Evaluation of mental foramen and inferior alveolar nerve canal and its relationship to adjacent anatomical landmarks using cone-beam computer tomography

S. Taschieri[1,2,3], C. Vitelli[1], D. Albano[3,4], L. Sconfienza[3,5], M. Del Fabbro[1,3], L. Francetti[1,3], M. Parrini[1] and S. Corbella[1,2,3]

[1]Department of Biomedical, Surgical and Dental Sciences, Università degli Studi di Milano, Milan, Italy; [2]IRCCS Istituto Ortopedico Galeazzi, Milan, Italy; [3]Institute of Dentistry, I. M. Sechenov First Moscow State Medical University, Moscow, Russia; [4]Sezione di Scienze Radiologiche, Dipartimento di Biomedicina, Neuroscienze e Diagnostica Avanzata, Università degli Studi di Palermo, Palermo, Italy; [5]Dipartimento di Scienze Biomediche per la Salute, Università degli Studi di Milano, Milano, Italy.

The objective of the research was to evaluate the location, size, variability, and morphologic features of mental foramen (MF) and the inferior alveolar nerve canal (IAN) on cone-beam CT. We evaluated the morphologic findings of mental foramen (MF) and inferior alveolar nerve (IAN) canal of 88 mandibular hemiarches of 65 Caucasian subjects (35 males, 30 females; age range 25-75 years) using cone beam CT. The most common horizontal position of MF was type 3 (53.4%), followed by type 4 (39.8%), type 1 (2.3%), type 2 (2.3%), and type 5 (2.3%). Regarding the vertical position, in 71.6% of cases (63/88) we found type 3 position, followed by type 2 (22.7%) and type 1 (5.7%). MF presented as oval in 51.1% and round in 42%, with double oval and triple foramens having been observed in 5.7% and 1.1% respectively. In 36.9% of cases, we found an anterior loop of the IAN. The mean depth of MF was 6.12±1.65mm; width and height were 3.7±0.83mm and 3.14±0.78mm. Width and height of the IAN distal to MF were 2.27±0.53mm and 2.74±0.51mm, while those of the incisive nerve canal mesial to MF were 1.37±0.44mm and 1.54±0.58mm, respectively. An increase in the width of MF was correlated to oval shape (r=0.45; $P < 0.01$), and there was a low but significant correlation (r=0.23; $P < 0.05$) between the round shape of MF and the size of the IAN. MF shape appears to be correlated to MF width and size of the IAN. The individual anatomical variability of this structure is a factor that must be considered when dealing with mandibular surgery.

The inferior alveolar nerve (IAN) is a branch of the mandibular nerve which is itself a branch of the trigeminal nerve. The IAN is a mixed nerve with a clear prevalence of sensitive fibers, which innervate the dental alveoli, teeth, and gums distally to the first premolar; the motor fibers innervate the mylohyoid muscle. The IAN travels, after branching from the mandibular nerve, behind the lateral pterygoid muscle, then provide the mylohyoid nerve before entering in the medial face of the mandibular ramus into the mandibular canal; such canal runs close to the apexes of the teeth until it reaches the premolars, where it divides into its two terminal branches: the mental nerve, which exits from the mandibular canal through the mental foramen (MF), and the incisive nerve (IN), which continues along the mandibular canal until it anastomosed with the contralateral, at the midline.

Key words: cone beam computed tomography; mandibular anatomy; mental foramen; inferior alveolar nerve; mental nerve; incisive nerve

Corresponding author:
Dr. Stefano Corbella,
IRCCS Istituto Ortopedico Galeazzi,
Via R. Galeazzi 4, 20161 Milan, Italy
e-mail: stefano.corbella@unimi.it

0393-974X (2020)

DISCLOSURE: ALL AUTHORS REPORT NO CONFLICTS OF INTEREST RELEVANT TO THIS ARTICLE.

Dental surgical procedures like tooth extraction, surgical curettage after tooth extraction, implant placement, or periapical surgery require an accurate pre-operative planning, which includes knowing the exact position of the IAN canal, its branches and MF to avoid injuries of the neurovascular bundles. Any damage to the MC may result in sensitivity changes or bleeding complications possibly leading to severe complications for the patients. As an example, according to a study on human specimens, Solar et al postulated that a minimum distance of 6 mm between the implant and the MF should be respected when performing surgery in the mandibular premolar region (1–3); number, and size of the mental foramen, mental nerve anatomy, and consequences of nerve damage were evaluated for information pertinent to clinicians performing implant dentistry. Nevertheless, as a matter of fact, MF may present a wide anatomical variability. As far as its position is concerned, the foramen is usually single and located on the outer side of the mandible (vestibular wall), between the first and second premolar (4). Regarding the shape, the foramen can be oval or round and can be single, double, or multiple (5)African Americans and American Whites, and Pre-Columbian Nazca Indians. AMF were found less frequently in the American White and Asian Indian populations than in the other groups (American White, 1.4%: Asian Indian, 1.5%; African American, 5.7% and Nazca, 9.0%. Location and morphologic features of MF seem to vary according to different ethnic origins, with some authors having reported significant changes also based on sex (6, 7).

