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Frequency of Anatomical Indicators Related to the Mental Foramen and Mandibular Canal of Edentulous Patients on Digital Panoramic Radiographs

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Abstract

Background: Determining the location of mandibular canal and mental foramen in the implant treatment is important to prevent any damage to the mental foramen and mandibular canal. The interpretation of a radiographic image depends on the individual interpretation of the observer. The aim of this study was to assess the agreement between two radiologists on the identification of mental foramen and mandibular canal.

Methods: In this study, 95 digital panoramic images of edentulous patients were evaluated by two radiologists to determine the type of mental foramen according to the Yosue and Brooks classification as well as the type of mandibular canal according to the classification of Angelopoulos. Data were analyzed using SPSS version 17.

Results: The most common appearance of mental foramen was continuous type. The intra-examiner agreement on the type of mental foramen on the right and left sides was as much as 0.60 and 0.72, respectively. The highest frequency was observed in the anterior and middle one-third of the superior border of the mandibular canal related to type zero and posterior one-third related to type three. Type three in the inferior border of mandibular canal was the most frequent type in all one thirds. There was also a significant difference in the anterior, middle, and posterior one-third of the superior and inferior borders of mandibular canal observations.

Conclusion: The most common appearance of mental foramen on panoramic images was continuous type. The posterior one-third of mandibular canal was more clearly in panoramic images.

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Introduction

With regard to the increasing trend of implant surgery in the mental foramen and mandibular canal areas and the inability to observe and touch these bones directly, radiographic evaluations are necessary to prevent any damage to the nerves and vessels (1,2).

Mandibular canal is an important bony landmark located in the mandible, which starts from the mandibular hole in the middle one-third of the ramus and extends to the mental foramen (3). There is a bundle of nerves, arteries, and veins inside the canal. These components are responsible for sensory and motor innervation and blood supply to mandibular teeth, interdental papillae, periodontal tissues, and alveolar bones. Not paying attention to the variation of this anatomical structure can lead to some complications during intraoral dental treatments, such as removing third molar by surgical or non-surgical procedures and removing bone for bone grafting and implant replacement (4).

The mental foramen is also an important anatomical landmark in the buccal surface of mandible, slightly above mandibular canal and under the second premolar that opens obliquely on the outer surface of the mandible. It is difficult to determine the location of mental foramen for some reasons, such as the absence of anatomical landmark reference, as well as the lack of observation and touch of the foramen clinically. Mental vessels and nerves passing through the mental foramen, provide sensory and nutritional support to the soft tissue of the chin, lower lip, and gingiva on the same side of the mandible (5).

Radiographic density of the foramen is very variable on radiographs, probably due to multiple variations in the shape and thickness of the walls (6).

The awareness of the mental foramen's location is very important in performing local anesthesia, periapical surgery, and implant surgery in the mandible (7). Mental nerve injury during surgery can cause paresthesia or anesthesia in the mental region of the mandible (2).

Panoramic radiography is widely prescribed for implant treatment plan because it provides a wide coverage of facial bones and tooth that are useful in the primary evaluation of structures (8). In most cases, panoramic radiography is used to examine the mandible due to the precise determination of mandibular canal location (7). However, other techniques such as CBCT can replace panoramic images because of the ability to analyze images in three dimensions (9). Even with limitations of panoramic radiographs such as low resolution, image distortions, and lack of information about bone width, many implantologists still use this type of radiography to evaluate implant osseointegration for some reasons, such as lower cost, better accessibility, and lower radiation dose in panoramic radiography (10-12).

The interpretation of a radiograph depends on the individual interpretation of the observer. Therefore, the evaluation of agreement between the interpretations of two observers on the radiography would be effective (13).

Currently, dental implant has become one of the most commonly used treatments for edentulous patients (14). It is necessary for dentist to know the position of anatomical landmarks of mandible and the quantity and quality of bone in the specific area before implant surgery (15), hence, the purpose of this study was to assess the level of the agreement between two oral and maxillofacial radiologists in identifying mandibular canal and mental foramen on a panoramic radiograph.

