Mandibular canal and its incisive branch: A CBCT study

Sina Haghanifar (1)
Ehsan Moudi (2)
Ali Bijani (3)
Somayyehsadat Lavasani (4)
Ahmadreza Lameh (5)

(1) Oral and Maxillofacial Radiology Department, Dental School, Babol University of Medical Science, Babol, Iran
(2) Oral and Maxillofacial Radiology Department, Dental School, Babol University of Medical Science, Babol, Iran
(3) Social Determinants of Health Research Center, Babol University of Medical Sciences, Babol, Iran
(4) Oral and Maxillofacial Radiology Department, Dental School, Babol University of Medical Science, Babol, Iran
(5) Radiology Department, Medical School, Mashhad University of Medical Sciences, Mashhad, Iran

Correspondence:
Somayyehsadat Lavasani*
Oral and Maxillofacial Radiology Department, Dental School, Babol University of Medical Science, Babol, Iran
Email : roya_lavasani@yahoo.com

Abstract

Objective: Prevention from damage to the mandibular canal (MC) during invasive dental procedures is essential. The aim of this study was to determine the course of MC, anterior branch and its relation to mandibular teeth.

Materials and Methods: In cross-sectional view, the MC diameter, the distance from root apex to MC, the distance of MC to mandibular lower border, the distance of MC from buccal and lingual cortical borders, from the distal root of third molar to first premolar in apex roots area of all posterior teeth were identified by using 207 CBCT images. The presence of the anterior loop, the position of mental foramen, position and diameter of incisive branch on the last visible point were also determined. Examples were divided into the groups in terms of age, sex and side and were analyzed with descriptive statistics.

Results: The nearest root to the MC was the distal root of third molar in women less than 30 years (0.38±0.58 mm) and the most distant root was the second premolar tooth in men 30-50 years (6.06±2.20 mm). The most common site for mental foramen, was between premolars and the area between the first premolar and canine teeth was the most common site for incisive canal on the last point of view. There was no significant differences between right and left mandibular measurements.

Conclusion: The position of MC towards mandibular posterior teeth is more influenced by age and sex. Also, the position of MC towards the bucco-lingual plate depends on the antero-posterior position of mental foramen. So any procedures in the mandibular posterior area should be performed with sufficient knowledge of the nervous canal.

Key words: Anatomy, Mandibular canal, Mental foramen, Incisive canal, CBCT

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Introduction

According to various mandibular surgeries, such as removing impacted third molar to implant placement, awareness of the position of inferior alveolar nerve is essential to ensure no damage to the nerve. (1,2). To achieve a successful treatment plan, adequate knowledge of the mandibular canal (MC) course and tooth roots is essential to reduce procedure bias (3). So, it is important to be aware of MC anatomy and possible variations in position, shape and course of canal for local anesthesia and during surgery (4). MC contains artery and inferior alveolar nerve, which have branches to the mandibular teeth and adjacent structures. MC can exhibit important anatomical variations and may be affected by inflammatory, infectious, neoplastic, idiopathic or iatrogenic lesions (5,6).

Full knowledge of anatomical structures in mental foramen area and the anterior loop is essential to prevent direct or indirect injury to the neurovascular bundle (7-9). Also, if the treatment plan includes surgical procedures in the area between mental and lingual foramen, the incisive branch of inferior alveolar nerve must be considered (9). In a study conducted in 2008 to evaluate the prognosis of mandibular molars apical surgeries, it was found that patients experienced more pain when the lesions were within 2 mm of the canal as depicted on a panoramic radiograph and there was a 19.4 % failure rate for lesions close to the canal. So, the accurate knowledge of the MC location can be useful not only during surgery, but also in the prognosis for surgery and evaluation of the patient's post-operative situation (10).

Findings from studies using cadavers may not be generalized to patient populations due to differences in age or disease. Dry skull studies often lack relevant data such as age or gender (11,12). Based on the results of studies that tried to compare the measurements made by the CBCT images and direct measurements on human samples, it was indicated that CBCT scans are excellent evaluation tools for the canal observations, which is similarly matched the anatomical measurements (10). Position of inferior alveolar canal and its connections have been described for a very long time, and many studies reported that the characteristics of these structures seem to be associated with race. For example, the mental foramen were often variable in position or even completely absent in some rare cases in different populations (13). Previous studies on human populations were more focused on the anatomical traits, while the relationship of these structures with each other and their relationship with the teeth apexes have been less described (3,13-18). The aim of this study was to evaluate the MC course and its anterior branch, and the impact of factors such as age, sex and side on canal status.