Previous studies have investigated the variability of MF by using cone-beam computed tomography (CBCT). This imaging modality, indeed, is optimal for this purpose, having several well-known strengths and advantages if compared to conventional 2D imaging techniques (e.g. orthopantomography). In fact, CBCT allows to acquire, quickly and with very low dose of ionizing radiations, high-resolution cross-sectional images with excellent contrast and spatial resolution, isotropic voxels and possibility to obtain multiplanar reconstructions, which are essential for a correct and detailed assessment of maxillofacial anatomic structures (8) three dimensions 3D.

The aim of our study was to evaluate the location, size and morphologic features of mental foramen and inferior alveolar nerve canal and its relationship to adjacent anatomical landmarks using cone-beam computer tomography. Possible disagreements were re-evaluated by all three specialists until a common opinion was reached.

MATERIALS AND METHODS

Study design

Ethical Committee approval (Ospedale San Raffaele, Milano, Italy, Ethical Committee: Protocol #RETRORAD) was obtained for this retrospective study and patients' informed consent was waived. This retrospective study is concerned with the evaluation of morphologic findings of MF and IAN canal of patients who underwent CBCT at our Institution IRCCS Istituto Ortopedico Galeazzi, Milano, Italy from January 2018 to August 2020. CBCT examinations were performed for different reasons, including pre-operative planning for implant placement or dental surgery. In our analysis, we included only CBCT of the mandible performed in patients with permanent (non-mixed or deciduous) teeth and with canines and both premolars in the examined hemiarch. The following exclusion criteria were used:

- presence of motion artifacts that made images inadequate for thorough evaluation;
- previous bone surgery in the examined hemiarch such as osteotomy;
- presence of benign or malignant lesions;
- mandibular fractures.

Among 212 patients eligible for inclusion, 98 underwent CBCT of the maxillary arch only and 49 were not included due to the above-mentioned exclusion criteria. Thus, 88 mandibular hemiarches (47 males, 41 females; 47 right hemiarches, 41 left hemiarches) of 65 Caucasian patients (35 males, 30 females; mean age 49,7 years; range from 25 to 75 years age range 25-75 years) were finally included in our study. In 23 out of 65 patients, both hemiarches were evaluated.

CBCT scan and images interpretation

CBCT examinations were performed on a 3D Accuitomo XYZ Slice View Tomograph® (Model MCT-1, Type EX-1/EX-2; Fushimi-ku, Kyoto: J. Morita Mfg.

Corp) with 60-80 kV and 1-10 mA, a voxel size of 0.125 mm per side, and an approximate exposure time of 18 seconds. Images were collected and analyzed using a computer software (OnDemand3D™, Cybermed, Seoul, South Korea), that was used to obtain all measurements.

One operator (CV), that was trained for a 3-month period by two board-certified radiologists (DA, LS), repeated twice the measurements and the evaluations on CBCT scans. For continuous variables, mean values of both measurements were considered and for categorical variables, in case of disagreement, it was resolved by consulting the radiologists (DA, LS).

Multiplanar reconstructions with slices of 0.125 mm thickness were used to obtain the following measurements:

- Horizontal location of the MF (9): type 1, between the canine and first premolar; type 2, at the level of the first premolar; type 3, between the first and second premolars; type 4, at the level of the second premolar; type 5, between the second premolar and the first molar; type 6, at the level of the first molar (Fig. 1).
- Vertical location of the MF based on the apices of the premolars (6): type 1, above the level of the apices of the first and second premolars; type 2, at the level of the apices of the first and second premolars; type 3, below the level of the apices of the first and second premolars (Fig. 1).
- Height and width of MF measured in mm (Fig. 2).
- Morphology of the MF: round, oval, double oval, multiple (Fig.3). The morphology was assessed calculating the ratio between height and width. The foramen was classified as oval when the ratio was greater than 1.24 or less than 0.76, as previously described by other authors (10, 11). Accessory mental foramina were identified when a foramen smaller in size was detected close to the MF (7, 12).
- Presence of anterior loop of the IAN, related to the course of the canal's nerve, which, in its first part, dips downwards and is then displaced upward and posteriorly to exit the MF (Fig. 4)(13).
- Distance between the most coronal extent of MF and the alveolar ridge (Fig. 5A).
- Distance between the most apical extent of MF and the alveolar ridge (Fig. 5B).
- Depth of MF (it means the depth between the mandibular canal and the mental foramen as the length of the mental canal) (Fig. 5C).
- Height and width of mandible at the level of MF (Fig. 6).
- Height and width of the IAN distal to MF (Fig. 7A).
- Height and width of the IN mesial to MF (Fig. 7B).

