Original Article

Investigating the Distance from Mandibular Canal to Molar Apices and Buccal Cortex in Bandar Abbas Population

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ABSTRACT

The present study investigates the distance between the mandibular inferior alveolar canal and the apex of the first and second permanent molars and the mandibular buccal cortex in CBCT images. This study was conducted on 100 radiographs. After recording demographic information, all parameters of the inferior alveolar canal were recorded in CBCT. Independent t-tests and Mann-Whitney tests were used to compare the studied variables. Investigating the age and gender of the subjects revealed that the distance from the root apex of tooth 6 to the buccal cortex of the mandible trunk was significantly higher in males than in females (5.44 vs. 4.2 mm) (especially in those under 40 years of age). The distance from the root apex of tooth 7 to the buccal cortex of the mandible trunk was significantly higher in males than in females (6.61 vs. 5.3 mm). Additionally, in all the subjects studied, only the distance from the canal to the mesial root apex of tooth 6 had an inverse and significant relationship with age (r= -0.2 and P=0.046). The mandibular inferior alveolar canal may be an appropriate criterion for determining the age and gender of individuals and can be used to identify age and gender in forensic medicine and other cases. However, further and more detailed investigation in this area is needed to achieve the diagnostic accuracy of various parameters. A more detailed investigation in future studies is needed in this regard.

Keywords: CBCT, Mandibular inferior alveolar canal, First and second molar apex, Mandibular buccal cortex

Introduction

The mandibular inferior alveolar canal passes through the body of the mandible in an anteroposterior direction. However, its position in the buccolingual and vertical directions varies from patient to patient [1). Knowledge of the anatomical location of the mandibular canal is clinically crucial due to its susceptibility to injury during surgical procedures involving the mandible [2]. The diversity in the anatomical location of the mandibular canal should always be considered to prevent injury to the inferior alveolar nerves during invasive surgical procedures of the mandible such as mandibular osteotomy, fracture restoration, bone screw placement, orthodontic surgeries, third molar extraction, and dental implant procedures [3]. The inferior alveolar nerve is a sensory nerve that supplies regional sensation to the mandible. It initially enters the mandible through the mandibular foramen. A part of the inferior alveolar nerve exits the mental part and becomes the mental nerve, which is a nerve network for the lower anterior teeth. Thus, the inferior alveolar nerve is the most important nerve of the mandibular teeth [4]. A study by Ozturk *et al*. revealed that the inferior alveolar canal is located about 1 mm above the lower border of the mandible and passes through the mental foramen, which is about 16.7 mm above the lower border of the mandible [2].

Liu *et al*. [5] examined the characteristics of the canal and its association with the third molar in 386 panoramic radiographs of subjects up to 16 years of age. They concluded that the distal root apex of the third molar was the root closest to the canal, with a mean distance of about 1.66 ± 1.27 mm. The proximity of the inferior alveolar nerve to root structures is a vital anatomical issue for surgery on mandibular molars, even with today's advanced technology. It has been reported that dentoalveolar and root-end surgeries cause persistent nerve dysfunction, including paresthesia, dysesthesia, or anesthesia of the inferior alveolar nerve [6-10]. The inferior alveolar nerve can be injured in various ways in endodontic procedures. Some of them are periapical surgery, root canal over-instrumentation, root canal cleaning medications, and overfilling with an obturator canal. Most inferior alveolar canal injuries related to endodontic treatment occur in the mandibular second molar. After that, the mandibular first molar and premolars are at high risk [11-14].