Materials and Methods

This is a descriptive retrospective study. The protocols of the study were approved by the Ethics Committee of Shahid Sadoughi University of Medical Sciences, Yazd (Ethical code: IR.SSU.REC.1395.190). Ninety-five digital panoramic radiographs were randomly selected from edentulous patients who referred to Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Shahid Sadoughi University of Medical Sciences, Yazd, in 2014-2016. The radiographs were taken with a digital panoramic Planmeca Proline XC X-ray unit (Planmeca, Helsinki, Finland) by a radiology technician or a post-graduate student of oral and maxillofacial radiology under the supervision of a radiologist. Exposure conditions varied for each patient according to the anatomical structures (mA: 5-12 and kVp: 60-76).

The inclusion criteria were images from edentulous patients who had appropriate diagnostic qualities with acceptable density and contrast. In addition, the images were taken with the least amount of patient positioning errors and minimum superimposition of anatomical structures. In the presence of radiolucent or radiopaque lesion in the ramus or mandibular body in the panoramic image, that image was excluded from the study.

All images were copied from the original Promax 3D software (Planmeca, Helsinki, Finland) onto a CD and they were transferred to Adobe Photoshop 7.0 (Adobe System) for assessment. The distance between mandibular to mental foramen was measured by this software. The obtained distance was divided into three and vertical lines were drawn to separate the anterior, middle, and posterior one-third of the mandibular canal based on the obtained results (Figure 1).

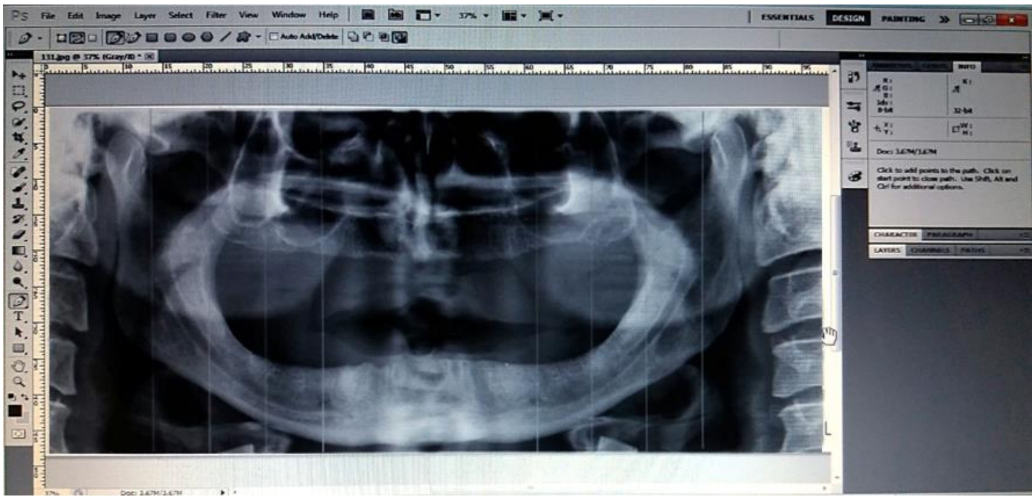

Figure 1. The vertical lines depicted by the Adobe Photoshop software, which divides the mandibular canal into anterior, middle, and posterior one thirds.

The right and left mental foramen and mandibular canals were examined separately for each panoramic radiograph. Two examiners assessed the images under standard conditions of images observation (reduced room lighting, observation of images of the same size on a single monitor) and recorded the results in a pre-made checklist.

The criteria for observing the mandibular canal in the calculated one-third were according to the classification of Angelopoulos et al. (16) as follows:

0: Observation of less than 25% of the mandibular canal in the specified one-third area

1: Observation of more than 25% and less than 50% of the mandibular canal in the specified one-third area

2: Observation of more than 50% and less than 75% of the mandibular canal in the specified one-third area

3: Observation of more than 75% of the mandibular canal in the specified one-third area

The criteria for observing the mental foramen in the panoramic radiography were according to the classification of Yosue and Brooks (17) as follows:

1. Continuous: The mental foramen is continuous with the mandibular canal (Figure 2).

2. Separated: The mental foramen is distinctly separated from the mandibular canal (Figure 3).

3. Diffuse: The mental foramen has an indistinct border (Figure 4).

4. Unidentified: The mental foramen cannot be visualized (Figure 5).

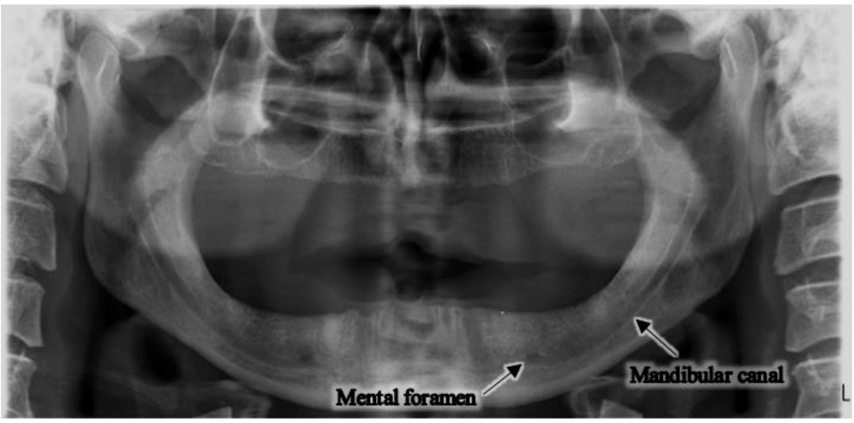

Figure 2. Continuous type of the mental foramen.

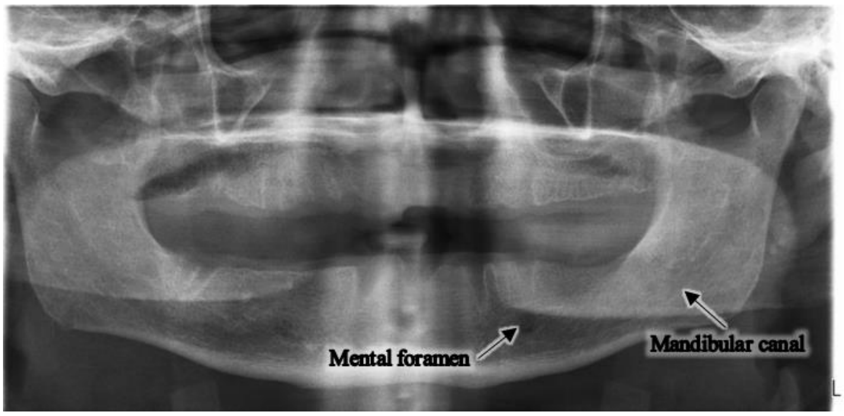

Figure 3. Separated type of the mental foramen.

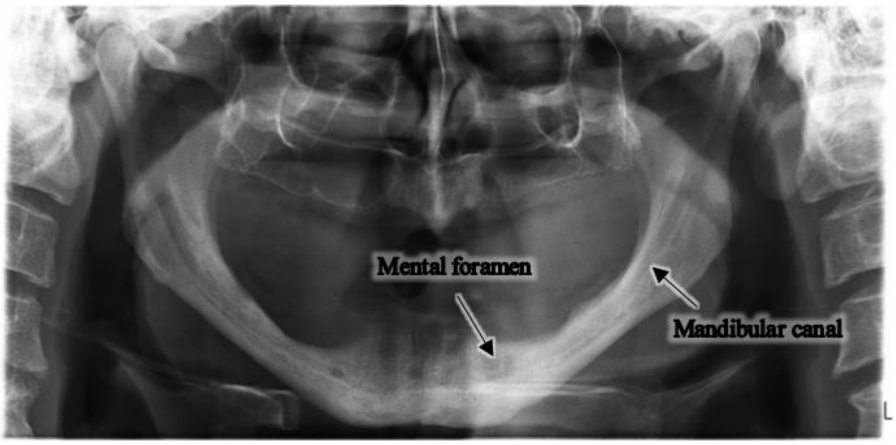

Figure 4. Diffuse type of the mental foramen on the left side.