Statistical analysis

The normality of the distributions of study variables was tested with the Shapiro-Wilk test. For normally distributed continuous variables descriptive statistics was provided by calculating mean +- standard deviations. The comparisons between groups were made by using the Student's t-test. For categorical variables, frequencies were provided. Pearson's correlation method served to evaluate correlations between variables. Statistical analysis was performed using SPSS® software (v. 26,

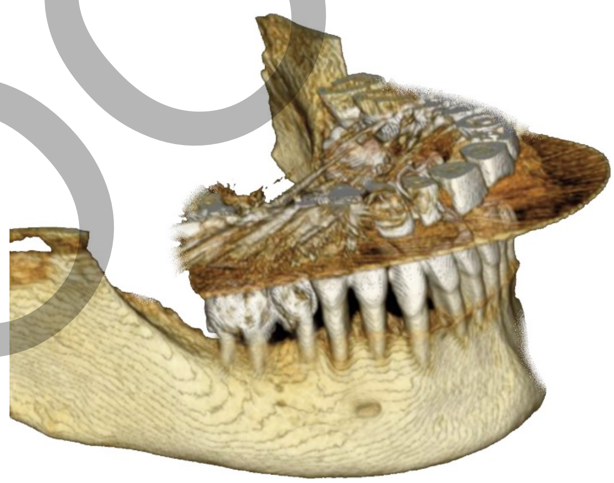

Fig. 1. *Volume rendering CBCT image of a MF in type 3 horizontal position (between the first and second premolars) and type 3 vertical position (below the level of the apices of the first and second premolars).*

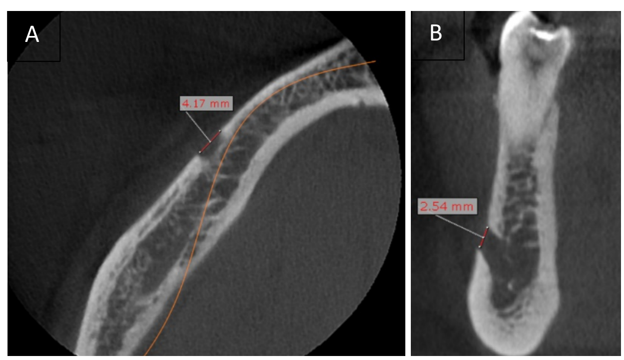

Fig. 2. *Axial image (**A**) and coronal oblique multiplanar reconstruction image (**B**) of CBCT scan show the width (4.17 mm) and height (2.54 mm) of MF, respectively.*

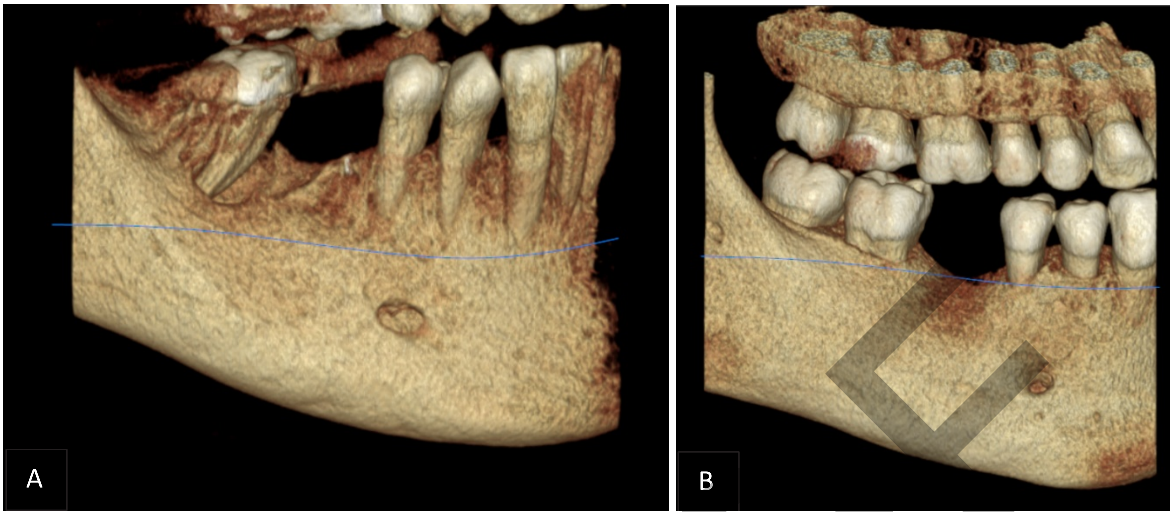

Fig. 3. *Volume rendering images of CBCT scans of two different patients with oval (**A**) and round (**B**) MF, respectively.*

