Original Article

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Assessment of the Mandibular Canal Position in the Mandibular Body using Cone Beam Computed Tomography

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ABSTRACT

BACKGROUND AND OBJECTIVE: Iatrogenic injury to the inferior alveolar nerve is one of the possible complications in surgical procedures such as implant placement. Considering the anatomic variety in nerve placement, the present study aims to assess the exact position of mandibular canal in the posterior mandibular body using cone beam computed tomography (CBCT).

METHODS: CBCT mandible images of 150 patients with mean age of 45 years were used in this cross-sectional study. The cross-sectional profiles of each patient were measured at intervals of 5 mm, starting from 1 mm before mental foramen to the anterior border of the ramus in two age groups, below 50 and above 50. In each profile, the distances from the walls of the mandibular canal to the cranial nerve (CN), inferior nerve (IN), buccal nerve (BN) and lingual nerve (LN) were measured.

FINDINGS: 70 men with mean age of 48.91±13.46 years and 80 women with mean age of 41.56±14.41 years participated in this study. The mean distances (mm) on the right and the left were respectively as follows: CN: 10.67±3.83, 10.38±3.73, BN: 4.44±1.42, 4.31±1.37, LN: 2.23±1.15, 2.42±1.23, and IN: 5.75±1.86, 5.63±1.86. According to the separate analysis of the profiles, the mandibular canal in men was more inclined to lingual nerve in buccolingual dimension and was more inclined to the top of the alveolar ridge in the inferior alveolar dimension. In terms of age, the bone in the cranial nerve (CN) in patients under 50 years in all profiles was significantly more than patients above 50 years ($p<0.001$).

CONCLUSION: According to the results of this study, age and sex may have significant effect on the position of inferior alveolar nerve and the use of 3D radiographies such as cone beam computed tomography is essential.

KEY WORDS: *Mandibular canal, Cone Beam Computed Tomography, Oral surgery*.

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Introduction

Iatrogenic injury to the inferior alveolar nerve is one of the possible complications in surgical procedures such as implant placement (1). The location of the nerve is not clearly detectable in some panoramic or periapical radiographies in some patients. On the other hand, the level of distortion and magnification ranges from 3.4% in periapical radiographies to 14% in panoramic images. Moreover, these images only contain limited information about the location and the path of nerve and they do not provide the possibility to assess the buccolingual position of the nerve (2).

Several studies have indicated that the diagnostic accuracy of Computed Tomography is higher than Conventional Tomography. Computed Tomography makes it possible to search the exact location of nerve and it position in association with alveolar crest in addition to buccolingual position (3).

Cone Beam Computed Tomography (CBCT) as a new technology benefits from several advantages compared with CT. CBCT decreases the dosage of ray and decreases costs and can present images with high spatial resolution of the teeth and their surrounding structures (4). The validity of the data obtained from CT images has been reported in several studies including the studies of Massey et al. (5) and Kamburoglu et al. (6).

Several studies in different regions of the world have been conducted to investigate the position of inferior alveolar nerve, indicating diverse results (7, 8). There was a significant relationship between the position of the canal and age and race in the study of Levine et al. (7).

The amount of bone surrounding the mandibular canal in several studies such as the studies of Ulm et al. in Austria (9), Kieser et al. in New Zealand (10) and Angle et al. in United States (2) did not indicate statistically significant difference between the two sexes. However, Yashar et al. found the difference to be significant (1).

Due to the wide anatomic variety in the location of this nerve, it is a difficult task to predict its position and on the other hand, the conventional radiographies are faced with limitations in this area and may not help dentists mush.

Considering the increasing prevalence of using implant in the posterior body of the mandible and the accuracy of CBCT images, we decided to investigate the exact position of mandibular canal in the aforementioned area in selected Iranian population.

Methods

In this cross-sectional study, after getting permission from the ethics committee of Babol University of Medical Sciences (Code: 3326), we used mandible images of 150 patients, aged 18 – 77 years with a mean age of 45 years, who referred to a private oral and maxillofacial radiology center from 2013 to 2015 for diagnostic reasons.

The images were studies by an experienced oral and maxillofacial radiologist to evaluate the position of mandibular canal. The subjects were excluded in cases of history of surgery or the presence of any evolutionary and pathological lesion in the posterior body of the mandible because of possible change in mandibular canal position in the area.

