RESEARCH ARTICLE

Evaluation of bone morphology in posterior mandible: A cone-beam computed tomography based study

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Abstract

Objective: To evaluate the position of the root apices of posterior teeth of mandible with inferior alveolar nerve canal and the cortical bone on cone beam computed tomography.

Method: The retrospective study was conducted from September to October 2021 at the Aga Khan University Hospital, and comprised cone beam computed tomography scans between November 2017 and October 2021 scans of healthy individuals of either gender aged 18-71 years with healthy, untreated, mandibular posterior teeth bilaterally. Shortest distance from apices of the mandibular posterior teeth to the border of inferior alveolar nerve canal, and to the mandibular buccal cortex were measured on the scans. Data was analysed using SPSS 23.

Result: Of the 106 scans, 55(52%) were males and 51(48%) were females. Of the 746 33teeth in the scans, 385(51.6%) were present in the scans of males and 361(48.4%) in those of the females. For all mandibular posterior teeth, the distances in females were shorter than males, but for the distance from root apices to the IAN canal, the difference between genders was significant for the roots of second premolar and second molar only on the left side ($p \leq 0.05$). Regarding the distance from the root apices to the buccal cortex, no significant difference was found between the genders, for each type of tooth, ($p > 0.05$). Correlations between the distance from apex to inferior alveolar nerve ($r < 0.30$) and between age and apex to buccal cortex distance ($r < 0.28$) were weak.

Conclusions: Procedures planned apical to second premolar and second molar teeth can potentially damage the inferior alveolar nerve.

Keywords: Inferior alveolar canal, Cone bone computed tomography, Root apices. (JPMA 73: 771; 2023)

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Introduction

The mandible is supplied by the trigeminal nerve's third division, known as the inferior alveolar nerve (IAN),[1] which enters the mandible and travels within the mandibular canal.[2] It lies in close vicinity to the roots of the mandibular teeth; premolars as well as molars.[3,4] Due to proximity to the roots, endodontic non-surgical treatment and surgical interventions in the lower jaw may cause iatrogenic injury to the nerve in procedures such as sagittal split osteotomy, placement of dental implant, and third molar extraction.[4-8] Buccal cortical thickness is also important during apical surgery.[9] A pre-surgical assessment is mandatory before invasive dental procedures.[4,10]

In endodontics, orthograde treatment may cause extrusion of the root-filling material beyond root's apical constriction, causing nerve impingement.[11] During apicoectomy procedure, gaining surgical access in the periapical area, root end preparation and retrograde sealing of the canal becomes challenging if the apex of the root is situated close to the IAN.[12] An injury to a nerve results in pain, paresthesia or anaesthesia.[10] A study has reported that 20-21% of the patients having apical surgery of the mandibular molars develop sensory disturbance.[13] Among 1% subjects, the loss of sensation becomes permanent.[13] The assessment of thickness of the buccal cortex is also important to plan for osteotomy site during molar apicoectomy.[14] The thicker the cortical plate of bone are, greater is the difficulty in performing apical surgery and poorer is the outcome.[15]

There are several methods to study anatomic variations in mandibular bone. One approach used to be studying of the sectioned human cadaver or dry mandibles.[16,17] Imaging techniques, such as panoramic and periapical radiographs, also provide information about the mandibular anatomy.[18] These could further be supplemented with occlusal and bitewing radiographs.[18] However, there are limitations of these two-dimensional (2D) radiographs in perceiving the relationship of the anatomic structures.[16] The newer, more accurate, imaging modality with 3D image recording is the cone-beam computed tomography (CBCT). If the patient's head is oriented correctly, CBCT provides precise linear measurements that are comparable to the actual physical measurements.[18]

The differences in the anatomy of the mandible varies,

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depending on gender,[10,19] age and race of the subject.[18] Anatomic differences exist on left and right sides of mandible as well.[16] Kawashima et al.[16] reported differences in distance from root apex to the IAN canal based on gender and side.[16] An Indian study also reported gender differences, the shortest mean distance from root apex to the IAN canal was for second premolar (0.88-13.03mm for males and 0.00-5.49mm for females). Distance between root apex of mesial root of first molar and IAN in males was 1.46-13.23mm, and in females, it was 0.93-8.03mm. In case of second molar, the average distance was 1.31-14.71mm in males and 0.00-6.91mm in females.[20] Kovisito et al. reported the distance from root apex to IAN canal, and also that thickness of buccal bone over second molar mesial root was more than at the root of second premolar (5.4mm and 2.6mm, respectively).[3]