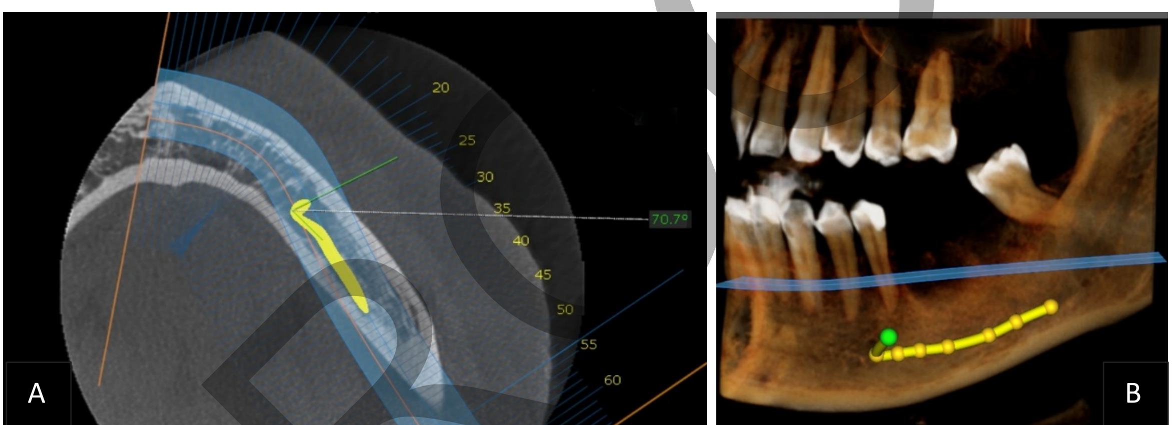

Fig. 4. *Axial CBCT image (**A**) and volume rendering image (**B**) show the anterior loop of the IAN, which in its first part, dips downwards and is then displaced upward and posteriorly with an angle of 70.7 degrees to exit the MF.*

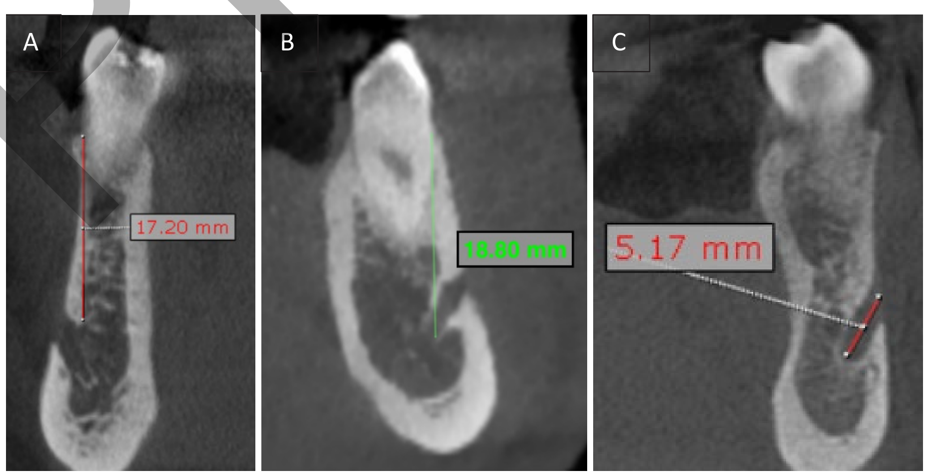

Fig. 5. *Coronal oblique multiplanar reconstruction image shows (**A**) the distance between the most coronal extent of MF and the alveolar ridge (17.20 mm); (**B**) the distance between the most apical extent of MF and the inferior margin of the mandible (18.8 mm); and (**C**) the depth of MF (5.17 mm).*

Fig. 6. *Coronal oblique multiplanar reconstruction images show the height (31.76 mm) of the mandible at the level of MF (**A**) and the width of the mandible at the level of the superior (8.30 mm) and inferior edge (9.56 mm) of MF (**B**).*