Materials and Methods

In this cross-sectional study, 207 mandibular scans of patients over 18 years (110 female and 97 male) with a mean age of 45.7±13.83 years, during 2013-2015 who referred to the maxillofacial radiology center were used. All scans were performed using Cranex 3D (Soredex, Helsinki, Finland) with Flat panel detector with the specifications of KVP=89, mA=6, Voxel size=0.2 mm and FOV=8 × 6 cm. The images were assessed using a personal monitor Macbook Air MD 760 (Apple Ltd, California, USA) with LCD 13-inch, Pix Resolution 900 × 1440 and assessed by Ondem and 3D Dental software.

Scans were examined by a maxillofacial radiologist to evaluate the relationship between MC and mandibular posterior teeth. Exclusion criteria included: 1. Any pathosis around teeth or in the mandibular body which can disturb the measurements 2. Supernumerary or impacted teeth in the mandible 3. Third molars with horizontal positions in the mandible 4. Single root molars in the mandible.

Measurements were started in the cross-sectional view (Interval =1 mm, Thickness =1 mm), if there was a distal root of third molar, and the MC diameter (D), the minimum distance of apex to superior border of MC (AP), the distance from inferior border of MC to the inferior border of the mandible (IC), the distance of MC from the cortical buccal border (BC) and the distance of MC from the cortical lingual border of mandible (LC) was traced (Figure 1). The bone width in the MC area (W) was also calculated by the sum of D, BC and LC. Then the same measurements were made again on the third molar mesial root and measurements continued forward on all posterior teeth roots to the first premolar. The measurements were made on both sides of the mandible. In the examination of mental foramen, its location and the presence or absence of anterior loop was evaluated. The diameter and position of incisive branch was evaluated at the last visible point.
The subjects were divided into three age groups: Group I (18-30 years = 34 patients), Group II (30-50 years = 87 patients) and Group III (over 50 years = 86 patients). The samples were separated according to gender and side. Data were analyzed using three ways (gender, age, side) by statistical tests: T-Test, ANOVA and SPSS version 18. P-value less than 0.05 was considered statistically significant.

Results

Among 207 patients under this study, the results showed that the distance of MC from posterior teeth apex, the nearest root was the distal root of third molar in women less than 30 years (0.38±0.58 mm) and the most distant root was second premolar tooth in men 30-50 years (6.06±2.20 mm). This distance in women was significantly less than men (P <0.05) (Table 1 and Figure 2) and under age 30 years was also significantly less than other age groups (P <0.05).

Minimum and maximum distance of MC from inferior mandibular cortex belonged to the distal root of the third molar in women over 50 years (4.66±0.52mm), and second premolar tooth in men over 50 years (9.29±1.94mm) respectively. This distance was lower in women than men (P<0.05) (Table 1 and Figure 2) and under age 30 years was also significantly less than other age groups (P<0.05).

In the assessment of MC distance from buccal and lingual cortical borders, the minimum buccal distance belonged to the second premolar tooth in women over 50 years (2.49±0.94mm), and the minimum lingual distance was located in the distal root of third molars in women over 50 years (0.90±0.32mm). These measured distances were significantly lower in women than men (P<0.05) (Table 1 and Fig 2) and it was observed that the distance of canal to the buccal cortical plate in patients over 50 years was less than other age groups (P<0.05).

The maximum horizontal bone width at MC area (10.22±1.15mm) was the mesial root of second molar in men under 30. Bone width in this area was significantly lower in women than men (P<0.05) (Table 1); and in patients over 50 years, it was significantly less than other age groups (P<0.05) (Figure 3).

It was observed that the minimum MC diameter on average was in the second premolar tooth in women 30-50 years (1.80±0.37mm), and the highest diameter on average was the distal root of the third molars in men 30-50 years (2.75±0.54mm). Over all, the MC diameter had a similar pattern in both sexes and three age groups from posterior to anterior. So that, the diameter was higher in posterior and it was reduced with a gentle slope to the anterior area (Figure 4).