CBCT has been extensively accepted over the past few years in the dentomaxillofacial field. This type of radiography can examine different planes with submillimeter resolution. This type of imaging can also provide accurate and reliable information about the position of the inferior alveolar canal and its relationship to the molars [15-17]. Cone beam computed tomography (CBCT) systems have been developed for computed tomography, especially in the maxillofacial region. The design of the first CBCT systems dates back to about 3 decades. However, the first articles and studies in this field date back to about 1998-1999. Then, several commercial CBCT systems were introduced to the market in a short time [18-22]. CBCT employs a rectangular or round X-ray beam focused on a two-dimensional X-ray sensor, so a scan is obtained by rotating 360 degrees around the patient's head. During the scan, 360 exposures (one exposure for each degree of rotation) are taken to provide raw digital information for the computer algorithm to reconstruct the exposed area [18-22]. CBCT allows for the generation of instantaneous images not only in the axial plane but also in two-dimensional images in the coronal, sagittal, and even oblique or curved planes (a process called multi-plane reconstruction). Additionally, the information obtained from CBCT can be reconstructed volumetrically and provide three-dimensional information.

Hemalatha Hiremath *et al*. conducted a study to evaluate the proximity of mandibular second molars and premolars to the inferior alveolar canal using CBCT images of an Indian population in 2015. After reviewing the data in this cross-sectional study, CBCT of 40 males and 40 females who met the inclusion and exclusion criteria were selected for the study. The results revealed that the mean distance of the second premolar from the inferior alveolar canal was 0.88 to 13.03 mm for males and 0.00 to 5.49 mm for females. The mean distance of the inferior alveolar canal to the mesial root of the first molar was 1.46 to 13.23 mm for males and 0.93 to 8.03 mm for females. For the second molar, the mean distance was 1.31 to 14.71 mm for males and 0.00 to 6.91 mm for females (the values on the left side were shorter than on the right side). In the entire population, only the second molar showed a significant difference in the distance from the root apex to the inferior alveolar canal. In addition to gender differences, age-related differences were significant for the first molar on the left and the second molar on the right side of the population [$P < 0.05$)[23].

A study by Maryam Paknahad *et al*. (2015) investigated the analysis of the path and position of the mandibular canal on CBCT images. This cross-sectional study was conducted on 242 CBCT patients (99 males and 143 females). The canal position was investigated in 4 different regions. In the transaxial view, the posterior mental foramen, where the mandibular canal loop is formed, was taken as point 1 for measurement, and 10 mm distances from this point were selected as points 2, 3, and 4 for measurement, respectively. The results revealed a significant relationship between the canal anatomical path and the gender of the patients, so it increased in the male gender. The mean vertical position of the canal was measured by the distance from the lower border of the inferior alveolar canal to the lower border of the jaw and it was obtained at 8.50 mm (in a range of 4.80 to 14.50 mm). On average, the mandibular canal was located more lingually in all locations until it reached the mental foramen, so it was located close to the buccal cortical plate in the mental foramen region (point 1) [24].

A study by Tyler Kovisto BS *et al*. (2010) examined the proximity of the mandibular canal and the teeth apex. This cross-sectional study was conducted on CBCT images of 139 patients to assess the proximity of the mandibular canal to the root apex of the first and second molars. The subjects were divided into subgroups based on age and gender. The results revealed that in all groups, the root apices of the mandibular second molars were closer to the mandibular canal than the other teeth. The mesial root of the second molar was closer to the nerve in female patients compared to male patients. The root apices of young patients (<18 years) were generally closer to the mandibular canal than in older patients [25].

Arwa Mousa *et al*. (2020) investigated the anatomy of the inferior alveolar canal of the mandible in the Egyptian population. Six of the eight measured distances differed significantly between the males and females, so it was significantly greater in males than in females. Regression analysis indicated a logistic function with a concordance index of 84%. The diagnostic capabilities of the linear measurements as predictors of gender were calculated using ROC analysis, and the 6 best predictors for gender determination were selected and ranked from highest to lowest predictive power. Additionally, the combination of these 6 predictors increased the predictive power to 84%. The position of the inferior alveolar canal in the Egyptian population differs significantly in terms of gender. This anatomical turning point can be used as a reliable indicator of gender dimorphism [26] Trustiya Tudtiam *et al*. (2019) examined the anatomy of the mandibular inferior alveolar canal. They showed that the mandible width, the IAC width, and the IAC height were different between male and female patients.