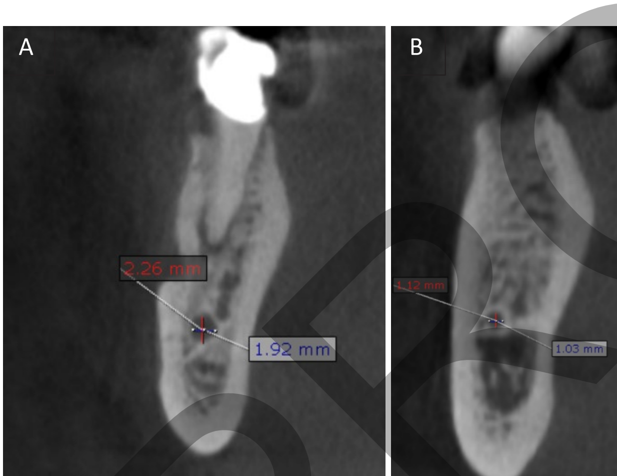

Fig. 7. *Coronal oblique multiplanar reconstruction image shows (**A**) the height (2.26 mm) and width (1.92 mm) of the IAN distal to MF; and (**B**) the height (1.12 mm) and width (1.03 mm) of the IN mesial to MF.*

IBM, Armonk, New York, NY). The level of statistical significance was posed to $P < 0.05$.

RESULTS

Regarding the horizontal position of the MF, the most common was type 3 (53.4%), followed by type 4 (39.8%), type 1 (2.3%), type 2 (2.3%), and type 5 (2.3%) position. When both hemiarches of the same patient were available, the horizontal position of MF was symmetrical in 61% of cases. Regarding the vertical position of MF, in 71.6% of cases we found type 3 position, followed by type 2 (22.7%) and type 1 (5.7%). The MF presented as oval in 51.1% and round in 42%, with double oval and triple foramens having been observed in 5.7% and 1.1%, respectively; 56% of patients evaluated bilaterally had the same MF morphology on both hemiarches. Of the six cases with accessory MF, three were very close to the main foramen, two were below the canine (anterior to the main foramen) and one was posterior to the main foramen at the root level of the first molar, with a distance between accessory and main foramen ranging between 1.8 and 9.5 mm. In twenty-four cases (36.9%), we found an anterior loop of the IAN. The mean depth of MF was 6.12±1.65mm; while width and height were 3.7±0.83mm and 3.14±0.78mm, respectively. Width and height of the IAN distal to MF were 2.27±0.53mm and 2.74±0.51mm, while those of the incisive nerve canal mesial to MF were 1.37±0.44mm and 1.54±0.58mm, respectively. All measurements concerning MF, mandibular hemiarch, and NAI are reported in Table 1. An increase in the width of the MF was correlated to oval shape (r=0.45; $P < 0.01$), and there was a low but significant correlation (r=0.23; $P < 0.05$) between the round shape of the MF and the size of the IAN.

DISCUSSION

Anatomical variability of MF was more frequently in presence of an oval shape, positioned between and below the first and second premolars and associated with accessory foramen in a significant number of cases. We also found interesting correlations between size and morphology of MF and size of IN and IAN, respectively.

In more than half of cases, the most frequent location of MF was between the first and second premolar, which is in line with previous studies on Caucasian (14, 15), white Americans (4), Brazilian (10), Saudi (16) and Polish populations (6). Conversely, type 4 horizontal position (at the level of the second premolar) has been reported as the most frequent in sub-Saharan Africa (17–21), Indian

Table I. *All measurements concerning MF, mandibular hemiarch, and IAN canal.*

Mental Foramen	Mean Size±SD (mm)	Range (mm)
Width of MF	3.7±0.83	(1.88 – 5.83)
Height of MF	3.14±0.78	(1.57 – 5.43)
Depth of MF	6.12 ± 1.65	(1.91 – 11.59)
Distance between superior edge of MF and alveolar ridge	11.89 ± 2.47	(6.29 – 19.17)
Distance between inferior edge of MF and alveolar ridge	19.6 ± 3.31	(8.93 – 28.63)
Mandibular hemiarch		
Height of mandible at the level of MF	29.65 ± 3.25	(22.86 – 40.16)
Width of mandible at the level of the superior edge of MF	9.71 ± 1.76	(5.90 – 14.77)
Width of mandible at the level of the inferior edge of MF	9.98 ± 1.73	(6.73 – 14.51)
Inferior alveolar nerve		
Height of IAN distal to MF	2.74 ± 0.51	(1.60 – 3.80)
Width of IAN distal to MF	2.27 ± 0.53	(1.12 – 3.74)
Height of IN mesial to MF	1.54 ± 0.58	(0.61 – 2.65)
Width of IN mesial to MF	1.37 ± 0.44	(0.47- 2.32)

SD: *Standard Deviation;* ***MF:*** *Mental Foramen;* ***IAN:*** *Inferior Alveolar Nerve;* ***IN:*** *Incisive Nerve.*

(22–26), and Chinese populations (27, 28). Notably, while our data concerning horizontal positions 1 and 2 are in line with previous papers, we found very low frequency of type 5 and no cases of type 6. In literature, frequency of position 5 (between second premolar and first molar) varies from 12% to 31% (18, 20), while that of position 6 varies from 0.8% to 9.4% (16, 29). For what concerns the vertical position of MF, it was mostly located below the apexes of the lower premolars (71.6%), which is in line with already published data (6, 16, 30, 31) on CBCT, CT and orthopantomography.