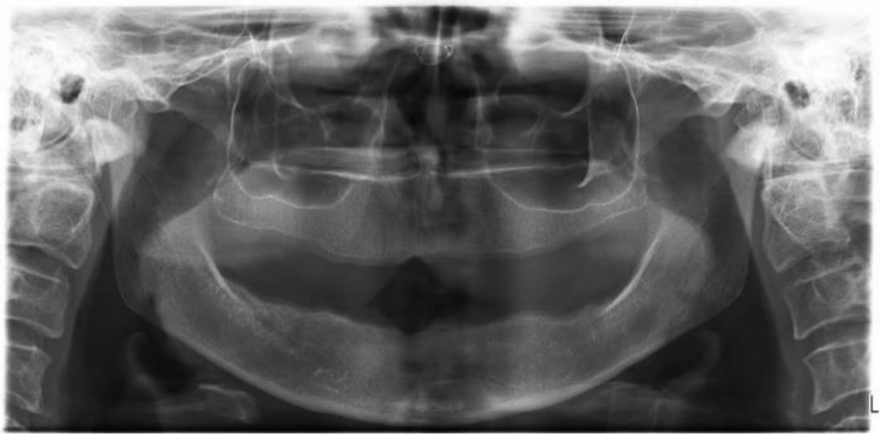

Figure 5. Unidentified type of the mental foramen.

The intra-examiner agreement on the interpretation of the mandibular canal and the mental foramen on digital panoramic radiographs was performed using Cohen's kappa coefficient (13). K values were classified according to Landis and Kock (18) as poor agreement (K < 0.00), slight agreement (0.00-0.20), fair agreement (0.21-0.40), moderate agreement (0.41-0.60), good agreement (0.61-0.80), and almost perfect agreement (0.81-1.00).

Data were analyzed using SPSS version 17 (Chicago, IL, USA). Statistical significant level was considered at P = 0.05.

Results

In this study, 95 digital panoramic radiographs from edentulous patients were evaluated separately by two observers. All analyses were statistically significant (P = 0.0001).

According to Table 1, for both observers, the highest frequency of the mental foramen on the right and left sides was related to the continuous type and the lowest one was related to the diffuse type. The intra-examiner agreement on the mental foramen on the right and left sides was reported moderate (K = 0.601) and good (K = 0.723), respectively.

Table 1. Frequency distribution of different manifestations of mental foramen in each observation

Side	Observer	Continuous		Separated		Diffuse		Unidentified		Kappa
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Index
Right	A	54	56.8	23	24.2	6	6.3	12	12.6	0.601
	B	60	63.2	14	1`4.7	5	5.3	16	16.8	
Left	A	45	47.4	25	26.3	7	7.4	18	18.9	0.723
	B	41	43.2	21	22.1	11	11.6	22	23.2	

The frequency distribution of various manifestations of the superior and inferior border of mandibular canal on panoramic radiographs, based on the anterior, middle, and posterior one thirds are given in Tables 2 to 7.

Table 2 shows that for both observers, the highest frequency of visibility in the anterior one-third of the superior border of mandibular canal on the right and left sides was related to zero scale (observation of less than 25% of the canal border). In this area, the lowest frequency of visibility on the right side belonged to type 2 (observation of 50-75% of the canal border) while the lowest one on the left side was related to type 2 and type 1 (observation of 25-50% of the canal border) for observer A and B, respectively. The intra-examiner agreement on the anterior one-third of the superior border of mandibular canal on the right and left sides was reported moderate (K = 0.567) and good (K = 0.683), respectively.

Table 2. Frequency distribution of different manifestations of the anterior one-third of the superior border of mandibular canal

Side	Observer	0		1		2		3		Kappa
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Index
Right	A	66	69.5	5	5.3	2	2.1	22	23.2	0.567
	B	62	65.3	6	6.3	4	4.2	23	24.2	
Left	A	67	70.5	4	4.2	3	3.2	21	22.1	0.683
	B	64	67.4	2	2.1	4	4.2	25	26.3	

Table 3 shows that for both observers, the highest frequency of visibility in the anterior one-third of the inferior border of mandibular canal on the right and left side was related to type 3 (observation of more than 75% of the canal border). In this area, for both observers, the lowest frequency of visibility on the right and left sides was related to type 2 (observation of 50-75% of the canal border). The intra-examiner agreement on the anterior one-third of the inferior border of mandibular canal on the right and left sides was reported almost perfect (K = 0.925) and good (K = 0.745), respectively.

Table 3. Frequency distribution of different manifestations of the anterior one-third of the inferior border of mandibular canal

Side	Observer	0		1		2		3		Kappa
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Index
Right	A	21	22.1	5	5.3	0	0	69	72.6	0.925
	B	22	23.2	3	3.2	1	1.1	69	72.6	
Left	A	31	32.6	7	7.4	5	5.3	52	54.7	0.745
	B	28	29.5	7	7.4	5	5.3	55	57.9	

According to Table 4, for both observers, the highest frequency of visibility in the middle one-third of the superior border of mandibular canal on the right and left sides was related to zero scale (observation of less than 25% of the canal border). In this area, for both observers, the lowest frequency of visibility on the right and left sides was related to type 2 (observation of 50-75% of the canal border). The intra-examiner agreement on the middle one-third of the superior border of mandibular canal on the right and left sides was reported good (K = 0.720 and 0.728, respectively).