The area between premolars was the most common site for the presence of mental foramen on the right (69.6%) and left (62.3%) side. Then, the second premolar apex, distal of second premolar and first premolar apex were located, respectively. 197 patients (95.2%) had anterior loop on both sides, in which, it was found that age and gender have no significant effect on the presence of loop and mental foramen position. In incisive canal examinations, it was observed that the average canal diameter on the last visible point was 1.12±0.31 mm and 1.06±0.28 mm on right and left side respectively. The most common area on the last point of view for incisive canal, according to its frequency, was on the right (60.4%) and left (61.4%) side between the first premolar and canine. After that, there was an area between the canine and lateral teeth. In both sides lateral incisor apex, was the lowest region to end its canal. Also, no relationship was observed between age and sex with incisive canal diameter and its location (Table 2).

Secondary findings from this study showed that 11 patients had bifid canal, in which 3 cases had two bifid canals on both sides. When this occurred the closest MC to the cortical plates was used for measurements. 12 patients had accessory mental foramen, in which 4 cases had multiple mental foramen on both sides. The MC course was started from an area near the lingual plate of posterior mandibular teeth and in the second premolar tooth reached to the mid bucco-lingual plate. In the vertical dimension, canal was closer to the posterior teeth roots than inferior cortex. Regardless of age and sex, there was no significant difference between all measured distances in the left and right sides (Figure 5).

Table 1: The prevalence and rate of incisive canal at the last visible point according to gender and position

Left			Right			Dental area
Total	Male	Female	Total	Male	Female	
127 61/4%	63 64/9%	64 58/2%	125 60/7%	55 56/7%	70 64/2%	Between 3-4
44 21/1%	20 20/6%	24 21/8%	49 23/8%	25 25/8%	24 22/0%	Between 3-2
26 12/6%	10 10/4%	16 14/5%	25 12/1%	13 13/3%	12 11/0%	Apex 3
2 1/0%	1 1/0%	1 1/0%	4 1/9%	2 2/1%	2 1/8%	Apex 4
6 2/9%	1 1/0%	5 4/5%	3 1/5%	2 2/1%	1 1/0%	Apex 2
2 1/0%	2 2/1%	0 0/0%				Between 1-2

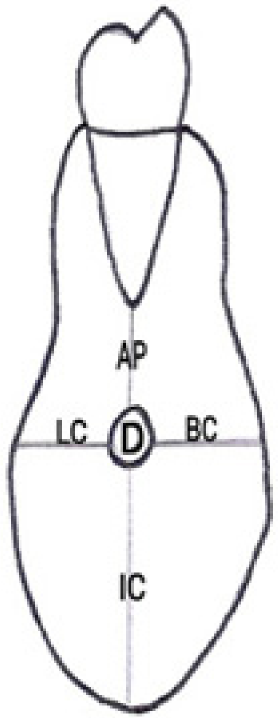

Figure 1: measurements in posterior teeth roots area in Cross-sectional view, D: MC diameter, AP: distance from root apex to superior border of MC, IC: distance from inferior border of MC to mandibular inferior border, BC: distance from MC to buccal cortical border, LC: distance from MC to lingual cortical border