The most common morphology of MF in our study was oval shape, in line with data reported in Peruvian (29), Tanzanians (21) and Zimbabweans (32) populations. Even higher frequency of oval shape has been reported in Indian (23, 26), Brazilian (10) and in Bosnian populations (33, 34). Conversely, round shape has been highlighted as the most common morphology of MF in Arabic populations (16). Of note, in studies based on CBCT, some authors have classified the round/oval form based on the height/weight ratio, while others have subjectively established the morphology of MF in an operator dependent manner without specific criteria.

The frequency of accessory MFs is highly variable in literature. In our series, 6.8% of accessory MFs were detected, which is similar to the frequency reported in Indian (22, 23, 25, 26), black Americans (5), and Kenyans populations (20). The lowest frequency has been found in white (1.4%) and Indian (1.5%) American patients (5), in Russian (1.5%)

and French (2.6%) (35), in Bosnian (2.7%) (33) and Saudi (2.3%) populations (16). Conversely, higher frequencies of accessory MF have been described in Jordanians (31) and South Americans (9%) (5). The distance between accessory and main foramen reported in literatures is variable, but generally is under 10 mm, as in our study. The occurrence of a triple accessory MF is rare and reported with frequency around 1% in previous studies (12, 34, 36), similar to that of our study. Interestingly, the studies of Toh et al. (37) and Imada et al. (38) showed that accessory MFs may not be detected by orthopantomography. Accessory MF results from the ramification of the mental nerve before emerging into the MF. It means, that surgery in this region may determine damage to neurovascular bundles with hemorrhage, paresthesia, or dysesthesia if accessory MF remains undetected pre-operatively (39).

In our study, no significant differences were found regarding the size of MF based on gender and hemiarch side. This result is in contrast with studies conducted with CBCT by Gungor et al. (40), Zhang et al. (11), Kalender et al. (7) and Zmyslowska-Polakowska et al. (6), which show that both height and width of MF are significantly larger in men than in women. Our data concerning foramen size is in line with measurements reported in Caucasian (14) and Indian patients (24), but lower than Polish (6) and Chinese population (11), and higher than Turkish (40) and Bosnian series (33). Therefore, an extreme variability exists regarding location, morphology, and size of MF between the different populations.

Regarding the distance between MF and alveolar ridge, no significant differences were found based on gender and hemiarch side, as in previous studies. The mean distance was of 11.89 mm, similar to that reported by Von Arx et al. (12.6 mm) (41) and Dos Santos Oliveira et al. (11.21 mm) (42). Although greater values have been reported by Haktanir et al. (14.2 mm) (43), it must be taken into account that this distance is affected by the processes of reabsorption of alveolar bone. Indeed, some authors have considered more reliable to use as a reference point the amelo-cement junction instead of the alveolar ridge (4, 14, 27).

Before proceeding with the placement of implants in mandibular interforaminal region, the position and caliber of the IN as well as to evaluate the mandibular shape and size should be carefully assessed to avoid injury to the nerve and perforation to the lingual cortex. In our series, the IN retains a considerable diameter, even larger than 1.5 mm. Any resection of the incisive nerve will result indeed in paresthesia of the skin of the chin and lower lip. Further, the placement of an implant without the correct evaluation of the caliber of the incisive nerve could cause the nerve to wrap itself around the implant, causing a "pulley" effect upstream, i.e. the stretching of the entire inferior alveolar nerve, with subsequent symptoms affecting the entire hemi-mandible. According to our data, it seems that the width of the MF could be correlated to oval shape of MF. Therefore, patients with oval MF tend have an increased size of mental nerve canal. This data might be used by the surgeon for pre-operative planning of implantations in the inter-foraminal region. Further, we found an interesting correlation between round MF and increased size of the IAN distal to MF, so that smaller size of the IAN seems to be associated with an oval foramen.

Some limitations of this study should be considered. First, the relatively small sample size. Thus, given that no previous studies have investigated the associations of the shape of MF with the caliber of the mental nerve canal and IAN, these results need to be confirmed by larger series. Second, our data is based on a non-standardized population, so our results cannot be generalized. Then, measurements are not directly related the actual size of the canal's nerve but to the bone channel in which it runs. Last, we did not test the reproducibility of our measurements. However, it is especially important when dealing with novel quantitative methods (44), while those investigated in our study have been already tested by several previous studies mentioned in our paper.