The IMTM roots showed close contact with the IAC in 96.67% of cases. The IAC location was more lingual in both genders. The IAC diameter was much larger in males in terms of width and height compared to females. This study also revealed that the distance from the root apex of teeth 6 and 7 to the buccal cortex of the mandibular trunk was significantly higher in males than in females [27]. Since a similar study has not been conducted in Bandar Abbas in recent years, the present study investigated the distance of the mandibular inferior alveolar canal to the apex of the first and second permanent adult molars and the buccal cortex of the mandible in CBCT images of the population of Bandar Abbas in 2019-2020.

Materials and Methods

This retrospective cross-sectional study examined CBCT images of people who were referred to the radiology centers of Bandar

Abbas City in 2019-2020 and met the inclusion criteria of our study. Some CBCTs were selected from the radiology clinics of Bandar Abbas City using random sampling methods. Those who met the inclusion criteria of the study were selected. The sample size was determined to be 38 males and 38 females by considering $\alpha=0.05$ and $\beta-1=0.9$ and using information extracted from the study by Trastia Tudtiam *et al*.

Inclusion criteria were all images with good quality, and sufficient demographic information was available in their records. Age between 18 and 60 years, absence of any developmental disorder or pathology or previous treatment that could affect the inferior alveolar nerve or its canal or the position of the mandibular posterior teeth, a complete set of 28 teeth excluding the third molars, the inferior alveolar canal cortex was completely cortical bilaterally, and no radiological evidence of skeletal/dental malocclusion that could alter the position of the posterior teeth or inferior alveolar canal [18]. Exclusion criteria included images with developmental, pathological, and mandibular fractures and edentulous and damaged mandibles. The exact location of the inferior alveolar canal and dental apex was determined using sagittal and coronal sections. Linear measurements were taken in the sagittal section. The vertical position of the inferior alveolar canal was measured as the distance from the lower border of the inferior alveolar canal to the lower border of the mandible.

Using 200 μm thick sections, the distance from the root apex to the upper border of the lower inferior alveolar canal and to the buccal cortex of the mandible was measured. Anatomical measurements were performed by two observers and the mean values were considered for the patient. Measurements were performed bilaterally for each patient [18]. A data collection form was used tool. It was designed by the researcher and based on CBCT images. Linear models were used to examine the results simultaneously. The IBM-SPSS v.20 software was used in this study and the significance level of the tests was considered less than 5%.

Results and Discussion

In this study, 100 radiographs were examined. Among the 100 subjects studied, 50 (50%) were male and 50 (50%) were female. The mean age of the subjects was 36.36 ± 10 years (from 18 to 60 years).

Table 1. Mean and standard deviation of the findings in the total subjects

Variable	N	Min	Max	Mean (mm)	SD
Distance from the canal to the mesial root apex of tooth 6	100	0	13.80	5.71	2.526
Distance from the canal to the distal root apex of tooth 6	100	0.36	13.67	5.28	2.551
Distance from the root apex of tooth 6 to the buccal cortex of the mandibular trunk	100	0.55	10.55	4.82	2.107
Distance from the canal to the mesial root apex of tooth 7	100	0	10.58	3.51	2.415
Distance from the canal to the distal root apex of tooth 7	100	0	9.05	3.03	2.321
Distance from the root apex of tooth 7 to the buccal cortex of the mandibular trunk	100	1.13	14.49	5.95	2.524

As shown in **Table 1**, the mean distance from the canal to the mesial root apex of tooth 6 is 5.71 mm, the distance from the canal to the distal root apex of tooth 6 is 5.28 mm, and the distance from the root apex of tooth 6 to the buccal cortex of the mandibular trunk is 4.82 mm. For tooth 7, they are 3.51, 3.03, and 5.95 mm, respectively.