To our knowledge, no CBCT study has explored the location of IAN with respect to the mandibular molar root apices and the buccal plate in Pakistani population. The current study was planned to measure the distance of the posterior teeth root apices of the mandible (first mandibular premolar, second mandibular premolar, first mandibular molar and second mandibular molar) from the IAN canal, and the buccal cortical plate thickness over the roots of mandibular posterior teeth.

Materials and Methods

The retrospective study was conducted from September to October 2021 at the Aga Khan University Hospital (AKUH), Karachi, and comprised CBCT scans done between November 2017 and October 2021 of healthy individuals of either gender aged 18-71 years with healthy, untreated, mandibular posterior teeth bilaterally.

After exemption from the institutional ethics review committee, the sample size was calculated using the World Health Organisation (WHO) calculator[21] while keeping absolute precision 0.40 and level of confidence 95% in line with literature.[22] Scans related to mandibular posterior teeth treated endodontically or orthodontically, periodontal disease, broken down roots, scans with craniofacial anomaly and absence of mandibular posterior teeth, bilaterally were excluded. Data of the patients were obtained by reviewing the files. All CBCT scans had been carried out using the Orthophos XG 3D Ready/Ceph (Sirona) operating at 60 kV-90kV/ 3mA-6mA, image volume 8x8cm, voxel size 0.2mm and 0.1mm, scanning time 14s and exposure time 2-5s. The scans remain saved in the Sidexis software. The CBCT images were viewed on a monitor (Hewlett-Packard [HP] EliteDisplay E271i 27-inch in-plane switching [IPS] light-emitting diode [LED] Backlit monitor; 1920x1080 @ 60Hz resolution, Contrast Static: 1000:1; Dynamic: 5,000,000:1). The measurements were made by the primary investigator.

Each CBCT scan was examined in tangential, axial, and cross-sectional views of the image planes. The measurements were taken in tangential and cross-sectional views. Initially, the superior border of IAN canal was traced, in the tangential view, on the software, which was then also visible in the cross-sectional view. The cross-sectional view was scrolled until the full apico-coronal length (longitudinal section) of the tooth could be seen. The apex of the roots of each mandibular posterior tooth (except the third molar) on both sides was then identified. Shortest linear distance from root's apex (of both premolars and first and second molar) to the superior border of the IAN canal was then measured and recorded in millimetres (Figure 1). The measurements were made with the straight-line scale provided in the software.

Buccal cortical thickness was then measured. Measurements were taken, from the outer surface of the tooth's root to the outer surface of buccal cortex at two levels; one at the root apex (a) and other at 3mm coronal to the apex (the root section site), (b) (Figure 2). This was done for each root of the mandibular premolar and molars (except the third molars), on both sides, after aligning the coronal and sagittal planes with the long axis of each root. All the length measurements were recorded in a tabulated form.

Data was analysed using SPSS 23.0 Mean values and standard deviations (SDs) were calculated for continuous variables. Independent sample t-test was applied to determine the difference in distance of the root apices to IAN canal, and the distance from the root apices to the buccal cortex between the two genders. Paired sample t-

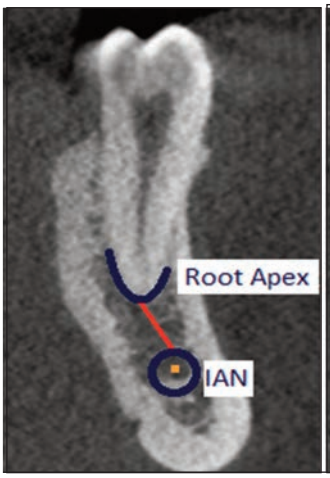

Figure-1: Perpendicular distance between root apex and the inferior alveolar nerve (IAN).