All the images were prepared using Cranex 3D/ Soredex/Helsinki/Finland (Field of view: 8×6 and option: High Resolution) and then the images were processed using Ondemand 3D Dental software. The cross-sectional profiles of each patient's CBCT image were measured at intervals of 5 mm, starting from 1 mm before mental foramen to the anterior border of the ramus (Fig 1).

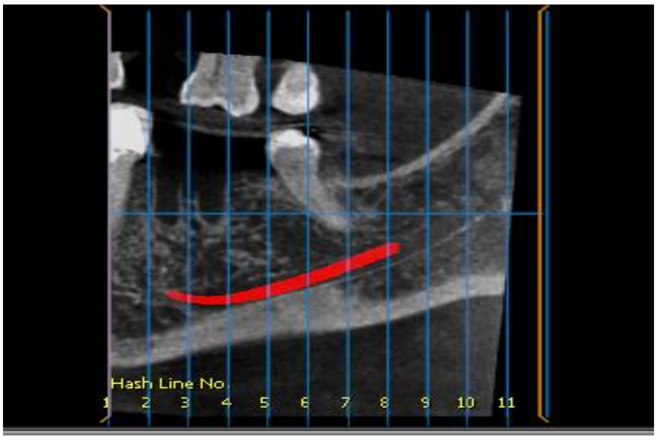

Figure 1. Panorama CBCT image showing the studied sections with 5 mm intervals

CN=The interval between the posterior border and alveolar crest

BN=The interval between mandibular canal and buccal cortical plate

LN=The interval between mandibular canal and lingual cortical plate

IN=The interval between mandibular canal and inferior border

4 intervals were measured in each cross-section: 1. The amount of bone between the external wall of mandibular canal and the buccal cortical plate (BN), 2. The amount of bone between the internal wall of mandibular canal and the lingual cortical plate (LN), 3. The amount of bone between the inferior wall of mandibular canal and inferior border (IN) and 4. The amount of bone between the posterior wall of

mandibular canal and alveolar crest (CN) (Fig 2). The subjects were divided into two groups of below 50 years old (89 patients) as well as 50 years old and above (61 patients). Subjects were also divided based on sex and target position. The position of mandibular canal on both side of mandible was analyzed in both sex and age groups using SPSS Ver. 18 as well as T-test and ANOVA tests, while p<0.05 was considered significant.

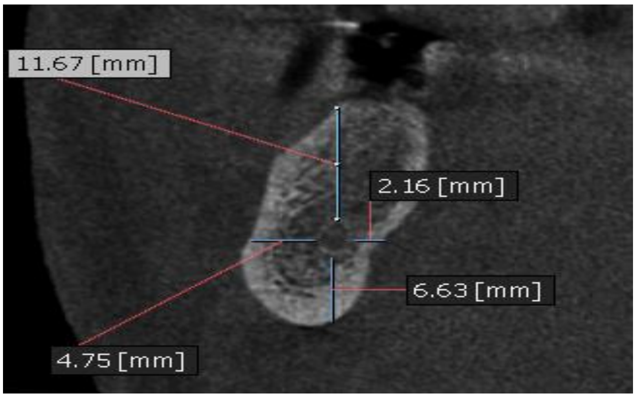

Figure 2. Cross-sectional image of all measurements

Results

70 men with mean age of 48.91 ± 13.46 years and 80 women with mean age of 41.56 ± 14.41 years participated in this study. The mean intervals (mm) on the right and the left were respectively as follows: CN: 10.67±3.83 and 10.38±3.73, BN: 4.44±1.42 and 4.31±1.37, LN: 2.23±1.15 and 2.42±1.23, and IN: 5.75±1.86 and 5.63±1.86. The differences observed in BN and LN on both sides were significant (p<0.05). On the other hand, the analysis of results in separate sections on the two sides of jaw showed that the observed differences were not significant in any of the measured intervals (table 1).