Table 2. Correlation between age and the studied indicators

		Age
Distance from the canal to the mesial root apex of tooth 6	Pearson's correlation coefficient	-0.200*
	p-value	0.046
Distance from the canal to the distal root apex of tooth 6	Pearson's correlation coefficient	-0.130
	p-value	0.198
Distance from root apex of tooth 6 to the buccal cortex of mandibular trunk	Pearson's correlation coefficient	-0.055
	p-value	0.589
Distance from the canal to the mesial root apex of tooth 7	Pearson's correlation coefficient	-0.050
	p-value	0.619
Distance from the canal to the distal root apex of tooth 7	Pearson's correlation coefficient	-0.038
	p-value	0.708
Distance from root apex of tooth 7 to the buccal cortex of mandibular trunk	Pearson's correlation coefficient	-0.011
	p-value	0.915

As shown in **Table 2**, in all the subjects studied, only the distance from the canal to the mesial root apex of tooth 6 has a significant inverse relationship with age (r= -0.2 and P=0.046).

Table 3. Correlation between age and the studied indicators in males

		Age of males	Age of females
Distance from the canal to the mesial root apex of tooth 6	Pearson's correlation coefficient	-0.197	-0.200
	p-value	0.170	0.165
Distance from the canal to the distal root apex of tooth 6	Pearson's correlation coefficient	-0.182	-0/069
	p-value	0.205	0.632
Distance from root apex of tooth 6 to the buccal cortex of mandibular trunk	Pearson's correlation coefficient	-0.064	-0.032
	p-value	0.658	0.828
Distance from the canal to the mesial root apex of tooth 7	Pearson's correlation coefficient	-0.030	-0.069
	p-value	0.835	0.636
Distance from the canal to the distal root apex of tooth 7	Pearson's correlation coefficient	-0.014	-0.064
	p-value	0.923	0.659
Distance from root apex of tooth 7 to the buccal cortex of mandibular trunk	Pearson's correlation coefficient	-0.051	0.052
	p-value	0.723	0.720

As shown in **Table 3**, no significant correlation was observed between age and the studied indicators in males (P>0.05). As shown in the table, no significant correlation was observed between age and the studied indicators in females (P>0.05).

Table 4. Relationship between age and the studied indicators based on regression analysis

Ramus mandibular index	Non-standard coefficient		standard coefficient	t	Sig
	B	Std. Error	Beta		
Distance from the canal to the mesial root apex of tooth 6	41.56	3.423		12.144	0.000
Distance from the canal to the distal root apex of tooth 6	-1.683	0.891	-0.425	-1.888	0.062
Distance from the root apex of tooth 6 to the buccal cortex of the mandibular trunk	0.269	1.068	0.069	0.252	0.802
Distance from the canal to the mesial root apex of tooth 7	-0.608	0.670	-0.128	-0.907	0.367
Distance from the canal to the distal root apex of tooth 7	1.124	1.335	0.271	0.842	0.402
Distance from the root apex of tooth 7 to the buccal cortex of the mandibular trunk	-0.311	1.221	-0.072	-0.255	0.799

a. Dependent Variable: AGE

As shown in **Table 4**, all measured variables were not associated with age by eliminating the effect of confounding factors (P>0.05)

Table 5. Descriptive characteristics of the study subjects based on age

	Age	n	(mm) mean	SD	p-value
Distance from the canal to the mesial root apex of tooth 6	<40	66	6.13	2.604	0.016
	≥40	34	4.92	2.191	
Distance from the canal to the distal root apex of tooth 6	<40	66	5.59	2.809	0.1
	≥40	34	4.70	1.857	
Distance from root apex of tooth 6 to the buccal cortex of mandibular trunk	<40	66	4.99	2.084	0.269
	≥40	34	4.49	2.144	
Distance from the canal to the mesial root apex of tooth 7	<40	66	3.69	2.565	0.29
	≥40	34	3.18	2.092	
Distance from the canal to the distal root apex of tooth 7	<40	66	3.24	2.440	0.201
	≥40	34	2.64	2.052	
Distance from root apex of tooth 7 to the buccal cortex of mandibular trunk	<40	66	6.16	2.533	0.273
	≥40	34	5.57	2.501	

As shown in **Table 5**, the distance from the canal to the mesial root apex of tooth 6 was significantly higher in patients younger than 40 years of age than in patients older than 40 years of age (6.13 vs. 4.92 mm) (P=0.003).