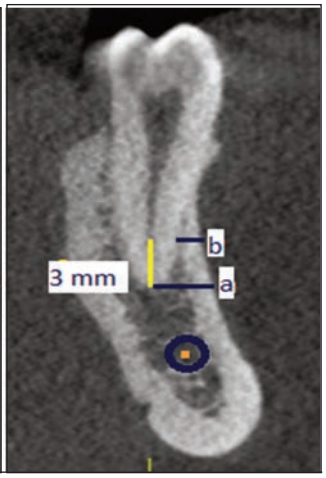

Figure-2: Perpendicular distance between root and the buccal cortex at 0mm and 3mm from the apex.

test was applied to determine the existence of bilateral spatial symmetry in each mandible. Pearson's correlation was applied to see if there was a correlation present between age and distance of root apices to the inferior alveolar nerve canal or the buccal cortex. P<0.05 was taken as statistically significant.

Results

Of the 106 scans, 55(52%) were males and 51(48%) were females. Of the 746 33teeth in the scans, 385(51.6%) were present in the scans of males and 361(48.4%) in those of the females.

The shortest mean distance from the root apex to the IAN canal was recorded for the second premolar, while the greatest distance was for the root of first premolar (Table 1).

The shortest mean distance from apex to the buccal bone cortex in males was of first premolar on both sides, but in females, the right premolar apex was the closest, and the second premolar was the closest on the left (Table 2).

For all mandibular posterior teeth, the distances in females were shorter than males, but for the distance from root apices to the IAN canal, the difference between genders was significant for the roots of second premolar and second molar only on the left side ($p \leq 0.05$). Regarding the distance from the root apices to the buccal cortex, no significant difference was found between the genders, for each type of tooth, ($p > 0.05$).

A weak correlation existed between age and the proximity of root apices to the IAN ($r < 0.30$); and between age and apex to buccal cortex thickness ($r < 0.28$).

Discussion

The pre-operative measurement of the distance from the root apices to the IAN canal and buccal cortex is important when performing surgical and non-surgical endodontic procedures in the posterior mandible. The current study measured these distances in a sample of Pakistani population. Differences have been reported to exist in the anatomy based on gender, age and race.[10,16,19]

The study found that the root apex of the second premolar was the closest to the superior border of the IAN canal. A study in 2016, in Americans measured only the distance of second molar roots to the IAN canal[16] and found that the distal root was closer. A study in Germany measured the distances of second premolar and all mandibular molars using CBCT, and the shortest distance was recorded for the third molars.[23] A study found that the mesial root of the second molar was closest to the IAN nerve.[22] A similar study reported that the roots of the third molar were closest to the nerve.[1] One study reported the distal root of the mandibular second molar to be the closest to the IAN canal.[9] Oliveira et al. found that the distal roots of the second molars was the closest to the nerve.[24]

Table-1: Descriptive statistics, and distance from the root apex to the inferior alveolar nerve (IAN) canal.*

Tooth Type	Males		Females		*p*-value	*r*-value
	n	Mean±SD	n	Mean±SD		
Left 1st Premolar	53	6.95±2.77	51	6.14±2.47	0.11	0.28
Left 2nd Premolar	53	5.22±2.30	48	3.84±2.46	0.005*	0.20
Left 1st Molar (mesial root)	45	6.36±2.28	40	5.55±2.60	0.12	0.17
Left 1st Molar (distal root)	45	6.35±2.45	40	5.12±2.63	0.028*	0.23
Left 2nd Molar (mesial root)	43	6.28±3.17	45	4.47±2.94	0.007	0.18
Left 2nd Molar (distal root)	43	5.96±2.82	45	4.22±2.81	0.005*	0.23
Right 1st Premolar	52	7.12±3.04	48	6.18±2.70	0.10	0.30
Right 2nd Premolar	52	4.69±2.24	47	3.88±2.13	0.07	0.30
Right 1st Molar (mesial root)	44	6.43±2.83	35	5.61±2.66	0.19	0.24
Right 1st Molar (distal root)	44	6.64±3.38	35	5.91±2.85	0.31	0.12
Right 2nd Molar (mesial root)	43	6.02±3.50	47	5.00±2.77	0.12	0.14
Right 2nd Molar (distal root)	43	5.39±3.10	47	4.59±2.44	0.18	0.19

p= Independent t-test results, *($p \leq 0.05$); *r*=Pearson's correlation coefficient values; SD: Standard deviation.