Comparing men and women, the mean interval (mm) for men and women were respectively as follows: CN: 10.85±3.82 and 10.13±3.82, BN: 4.24±1.4 and 4.54±1.38, LN: 2.45±1.17 and 2.18±1.20, and IN: 5.50±1.73 and 5.91±1.99. In other words, the amount of bone in the posterior and lingual part of mandibular canal in women was significantly higher than men (p<0.0001). On the other hand, the amount of bone in the inferior and buccal part of mandibular canal in men was significantly higher than women (p<0.0001). Examining the sections separately, the interval between the canal and the alveolar crest in all sections was more in women. On the other hand, in most sections (except for sections 7 and 8), the interval between the canal and inferior border was found to be more in men. Investigating the interval between mandibular canal and buccal cortical plate, the interval was more in men in all sections and on the other hand, the interval between mandibular canal and lingual cortical plate was more in women in all sections (Fig 3); in other words, the canal is more inclined to be lingual in men. Overall, the highest measured intervals (mm) in patients below 50 years and patients 50 years and above were respectively is as follows: CN: 8.96±3.10 and BN: 4.59±1.47 and LN: 2.40±1.29 and 2.27±1.12 IN: 6.00±1.92 and 5.49±1.80, and these differences were significant in all cases (p<0.0001). Comparing sections separately in terms of age, the amount of bone in the posterior section of mandibular canal to alveolar crest in patients below 50 years old was assessed to be significantly more than patients 50 years old and above.

The amount of bone in the buccal edge of the mandibular canal in patients below 50 years old was less than patients 50 years old and above, while this difference was significant in sections 4, 5, 6 and 7. Similarly, the interval between the canal and the lingual cortical plate in all sections (except for sections 6 and 7) in patients below 50 years old was less than patients 50 years old and above, while this difference was only significant in section 2 (p≤0.05).

In addition, the interval between the canal and the inferior border was found to be less in patients below 50 years old, while this difference was significant in most sections (except for section 8) (p≤0.05) (Table 2). In an overall comparison of sections in 69 cases of complete edentulousness and 41 cases of complete dentulousness, the measured intervals were respectively as follows: CN: 14.79±3.17 and 8.73±2.79, BN: 4.31±1.24, LN: 2.05±1.04 and 2.33±1.17 and IN: 4.80±1.68 and 6.21±2.13. The observed differences were calculated to be significant, except for BN. Examining the sections separately demonstrated that the amount of bone in the posterior part of the canal to alveolar ridge was significantly different in the two groups in all sections; this amount was in dentulous patients was more than edentulous patients. The highest amount of bone was observed in section 1 in dentulous group (15.93±3.63) and the lowest amount was observed in section 4 in edentulous group (7.73±2.56). In these two mentioned groups, the interval between the canal and buccal cortical plate and lingual cortical plate showed no significant difference in most sections. The longest interval from buccal cortical plate and lingual cortical plate was respectively calculated for section 5 in edentulous group (5.27±1.41) and section 2 in edentulous group (2.43±1.01). The interval calculated to the inferior border in the edentulous group was significantly higher than the other group and it was highest in section 8 (7.41±2.97).

Table 1. The mean intervals of mandibular cortical walls (CN, BN, LN, IN) from the mandibular canal in different sections based on the side (mm)

Section	IN		LN		BN		CN	
	Left	Right	Left	Right	Left	Right	Left	Right
1	6.77±1.70 N=150	6.74±1.63 N=150	3.20±1.23 N=150	3.00±1.24 N=150	3.16±1.45 N=150	3.62±1.08 N=150	11.28±4.59 N=150	11.99±4.27 N=150
2	5.80±1.69 N=150	5.71±1.56 N=150	2.42±1.11 N=150	2.30±0.98 N=150	4.23±1.07 N=150	4.46±1.23 N=150	10.77±4.06 N=150	11.58±4.17 N=150
3	5.30±1.60 N=150	5.24±1.50 N=150	2.19±1.14 N=150	2.02±0.99 N=150	4.77±1.11 N=150	5.04±1.24 N=150	10.19±3.85 N=150	10.66±4.00 N=150
4	5.06±1.58 N=150	4.95±1.55 N=150	2.19±1.11 N=150	1.96±1.01 N=150	5.11±1.20 N=150	5.23±1.24 N=150	9.66±3.64 N=150	10.22±3.75 N=150
5	4.97±1.55 N=149	4.93±1.57 N=150	2.29±1.09 N=149	2.09±1.02 N=150	5.08±1.25 N=149	5.12±1.32 N=150	9.57±3.22 N=149	9.80±3.44 N=150
6	5.43±1.71 N=148	5.30±1.86 N=150	2.35±1.19 N=148	2.15±1.15 N=150	4.57±1.34 N=148	4.56±1.45 N=150	9.93±3.19 N=148	10.01±3.60 N=150
7	6.11±1.92 N=143	5.96±2.09 N=137	2.37±1.31 N=143	2.17±1.32 N=137	3.70±1.24 N=143	3.64±1.30 N=137	10.67±3.20 N=143	10.32±3.37 N=137
8	6.96±2.27 N=78	6.64±2.48 N=78	2.26±1.40 N=78	2.15±1.16 N=78	3.08±1.11 N=78	3.37±1.12 N=78	11.29±3.33 N=78	10.67±3.19 N=78