In conclusion, this paper reports the variability of MF in a series of Caucasian patients subjected to CBCT. The individual anatomical variability of this important structure is a factor that must be considered when dealing with mandibular surgery. Further studies with larger sample size are needed to confirm the correlations that we found between the caliber of nerve's canal and morphological features of MF.

REFERENCES

1. Greenstein G, Tarnow D. The mental foramen and nerve: clinical and anatomical factors related to dental implant placement: a literature review. J Periodontol 2006; 77(12):1933-1943.
2. Kuzmanovic DV, Payne AG, Kieser JA, Dias GJ. Anterior loop of the mental nerve: a morphological and radiographic study. Clin Oral Implants Res 2003; 14(4):464-471.
3. Solar P, Ulm C, Frey G, Matejka M. A classification of the intraosseous paths of the mental nerve. Int J Oral Maxillofac Implants 1994; 9(3):339-344.
4. Moiseiwitsch JR. Position of the mental foramen in a North American, white population. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1998; 85(4):457-460.
5. Sawyer DR, Kiely ML, Pyle MA. The frequency of accessory mental foramina in four ethnic groups. Arch Oral Biol 1998; 43(5):417-420.
6. Zmyslowska-Polakowska E, Radwanski M, Ledzion S, Leski M, Zmyslowska A, Lukomska-Szymanska M. Evaluation of Size and Location of a Mental Foramen in the Polish Population Using Cone-Beam Computed Tomography. Biomed Res Int 2019; 2019:1659476.
7. Kalender A, Orhan K, Aksoy U. Evaluation of the mental foramen and accessory mental foramen in Turkish patients using cone-beam computed tomography images reconstructed from a volumetric rendering program. Clin Anat 2012; 25(5):584-592.
8. Jacobs R, Salmon B, Codari M, Hassan B, Bornstein MM. Cone beam computed tomography in implant dentistry: recommendations for clinical use. BMC Oral Health 2018; 18(1):88.
9. Tebo HG, Telford IR. An analysis of the variations in position of the mental foramen. Anat Rec 1950; 107(1):61-66.
10. Junior EMO, Araújo AL, Da Silva CM, Sousa-Rodrigues CF, Lima FJ. Morphological and morphometric study of the mental foramen on the M-CP-18 Jiachenjiang point. Int J Morphol 2009; 27(1):231–238.
11. Zhang L, Zheng Q. Anatomic Relationship between Mental Foramen and Peripheral Structures Observed By Cone-Beam Computed Tomography. Anatomy & Physiology 2015; 5(4):182.
12. Katakami K, Mishima A, Shiozaki K, Shimoda S, Hamada Y, Kobayashi K. Characteristics of accessory mental foramina observed on limited cone-beam computed tomography images. J Endod 2008; 34(12):1441-1445.
13. Shaban B, Khajavi A, Khaki N, et al. Assessment of the anterior loop of the inferior alveolar nerve via cone-beam computed tomography. J Korean Assoc Oral Maxillofac Surg 2017; 43(6):395-400.
14. Neiva RF, Gapski R, Wang HL. Morphometric analysis of implant-related anatomy in Caucasian skulls. J Periodontol 2004; 75(8):1061-1067.
15. Fishel D, Buchner A, Hershkowith A, Kaffe I. Roentgenologic study of the mental foramen. Oral Surg Oral Med Oral Pathol 1976; 41(5):682-686.
16. Alam MK, Alhabib S, Alzarea BK, et al. 3D CBCT morphometric assessment of mental foramen in Arabic population and global comparison: imperative for invasive and non-invasive procedures in mandible. Acta Odontol Scand 2018; 76(2):98-104.
17. Ngeow WC, Yuzawati Y. The location of the mental foramen in a selected Malay population. J Oral Sci 2003; 45(3):171-175.
18. Kekere-Ekun TA. Antero-posterior location of the mental foramen in Nigerians. Afr Dent J 1989; 3(2):2-8.
19. Igbigbi PS, Lebona S. The position and dimensions of the mental foramen in adult Malawian mandibles. West Afr J Med 2005; 24(3):184-189.
20. Mwaniki DL, Hassanali J. The position of mandibular and mental foramina in Kenyan African mandibles. East Afr Med J 1992; 69(4):210-213.
21. Mbajiorgu EF, Mawera G, Asala SA, Zivanovic S. Position of the mental foramen in adult black Zimbabwean mandibles: a clinical anatomical study. Cent Afr J Med 1998; 44(2):24-30.
22. Shankland WE 2nd. The position of the mental foramen in Asian Indians. J Oral Implantol 1994; 20(2):118-123.
23. Budhiraja V, Rastogi R, Lalwani R, Goel P, Bose SC. Study of position, shape, and size of mental foramen utilizing various parameters in dry adult human mandibles from north India. ISRN Anat 2012; 2013:961429.
24. Oguz O, Bozkir MG. Evaluation of location of