Table 4. Frequency distribution of different manifestations of the middle one-third of the superior border of mandibular canal

Side	Observer	0		1		2		3		Kappa
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Index
Right	A	53	55.8	10	10.5	9	9.5	23	24.2	0.720
	B	45	47.4	12	12.6	9	9.5	29	30.5	
Left	A	59	62.1	13	13.7	4	4.2	19	20.0	0.728
	B	54	56.8	9	9.5	8	8.4	24	25.3	

Table 5 shows that for both observers, the highest frequency of visibility in the middle one-third of the inferior border of mandibular canal on the right and left sides was related to type 3 (observation of more than 75% of the canal border). In this area, for both observers, the lowest frequency of visibility on the right and left sides belonged to type 1 (observation of 25-50% of the canal border) and type 2 (observation of 50-75% of the canal border). The intra-examiner agreement on the middle one-third of the inferior border of mandibular canal on the right and left sides was reported moderate (K = 0.753) and good (K = 0.761), respectively.

Table 5. Frequency distribution of different manifestations of the middle one-third of the inferior border of mandibular canal

Side	Observer	0		1		2		3		Kappa
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Index
Right	A	10	10.5	4	4.2	8	8.4	73	76.8	0.753
	B	10	10.5	5	5.3	6	6.3	74	77.9	
Left	A	26	27.4	6	6.3	5	5.3	58	61.1	0.761
	B	18	18.9	7	7.4	6	6.3	64	67.4	

According to Table 6, for both observers, the highest frequency of visibility in the posterior one-third of the superior border of mandibular canal on the right and left sides was related to type 3. In this area, the lowest frequency of visibility on the right side belonged to type 0 for both observers while the frequency on the left side was related to type 1 and type 2 for observers A and B, respectively. The intra-examiner agreement on the posterior one-third of the superior border of mandibular canal on the right and left sides was reported moderate (K = 0.601) and good (K = 0.724), respectively.

Table 6. Frequency distribution of different manifestations of the posterior one-third of the superior border of mandibular canal

Side	Observer	0		1		2		3		Kappa
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Index
Right	A	4	4.2	4	4.2	7	7.4	80	84.2	0.601
	B	3	3.2	5	5.3	8	8.4	79	83.2	
Left	A	10	10.5	3	3.2	6	6.3	76	80.0	0.724
	B	9	9.5	3	3.2	2	2.1	81	83.5	

Table 7 shows that for both observers, the highest frequency of visibility in the posterior one-third of the inferior border of mandibular canal on the right and left sides was related to type 3. In this area, the lowest frequency of visibility on the right side belonged to type 2 and type 1 for observers A and B, respectively. For both observers, the lowest frequency on the left side was related to type 1. The intra-examiner agreement on the posterior one-third of the inferior border of mandibular canal on the right and left sides was good (K = 0.746 and 0.765, respectively).

Table 7. Frequency distribution of different manifestations of the posterior one-third of the inferior border of mandibular canal

Side	Observer	0		1		2		3		Kappa
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Index
Right	A	7	7.4	5	5.3	3	3.2	80	84.2	0.746
	B	6	6.3	1	1.1	4	4.2	84	88.4	
Left	A	9	9.5	3	3.2	7	7.4	76	80.0	0.765
	B	7	7.4	2	2.1	6	6.3	80	84.2	

According to Table 8, the Friedman test was used to compare the mean values obtained in the anterior, middle, and posterior one-third of the superior and inferior border of mandibular canal. The results showed that the highest mean value for the superior and inferior borders of mandibular canal on the left and right sides was related to the posterior one-third and the lowest one was related to the anterior one-third of the superior border of mandibular canal.