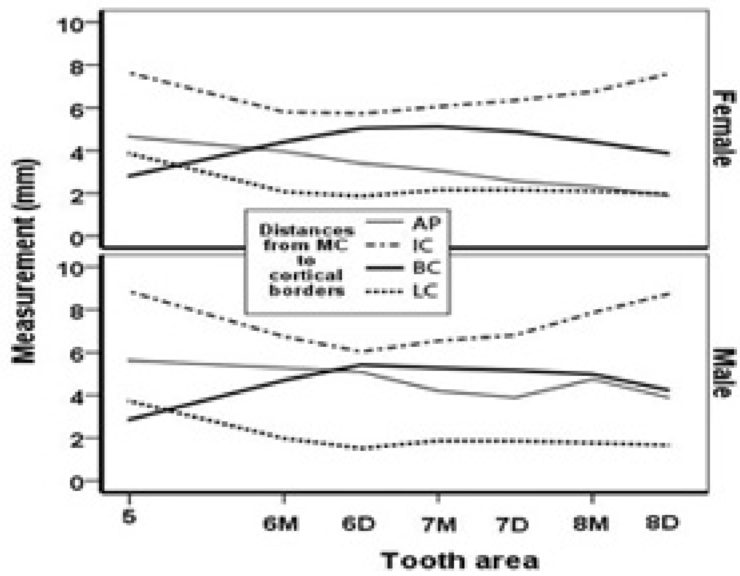

Figure 2: The path of measurements according to gender

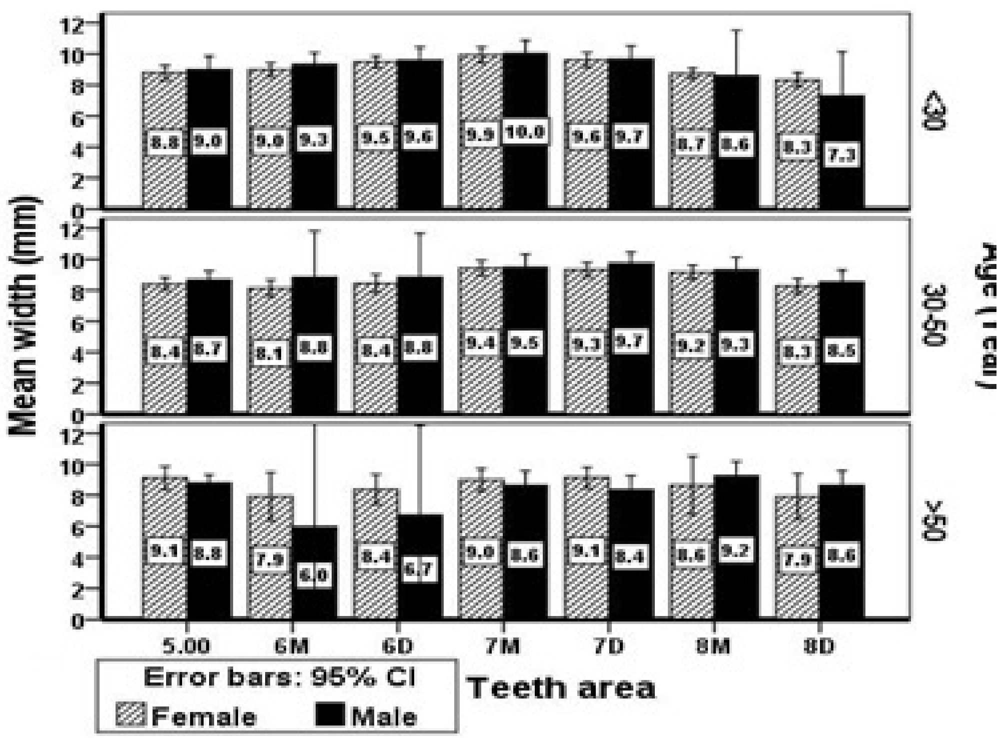

Figure 3: The mandibular width in MC area of posterior teeth according to age and gender