Table 2. The mean intervals of mandibular cortical walls (CN, BN, LN, IN) from the mandibular canal in different sections based on age (mm)

Section	IN		LN		BN		CN	
	≥50	<50	≥50	<50	≥50	<50	≥50	<50
1	6.98±1.73 N=122	6.59±1.60 N=178	3.25±1.29 N=122	2.99±1.20 N=178	3.65±1.25 N=122	3.46±1.03 N=178	10.14±3.80 N=122	12.66±4.57 N=178
2	6.02±1.71 N=122	5.57±1.54 N=178	2.52±1.14 N=122	2.25±0.97 N=178	4.48±1.32 N=122	4.25±1.02 N=178	9.49±3.43 N=122	12.34±4.18 N=178
3	5.56±1.63 N=122	5.07±1.46 N=178	2.27±1.20 N=122	1.99±0.95 N=178	5.05±1.29 N=122	4.80±1.09 N=178	8.71±3.12 N=122	11.60±4.00 N=178
4	5.31±1.62 N=122	4.79±1.49 N=178	2.15±1.20 N=122	2.02±0.96 N=178	5.43±1.24 N=122	4.99±1.17 N=178	8.30±2.99 N=122	11.07±3.72 N=178
5	5.35±1.68 N=121	4.68±1.41 N=178	2.21±1.14 N=121	2.17±1.00 N=178	5.37±1.31 N=121	4.92±1.23 N=178	8.25±2.65 N=121	10.66±3.39 N=178
6	5.82±1.82 N=120	5.05±1.69 N=178	2.23±1.26 N=120	2.25±1.11 N=178	4.79±1.42 N=120	4.41±1.36 N=178	8.50±2.65 N=120	10.97±3.49 N=178
7	6.48±2.13 N=110	5.57±1.86 N=170	2.18±1.37 N=110	2.33±1.28 N=170	3.87±1.32 N=110	3.55±1.22 N=170	9.20±2.70 N=110	11.33±3.36 N=170
8	7.06±2.63 N=54	6.66±2.22 N=102	2.34±1.50 N=54	2.14±1.15 N=102	3.35±1.16 N=54	3.16±1.10 N=102	9.30±2.52 N=54	11.86±3.28 N=102

CN=The interval between the posterior border and alveolar crest, BN = The interval between mandibular canal and buccal cortical plate, LN= The interval between mandibular canal and lingual cortical plate, IN = The interval between mandibular canal and inferior border.