Table 8. Comparison of the mean values obtained from observation of the anterior, middle, and posterior one thirds of mandibular canal

Side	Canal Border	Anterior One-third	Middle One-third	Posterior One-third	P-value
Right	Superior	1.59	1.75	2.72	0.0001
	Inferior	1.87	2.01	2.16	
Left	Superior	1.67	1.71	2.67	0.0001
	Inferior	1.81	1.99	2.26	

Discussion

Panoramic radiography is routinely used by surgeons and dentists in many cases, including the implant placement due to advantages such as the exhibition of a vast area of hard tissue and teeth, the continuity in the presented structures, the high speed of the image construction considering the amount of provided information, as well as the relative simplicity of its provision (5).

Mental foramen is an anatomical and radiographic landmark that can be seen in the most panoramic radiographs. The manifestation of this anatomical landmark is different, even without any changes in radiographic conditions. In this study, the manifestation of the mental foramen was evaluated on 95 panoramic radiographs (a total of 190 mental foramen) by two examiners.

The most common type of mental foramen was the continuous type and the lowest one was diffuse type for both observers. Based on the results of Kappa test, the intra-examiner agreement on observing the mental foramen on the right and left sides was 0.601 and 0.723, respectively (P = 0.0001), which is consistent with the results of a study by Al-Faleh et al. (2005) who examined the manifestation of the mental foramen on 100 panoramic radiographs (5). In addition, the results of the study of Al-Faleh (5) were also consistent with those of the present study in terms of the lowest type of mental foramen. In this study, the second most frequent manifestation of the mental foramen for observers A and B was related to the separated and unidentified types, respectively, which is consistent with the results reported by Al-Faleh et al. (5). In the present study, there was an intra-examiner agreement on observing the mental foramen in the moderate to good range while Al-Faleh et al. (5) reported the fair to moderate range. This difference is probably due to the difference in the number of observers in the two studies.

Shah et al. (2013) examined 204 panoramic radiographs (19). The most common type of mental foramen manifestation according to the Yosue and Brooks (17) classification was separated type (53.53%). In the present study, the separated type was reported as the second frequent type of mental foramen, and the continuous type was reported as the most common type of mental foramen manifestation. The difference can be due to variations in sample number, methods, or exposure conditions.

Unlike other dense bones, the superior and inferior borders of the mandibular canal are comprised of fine to extremely dense structures. It should also be noted that the trabeculation of mandibular canal cortex is different among individuals as well as in different areas of the mandible bone in one person (20). Carter and Keen (21) as well as Werhmann and Manson-Hing (22) believed that the absence of the mandibular canal in radiographs might be due to the fact that inferior alveolar neurovascular bundle is not always surrounded by a bony canal.

Oliveira-Sa`1``[ntos et al. (2011) conducted a study to observe the mandibular canal on cross-sectional CBCT images. 116 mandibular canals were investigated in terms of the visibility method. In their study, the mandibular canal was clearly visible in 53% of the cases, and the visibility of the canal was difficult and very difficult in 25% and 22% of the cases, respectively (20).

In the present study, the most common manifestation of the mandibular canal was type 3 (observation of more than 75% of the canal border) except for the anterior and middle one-third of the superior border of the mandibular canal, which is consistent with the results of the study of Oliveira-Santos et al. (20). In the present study, there was also a significant difference in the anterior, middle, and posterior one thirds of the mandibular canal; so that the visibility of the posterior one-third of the mandibular canal was better than that of the anterior and middle one thirds of the canal, which is consistent with the results of the study of Oliveira-Santos et al. (20), who reported that the observation of mandibular canal in the distal region was better.

The results of this study also showed that the observation of mandibular canal in the posterior one-third (in the mandibular ramus) was better than that in the anterior and middle one thirds, which is consistent with the results of the study of Angelopoulos et al. (16). The frequency of middle one-third (the molar area) and anterior one-third (premolar area) was ranked as the second and third. This could be due to the buccal displacement of the mandibular canal before opening into the mental foramen. In Gowgiel's study (1992), it was suggested that the inferior alveolar neurovascular bundle in the posterior regions was usually in contact with the lingual cortical plate and created a depression in this plate, which made this part of the mandibular canal better depicted (23).

Conclusion

According to the results, the superior and inferior borders of alveolar canal were observed better in the posterior one-third compared to the anterior and middle one thirds. In addition, in the anterior and middle one thirds, the observation of the inferior border of mandibular canal on higher scales was more frequent than that of the superior border on these scales, but in the posterior one-third, these frequencies in the superior and inferior borders of the mandibular canal were close to each other.

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