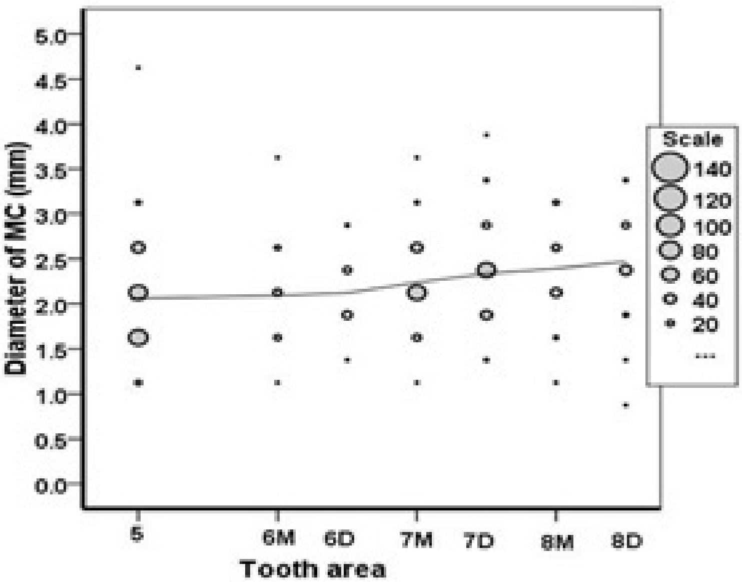

Figure 4: The mandibular canal diameter in posterior teeth

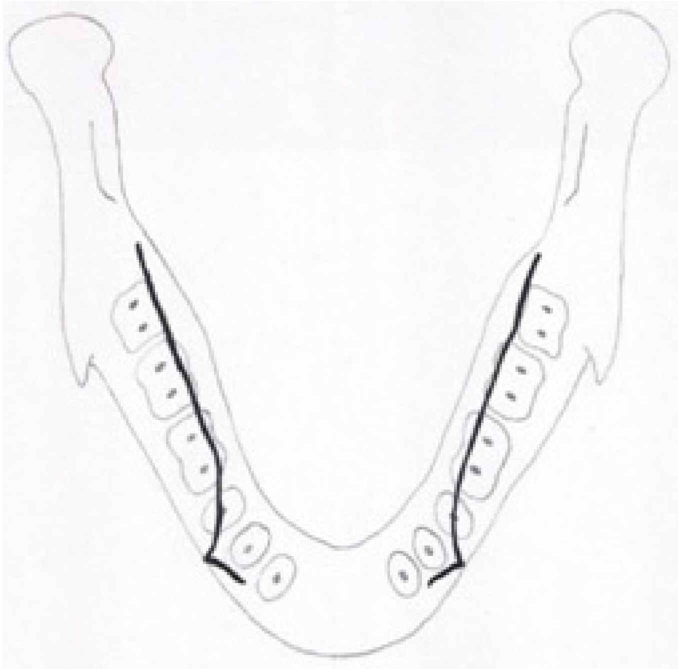

Figure 5: The course of MC in horizontal schematic view

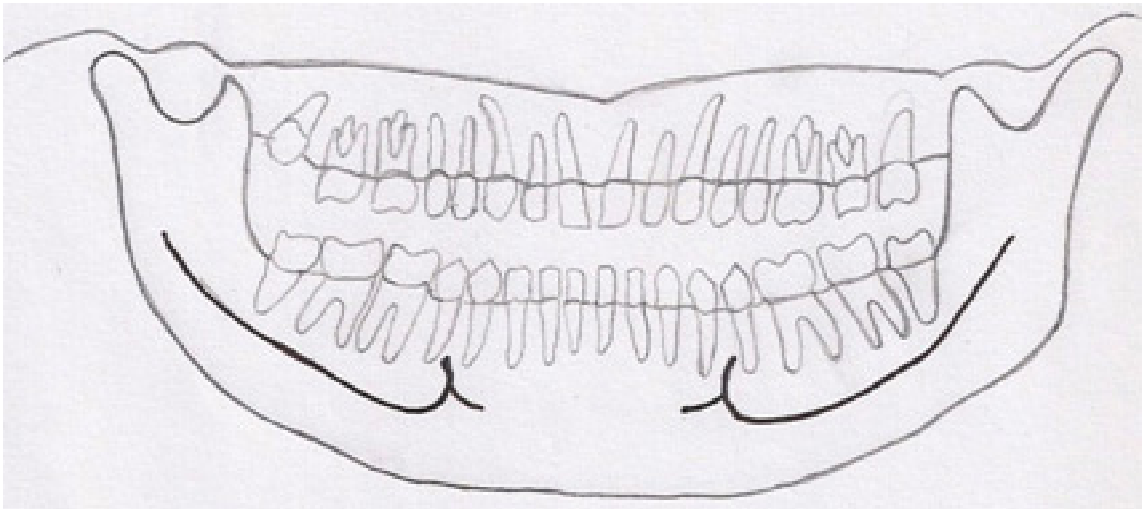

Figure 6: The course of MC in schematic panoramic view

W		LC		BC		IC		AP		
Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
8/41±1/52 n=31	8/23±1/09 n=51	1/66±0/77 n=31	1/93±1/07 n=51	4/22±1/23 n=31	3/86±1/01 n=51	8/74±2/05 n=31	7/59±2/18 n=51	3/88±2/98 n=31	1/88±2/98 n=51	D8
9/18±1/49 n=31	8/89±1/03 n=51	1/76±0/67 n=31	2/10±0/96 n=51	4/98±1/30 n=31	4/41±1/07 n=51	7/58±2/13 n=31	6/75±1/97 n=51	4/37±2/77 n=31	2/31±2/80 n=51	M8
9/32±1/64 n=48	9/38±1/37 n=90	1/85±0/76 n=48	2/16±0/81 n=90	5/15±1/30 n=48	4/89±1/35 n=90	6/81±2/36 n=48	6/35±1/47 n=90	3/88±2/66 n=48	2/57±1/79 n=90	D7
9/38±1/70 n=48	9/51±1/52 n=90	1/86±0/76 n=48	2/15±0/79 n=90	5/27±1/36 n=48	5/27±1/50 n=90	6/35±2/20 n=48	6/06±1/32 n=90	4/19±2/56 n=48	3/06±0/37 n=90	M7
9/08±1/58 n=17	9/03±1/09 n=46	1/51±0/66 n=17	1/86±0/72 n=46	5/41±1/32 n=17	5/04±1/15 n=46	6/03±1/68 n=17	5/73±1/24 n=46	5/08±2/6 n=17	3/40±1/72 n=46	D6
8/81±1/64 n=17	8/58±1/09 n=46	1/97±0/94 n=17	2/07±0/75 n=46	4/69±1/29 n=17	4/40±1/14 n=46	6/74±1/77 n=17	5/80±1/28 n=46	5/27±2/35 n=17	3/96±1/96 n=46	M6
8/76±1/55 n=82	8/67±1/58 n=124	3/71±1/36 n=82	3/85±1/23 n=124	2/85±1/13 n=82	2/81±1/08 n=124	8/84±2/04 n=82	7/62±1/70 n=124	5/61±2/33 n=82	4/64±2/22 n=124	5

Table 2: The prevalence and rate of incisive canal at the last visible point according to gender and position

Discussion

The results of this study on the distance of MC from posterior teeth roots showed that the distal root of third molar was the closest root to canal, so that, the average distance between the left and right sides was 2.88 and 2.49 mm, respectively. By moving towards the anterior area, the canal gets farther away from posterior teeth apex, so that, the average distance of mesial root of the first molar on the left and right sides was, 3.96 to 4.64 mm, respectively. Fewer studies were performed to examine the distance of the third molars roots from MC, and most studies in this field only tried to examine the canal course in the impacted and unerupted third molar area (19, 20). Chong et al. on 272 second mandibular molars, reported that in 55% of cases, the distance between the root apex and inferior alveolar nerve was less and equal to 3 mm, which is close to the results of this study (21). Simonton in a study reported that the distance of MC from mesial root of first molar was 4.9 mm in women and 6.2 mm in men, which is closely consistent with the results of this study (22).

