterior from it, and for African population it was located predominantly at the level of the second premolar and distal to it.
Conclusions

This is a unique and complex study of the MnF topography on the sagittal plane, performed on Romanian population, by direct and imaging morphometry on 67 human mandibles, with a total of 134 observations. Variations regarding the sagittal location of the MnF could be responsible of therapeutic failures following oral rehabilitation procedures in the mandibular premolar area. Accurate knowledge of both the MnF topography and the key anatomical landmarks used in locating it proves to be essential and clinically relevant in dentoalveolar and endodontic surgery, and for improving anesthesia techniques.

Conflict of interests

The authors declare that they have no conflict of interests.

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