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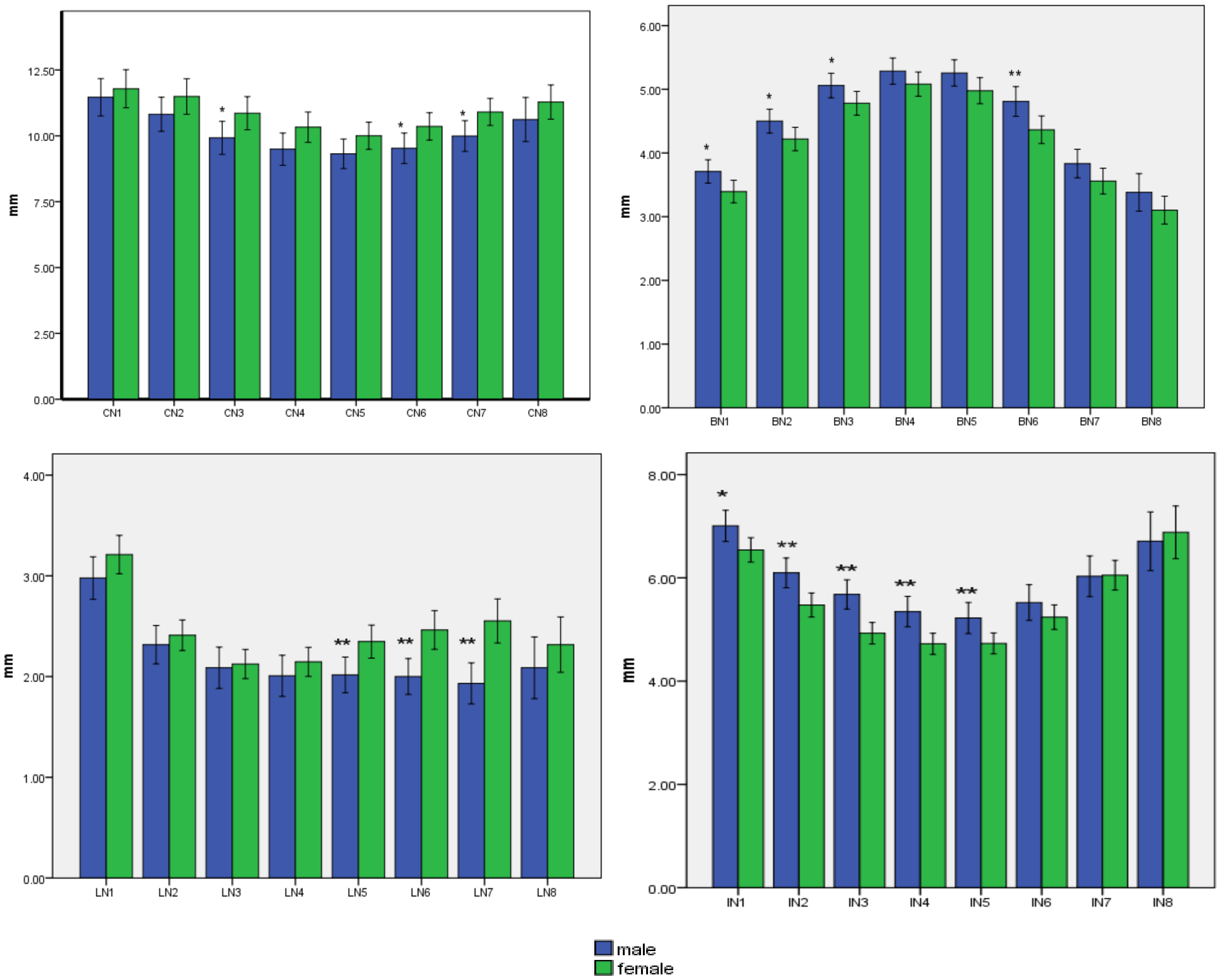

Figure 3. Comparing the amount of bone between the mandibular canal and CN, IN, BN and IN based on sex; *p<0.05, ** p<0.01.

Discussion

In this study, the longest interval to buccal cortical plate was observed in section 4 (almost in the range of the first and last mandibular molar area). The mean intervals in the right and left sides were 5.11±1.20 and 5.23±1.24 mm, respectively. Levine et al. reported this interval in the first molar area to be 4.9±1.3 on average (7). In the study of Yoshioka et al., the intervals from the canal to buccal cortical plate in the second molar area were found to be 6.04±1.66 and 6.50±2.11 in 28 patients with mandibular prognathism and 30 normal patients, respectively (11).

According to the study of Levine et al., there was a significant relationship between canal position and buccal cortical plate in terms of age and race; this interval decreased with increased age in white people (7). However, this interval in patients below 50 years old was significantly less than patients 50 years old and above. Sekerci et al. examined the CBCT images of 250 patients (500 hemi – mandibles) with a mean age of 26 years and reported the interval between the canal and buccal cortical plate in a section between first and second molar area in both sides and both sexes to be 6.3±1.85 to 6.6±1.38.

According to this study, the linear intervals were measured in three sections (between the first and second molar area, between the second and third molar area, right after the third molar area) and it was shown that the interval between the canal and buccal cortical plate significantly decreases from anterior to posterior (8). We can say that this result is consistent with the present study, since buccal cortical plate decreased from section 4 (approximately, in the first molar area) toward the posterior part in our study. In the present study, the shortest interval from the buccal cortical

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plate was observed in section 8 (approximately, in the third molar area). Similarly, the evaluations of Rajchel et al. demonstrate that the longest interval to buccal cortical plate is in the first and second molar area, while the shortest interval is in the third molar area (12). The minor differences in the results of the above – mentioned studies may be due to differences in race, age or measurement techniques.