In this study, MC distance from the inferior mandibular cortex in the distal root of third molar area was 7.52 to 8.41 mm on the right and left sides respectively, and this distance decreased gradually by moving forward to the mesial root of first molar and increased again in the premolar area. Rajchel et al. in a study on cadavers reported that this distance was mm10 in the third molar area (23); with respect to the fact that mandibular form vary in different people and in different age ranges, so the differences in measurement seems normal. Also in this study, it was observed that MC was closer to the apex of posterior teeth rather than the inferior mandibular cortex. Sato in a study on panoramic images indicated that the MC course in the vertical dimension was closer to the apex of first and second molars rather than inferior mandibular cortex (24).

The MC distance from buccal and lingual cortical borders, it was observed that distal root of third molar was the closest root to lingual plate and the second premolar tooth was the closest root to buccal plate. The average distance of MC to the lingual cortical plate in the distal root of third molar was 1.64 and 1.98 mm on the right and left sides, respectively. In Rajchel's study, the canal in the third molar area had approximately 2mm distance from the lingual plate, which is very close to our results (23). In the present study the average distance of MC from buccal cortex in the mesial root of the first molar was 4.44 and 4.53 mm on the right and left sides, respectively. Leith et al. in a study on 157 CBCT images of patients with a mean age of 48 years, this distance was 4.4 mm in 75% of cases, which is very close to the results of this study (5).

For the MC diameter, it was observed that the average minimum and maximum canal diameter was 1.80 and 2.75mm in second premolar and the distal root of third molar, respectively. Canal diameter from the posterior to the anterior decreased with a gentle slope. Rajechel demonstrated that when proximal to the third molar, MC diameter was 2 to 2.4 mm. on measurements obtained from 105 mandibular cadavers; Obradovic et al. also found that the mean MC diameter in its horizontal part was 2.6 mm, which is closely consistent with these results (23).
One of the common but inadvertant complications in the anterior mandible during implant placement is neurosensory alteration. Mental foramen shows many anatomical variations in shape, size and position. In the present study, 95.2% of patients had anterior loop and the area between premolars on both sides was the most common site for that. Investigations that compared radiographic and cadaveric dissection data with respect to identifying the anterior loop reported that radiographic assessments result in a high percentage of false-positive and false-negative findings (25).