Table 6. Descriptive characteristics of the study subjects based on age and gender grouping

Gender	Variable	Age	n	(mm) mean	SD	p-value
Male	Distance from the canal to the mesial root apex of tooth 6	<40	35	6.43	2.781	0.031
		≥40	15	5.01	1.651	
	Distance from the canal to the distal root apex of tooth 6	<40	35	5.77	2.945	0.221
		≥40	15	4.96	1.625	

	Distance from the root apex of tooth 6 to the buccal cortex of the mandibular trunk	<40	35	5.63	2.108	0.33
		≥40	15	4.98	2.123	
	Distance from the canal to the mesial root apex of tooth 7	<40	35	4.01	2.580	0.181
		≥40	15	3/14	1.818	
	Distance from the canal to the distal root apex of tooth 7	<40	35	3.49	2.319	0.144
		≥40	15	2.62	1.688	
	Distance from the root apex of tooth 7 to the buccal cortex of the mandibular trunk	<40	35	6.66	2.514	0.836
		≥40	15	6.50	2.460	
Female	Distance from the canal to the mesial root apex of tooth 6	<40	31	5.79	2.389	0.203
		≥40	19	4.84	2.582	
	Distance from the canal to the distal root apex of tooth 6	<40	31	5.39	2.682	0.192
		≥40	19	4.50	2.042	
	Distance from the root apex of tooth 6 to the buccal cortex of the mandibular trunk	<40	31	4.27	1.830	0.782
		≥40	19	4.10	2.134	
	Distance from the canal to the mesial root apex of tooth 7	<40	31	3.33	2.541	0.868
		≥40	19	3.21	2.334	
	Distance from the canal to the distal root apex of tooth 7	<40	31	2.95	2.577	0.685
		≥40	19	2.66	2.345	
	Distance from the root apex of tooth 7 to the buccal cortex of the mandibular trunk	<40	31	5.59	2.472	0.286
		≥40	19	4.84	2.339	

As shown in **Table 6**, the distance from the canal to the mesial root apex of tooth 6 in subjects younger than 40 years of age was significantly higher than that in subjects older than 40 years of age only in males (6.43 vs. 5.01 mm) (P=0.031).

The results revealed that the mean distance from the canal to the mesial root apex of tooth 6 was 5.71 mm, the distance from the canal to the distal root apex of tooth 6 was 5.28 mm, and the distance from the root apex of tooth 6 to the buccal cortex of the mandibular trunk was 4.82 mm, while these measurements for tooth 7 were 3.51, 3.03, and 5.95 mm, respectively. Regarding age and gender, the distance from the root apex of tooth 6 to the buccal cortex of the mandible trunk was significantly higher in males than in females (5.44 vs. 4.2 mm) (especially in those under 40 years of age). Additionally, the distance from the root apex of tooth 7 to the buccal cortex of the mandible trunk was significantly higher in males than in females (6.61 vs. 5.3 mm). Additionally, in all the subjects studied, only the distance from the canal to the mesial root apex of tooth 6 showed a significant and inverse relationship with age (r= -0.2 and P=0.046).

Hemalatha Hiremath *et al*. (2015) investigated the proximity of mandibular second molars and premolars to the inferior alveolar canal using CBCT images of an Indian population. After reviewing the data in this cross-sectional study, CBCT of 40 males and 40 females who met the inclusion and exclusion criteria were selected for the study. The results revealed that the mean distance of the second premolar from the inferior alveolar canal was 0.88 to 13.03 mm for males and 0.00 to 5.49 mm for females. The mean distance of the inferior alveolar canal to the mesial root of the first molar was 1.46 to 13.23 mm for males and 0.93 to 8.03 mm for females. For the second molar, the mean distance was 1.31 to 14.71 mm for males and 0.00 to 6.91 mm for females (the values on the left side were shorter than on the right side). In the entire population, only the second molar showed a significant difference in the distance from the root apex to the inferior alveolar canal in a pairwise comparison. In addition to gender differences, age-related differences were significant for the first molar on the left and the second molar on the right side of the population (P < 0.05) [23].