mandibular and mental foramina in dry, young, adult human male, dentulous mandibles. West Indian Med J 2002; 51(1):14-16.
25. Gupta T. Localization of important facial foramina encountered in maxillo-facial surgery. Clin Anat 2008; 21(7):633-640.
26. Udhaya K, Saraladevi KV, Sridhar J. The morphometric analysis of the mental foramen in adult dry human mandibles: A study on the south Indian population. J Clin Diagn Res 2013; 7(8):1547–1551.
27. Guo JL, Su L, Zhao JL, et al. Location of mental foramen based on soft- and hard-tissue landmarks in a chinese population. J Craniofac Surg 2009; 20(6):2235-2237.
28. Wang TM, Shih C, Liu JC, Kuo KJ. A clinical and anatomical study of the location of the mental foramen in adult Chinese mandibles. Acta Anat (Basel) 1986; 126(1):29-33.
29. Padilla C, Cahuana Q. Morphological and morphometric study of the mental foramen using cone-beam CT in dentate adult patients. Odontoestomatologia 2014; 16(24):4–12.
30. Sisman Y, Ercan-Sekerci A, Payveren-Arikan M, Sahman H. Diagnostic accuracy of cone-beam CT compared with panoramic images in predicting retromolar canal during extraction of impacted mandibular third molars. Med Oral Patol Oral Cir Bucal 2015; 20(1):e74-e81.
31. Al-Khateeb T, Al-Hadi Hamasha A, Ababneh KT. Position of the mental foramen in a northern regional Jordanian population. Surg Radiol Anat 2007; 29(3):231-237.
32. Fabian FM. Position, shape and direction of opening of the mental foramen in dry mandibles of Tanzanian adult black males. Ital J Anat Embryol 2007; 112(3):169-177.
33. Voljevica A, Talović E, Hasanović A. Morphological and morphometric analysis of the shape, position, number and size of mental foramen on human mandibles. Acta Medica Academica 2015; 44(1):31–38.
34. Gershenson A, Nathan H, Luchansky E. Mental foramen and mental nerve: changes with age. Acta Anat (Basel) 1986;126(1):21-28.
35. Montagu MF. The direction and position of the mental foramen in the great apes and man. Am J Phys Anthropol 1954; 12(4):503-518.
36. Naitoh M, Hiraiwa Y, Aimiya H, Gotoh K, Ariji E. Accessory mental foramen assessment using cone-beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009; 107(2):289-294.
37. Toh H, Kodama J, Yanagisako M, Ohmori T. Anatomical study of the accessory mental foramen and the distribution of its nerve. Okajimas Folia Anat Jpn 1992; 69(2-3):85-88.
38. Imada TSN, Fernandes LMPSR, Centurion BS, et al. Accessory mental foramina: prevalence, position and diameter assessed by cone beam computed tomography and digital panoramic radiographs. Clin Oral Implants Res 2014; 25(2):e94-9.
39. Pancer B, Garaicoa-Pazmiño C, Bashutski JD. Accessory mandibular foramen during dental implant placement: case report and review of literature. Implant Dent 2014; 23(2):116-124.
40. Gungor E, Aglarci OS, Unal M, Dogan MS, Guven S. Evaluation of mental foramen location in the 10-70 years age range using cone-beam computed tomography. Niger J Clin Pract 2017; 20(1):88-92.
41. von Arx T, Friedli M, Sendi P, Lozanoff S, Bornstein MM. Location and dimensions of the mental foramen: a radiographic analysis by using cone-beam computed tomography. J Endod 2013; 39(12):1522-1528.
42. Dos Santos Oliveira R, Rodrigues Coutinho M, Kühl Panzarella F. Morphometric Analysis of the Mental Foramen Using Cone-Beam Computed Tomography. Int J Dent 2018; 2018:4571895.
43. Haktanır A, Ilgaz K, Turhan-Haktanır N. Evaluation of mental foramina in adult living crania with MDCT. Surg Radiol Anat 2010; 32(4):351-6.
44. Albano D, Martinelli N, Bianchi A, Giacalone A, Sconfienza LM. Evaluation of reproducibility of the MOCART score in patients with osteochondral lesions of the talus repaired using the autologous matrix-induced chondrogenesis technique. Radiol Med 2017; 122(12):909-917.