Perhaps these varied results may be attributed to different criteria used to define the anterior loop and dissimilar diagnostic techniques. Arzouman showed 92 to 96% of direct measurements on cadavers had detected anterior loop, while only 56 to 76 % of the panoramic machines showed the loop (25). With regard to the mental foramen, apex of the second premolars or the area between premolars have been reported as the most common site for that. In the study by Haqhanifar et al. on panoramic images, the area between premolars was the most common area for mental foramen, which is consistent with the results of this study (14).

The mean incisive canal diameter in the last visible point was 1.12±0.31mm on the right and 1.06±0.28mm on the left side. Jacobs et al. examined 230 spiral CT where the incisive canal was identified in 93% of the cases, and they reported the average inner diameter was 1.1 mm, which is consistent with our results (25).

For assessing the amount of incisive branch progression, an area between the first premolar and canine teeth was observed as the most common visible area for that on both sides. Most studies have investigated quantitative measures of incisive nerve length and there is no study that has tried to investigate the progression level of the canal compared to other surrounding anatomic structures. Mardinger et al. have examined anatomical and radiographic course of incisive canal in 46 cadaver mandibles, they found that the canal walls in some cases were complete, some incomplete and in others without corticated limits. They concluded that there are correlations between the anatomical structure and visible radiographic limits(26). The visibility or invisibility of incisive canal largely depends on racial differences, radiologists' experiences and radiographic technique. Pieres et al. showed that the incisive canal is better seen in CBCT images rather than panoramic radiography. They reported the average length of incisive canal was about 7±3.8mm (27). This distance is almost where the mandibular canine apex can be placed. The results of this study are very close to our results.

For the assessment of gender effect on the measured distances, it was found that the overall pattern of MC course was similar in both genders, but in general women have lesser distances than men, which is consistent with results of other studies in this domain (22, 28). About the influence of age on the measured points, it was observed that the average distance of MC from root apex and from the lower mandibular border was significantly less in under 30 years than other age groups; Given that skeletal growth in these patients is not yet complete, this result is justified. It was also observed that in patients over age 50, bone width was slightly less than other age groups, and according to the first molar was the most missing tooth in this age group; reduced bone width was more evident in this area. Simonton et al. have also reported reduced bone width in patients in their 50s-60s (22). Perhaps the rationale reason is that older patients have generally less bone mass than the younger age groups.

It should be mentioned, CBCT images in horizontal and vertical planes can help in the examination of the MC course, because the canal can pass different courses in each view for different patients. Anderson et al. in a study on panoramic radiographs found that the MC may slowly come down from anterior to posterior or have a gentle progressive curve, or even a combination of these two (23). Also, in the horizontal plane the canal course extends from lingual to the buccal border, which in most cases, the canal in the first molar area is in the middle distance between the bucco-lingual plates (23). In the present study, the second premolar apex was located in the middle of bucco-lingual plates; given that in this study, the most common area for mental foramen was between premolar teeth, it is justified. As Simonton said that as the mental foramen became more distally positioned, the MC became more buccally located within the mandible, and in relation to the roots of the mandibular first molar (22).

This study was conducted on adult patients most images taken due to the replacement of single edentulous area and there are a few studies that tried to examine the relationship between canal and all mandibular posterior teeth by CBCT imaging, and this is one of the salient points of this study. However, given that in this study, measurements were performed on patients with partial and complete tooth, and classification of the age groups needed more details, this limitation cannot be forgotten. It is recommended to perform further investigation with a greater sample size with complete teeth and considering panoramic and CBCT images can have many clinical benefits during surgical procedures in this area. The appropriate sensitivity and specificity of CBCT in the detection of these alterations reinforces its use in oral and maxillofacial radiology, and since the bone dimensions are not fixed in one's life, providing CBCT before surgery is necessary.

Conclusion

According to this study an important consideration in presurgical planning is that the measurements obtained from a CBCT scan will not stay constant throughout a person's lifetime, and a current CBCT might be recommended before surgical treatment. Collectively these data indicate that both age and gender have a marked effect on anatomic relationship and should be considered in pre-surgical treatment.

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