The results concerning the higher distances calculated in males are similar to the present study, but no significant difference was found between the distal and mesial distances in our study. Although it was higher in males, the distance from the root apexes of teeth 6 and 7 to the buccal cortex of the mandibular trunk was significantly higher in males than in females. Our study, similar to the mentioned study, revealed that the distance decreases with increasing age. However, a significant relationship was only observed with the distance from the canal to the mesial root apex of tooth 6.

Maryam Paknahad *et al*. (20150 analyzed the path and position of the mandibular canal in CBCT images. The results revealed a significant relationship between the anatomical path of the canal and the gender of the patients, so the distance increased in males. The mean vertical position of the canal was measured by the distance from the lower border of the inferior alveolar canal to the lower border of the jaw and it was obtained at 8.50 mm (at a range of 4.80 to 14.50 mm). The mandibular canal was located more lingually on average in all locations until it reached the mental foramen, so it was located closer to the buccal cortical plate in the mental foramen region (point 1) [24]. The obtained results, especially the higher distance in males than in females, are consistent with those of the present study. Some parameters that were examined in the mentioned study were not examined in the present study, so a more detailed investigation in future studies is required.

A study by Tyler Kovisto BS *et al*. (2010) examined the proximity of the mandibular canal and the teeth apex. This cross-sectional study was conducted on CBCT images of 139 patients to evaluate the proximity of the mandibular canal to the root apex of 743 mandibular second molars and first and second molars [25]. The mentioned study results on the shorter distance in females are in line with those of our study. Subjects over 18 years of age were included in the study in our study, but in the mentioned study, subjects under 18 years of age were also examined and a significant association was found with the sizes. Although our study revealed that only the distance from the canal to the mesial root apex of tooth 6 has an inverse and significant relationship with age, a more detailed study at younger ages should be conducted to achieve more accurate results.

A study by Arwa Mousa *et al*. (2020) investigated the anatomy of the inferior alveolar canal of the mandible in the Egyptian population. Six of the eight measured distances differed significantly between the genders, so it was significantly higher in males than in females. Regression analysis proposed a logistic function with a concordance index of 84%. The diagnostic capabilities of the linear measurements as predictors of gender were calculated using ROC analysis, and the 6 best predictors for gender determination were selected and ranked from highest to lowest predictive power. Additionally, the combination of these 6 predictors increased the predictive power to 84%. The position of the inferior alveolar canal in the Egyptian population differs significantly in terms of gender [26]. Although the distance between the root apex of teeth 6 and 7 to the buccal cortex of the mandibular trunk was significantly higher in males than in females in the present study, there was no statistically significant difference between them in all measured indicators. Although it was found that the measured indicators had a higher mean in males, the difference was not significant.

A study by Trustiya Tudtiam *et al*. (2019) investigated the anatomy of the inferior alveolar canal of the mandible. They showed that the mandible width, the IAC width, and the IAC height were different between male and female patients. The IMTM roots showed close contact with the IAC in 96.67% of cases. The IAC location was more lingual in both genders. The IAC diameter was much larger in males in terms of width and height compared to females. This study also revealed that the distance from the root apex of teeth 6 and 7 to the buccal cortex of the mandibular trunk was significantly higher in males than in females [27]. Although the variables studied in the mentioned study are different from those of the present study, the results on the higher distance between the root apexes of teeth 6 and 7 and the buccal cortex of the mandibular trunk in males compared to females are similar to results of the present study.

Conclusion

Based on the results, the inferior alveolar canal of the mandible may be an appropriate criterion for determining the age and gender of individuals and can be used to identify age and gender in forensic medicine and other cases. However, further and more detailed studies in this field are required to achieve the diagnostic accuracy of various parameters. Some limitations of the study were the lack of supplementary information and the low quality of the images. In these cases, the images were excluded. It is recommended to investigate other effective factors, including its relationship with the third molar tooth and comparison based on age and gender, and conduct a larger study with a higher sample size to compare with higher accuracy by matching the two groups of males and females.

Acknowledgments: None

Conflict of interest: None

Financial support:. None

Ethics statement: None

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