Results showed that in bacolingual dimension, the canal generally moves from anterior border of the ramus to 1 mm before mental hole nearer lingual cortical plate. This result is consistent with the study of Yashar et al. (1) on CT images of 195 patients with an age range of 22 to 88 years and the study of Stella et al. (13) on mandible of corpses. The mean interval from the canal to lingual cortical plate in the present study was calculated to be 2.18±1.20 and 2.45±1.17 in men and women, respectively.

In a pilot study by Balaji et al. in India using CBCT images of 20 dentulous patients (10 mean with mean age of 25.2 years and 10 women with mean of 23.2 years) reported this interval to be respectively 1.79 ± 0.46 and 1.48 ± 0.43 in men and women in the first molar area and 1.59 ± 0.74 and 1.34 ± 0.36 (14); the observed difference may be due to difference in sample size as well as mean age of patients.

The mean age of men and women in this study is more than the mean age of subjects in the study of Balaji et al. and on the other hand, the mean intervals to lingual cortical plate in that study are less than the present study. It can be said that the results of this study are consistent with the present study; as the age increases, the interval between the mandibular canal and lingual cortical plate increases.

According to the present study, measuring the alveolar ridge to the posterior border of mandibular canal demonstrated that the mandibular canal is located in the most inferior position in the first section (1 mm to mental hole) and gradually moves upward to reach section 5 (approximately, in the second molar area) and then again, finds longer interval to alveolar crest until it reaches section 8 (approximately, in anterior border of the ramus). This process was also reported by Yashar et al. (1). Evaluating the interval from the canal to inferior border of mandible demonstrated that the interval increased from section 1 to 5 in both sexes in both sides and increased after that till the final section. This result was also observed by Yashar et al. in a similar way (1). Sekerci et al. also reported increase in this interval from the first molar area to third molar area (8). The mean interval was respectively found to be 5.91±1.99 and 5.50±1.73 in men and women in the present study and 7.76±0.16 and 7.00±0.15 in the study of Yashar et al. (1). Higher values in the study of Yashar et al. compared with our study may be due to racial differences between Iranian and American populations. Significant differences were observed between the measured intervals and most of them were consistent with the results of Yashar et al. (1). On the other hand, Angle et al. did not report a significant difference between the two sexes after measuring the mentioned intervals in the first molar area in 165 CBCT images of 18 – 80 years old patients (2).

Results of the study of Kieser et al. (10) on 107 dry mandibles and the study of Ulm et al. (9) on 43 Half-Jaws in sections between the mental hole and the third molar area did not indicate significant result between the two sexes. Considering that these studies were conducted in different countries among different races, we can say that difference or lack of difference between the two sexes can be different in different populations.

As people age and lost their mandibular teeth, the alveolar ridge corrodes at different rates (10). In the present study, the amount of bone in the interval between mandibular canal and the alveolar ridge in patients 50 years old and above and in edentulous ridges was significantly less than patients below 50 years old and dentulous ridges. This result is consistent with the study of Yashar et al. (1). Lower values in other intervals in patients below 50 years old compared with patients 50 years old and above may be due to calcification in the inner walls of mandibular canal with increased age; although this explanation was not mentioned in any of the previous studies.

The validity of the data obtained from CT images has been reported in several studies. Massey et al. in their study on 16 dry hemi – mandibles directly measured the amount of bone surrounding the mandibular canal using a digital caliper and also in CT images using sogftware. There was no significant difference between the values obtained from the two methods (5). Similarly, Kamburoglu et al. studies 6 hemi – mandibles and reported similar results (6).

Analyzing the position of mandibular canal to adjacent bony walls in 5 mm intervals is one of the advantages of this study over most studies, which provides the possibility for accurate and detailed nerve condition assessment. However, it is worth mentioning that accurate mesuarment of canal diameter was not possible in all sections because of considerable

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differences in the geometric shape of the mandibular canal in different patients and even different sections in one patient. Therefore, measuring the mentioned parts is advised for future studies in order to have more complete and comprehensive assessments. More similar studies with emphasis on larger sample size can provide a wider view for dentists and surgeons before starting surgeries, particularly implant placement in these areas. Results of this study demonstrated that age and sex may have considerable impact on the position of the inferior alveolar nerve. Therefore, considering the importance of identifying the path and location of this nerve before surgeries including implant placement in the posterior area of the mandible, it is necessary to use 3D images such as CBCT.

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