Table-2: Distance from tooth root to buccal cortex.

Tooth Type	n	Root Apex to cortex (a)				3mm from apex to cortex (b)			
		Males	Females	*p*-value	*r*-value	Males	Females	*p*-value	*r*-value
Left 1st Premolar	44	4.11±0.92	4.08±1.31	0.91	-0.16	1.79±0.69	1.67±0.87	0.62	-0.22
Left 2nd Premolar	43	4.52±1.30	3.84±1.33	0.06	0.09	2.41±0.94	1.90±0.91	0.08	0.006
Left 1st Molar (mesial root)	34	4.36±0.95	4.81±1.11	0.20	-0.22	2.04±0.70	2.25±1.04	0.48	-0.10
Left 1st Molar (distal root)	34	5.43±1.45	5.80±1.55	0.47	0.08	2.79±1.26	3.17±1.24	0.38	-0.17
Left 2nd Molar (mesial root)	38	8.09±1.44	8.15±1.92	0.90	0.14	5.14±1.65	5.48±1.94	0.56	-0.03
Left 2nd Molar (distal root)	38	8.58±2.04	8.29±1.83	0.65	0.28	6.36±1.76	6.39±1.86	0.90	0.04
Right 1st Premolar	40	3.81±1.03	4.01±1.48	0.62	-0.11	1.56±0.96	1.58±0.96	0.96	-0.24
Right 2nd Premolar	40	4.25±1.03	4.40±1.63	0.72	-0.05	2.39±0.97	2.35±1.33	0.90	-0.13
Right 1st Molar (mesial root)	31	4.06±1.07	4.74±2.00	0.23	-0.10	2.06±1.71	3.08±2.08	0.09	-0.26
Right 1st Molar (distal root)	31	5.40±1.86	6.11±1.78	0.29	-0.03	3.11±1.20	3.42±1.88	0.57	-0.23
Right 2nd Molar (mesial root)	35	7.59±2.60	8.19±1.69	0.44	0.05	5.15±2.14	5.46±1.69	0.65	-0.09
Right 2nd Molar (distal root)	35	7.85±2.33	8.61±1.66	0.29	0.15	5.91±2.35	6.24±1.73	0.64	-0.10

p= Independent t-test results, *($p \leq 0.05$); *r*=Pearson's correlation applied between age and the apex to IAN distance or apex to buccal cortex distance in the two genders.

On the basis of these studies,[1,9,16,22-24] it can be inferred that due to anatomical variations based on ethnicities, each study found a different tooth being closer to the IAN canal, even though roots of the second molar were commonly the closest.

In the current study, when comparing the differences in distances of each root apex to the nerve canal, the distances were smaller in females compared to the males. However, the difference was significant for the roots of second premolar and second molar only on the left side ($p \leq 0.05$). Other studies also reported that in females the distances were shorter than in males.[1,16,22-24] Large body size of men contributed to this difference in the measured distances between the genders.[24]

The thickness of the buccal cortex is an important parameter to take into consideration when doing pre-surgical planning for apical surgery. The current study found the buccal cortex to be the thinnest at the root surface of the second premolar, and the thickest at the root surface of the second molar in both the genders. In a similar study on the Iranian population,[9] the distance from the root resection site (a point 3mm from the root apex to the buccal cortex) the thinnest buccal cortex was at the root surface of first premolar on both sides, and the thickest was at the distal root surface of the second molar. In the Asian population,[14] a study measured the distances from the outer surface of the buccal cortex to the dental canal at the level of root apex as well as between all anterior and posterior teeth in both the maxillary and mandibular arches.[14] Among the mandibular posterior teeth, it reported that the thinnest buccal cortex was measured at the root of the first premolar, and the thickest at the distal root of second molar.[14] The current findings agree with both these studies.

When studying the variation in proximity of mandibular posterior teeth to the nerve and buccal cortex with age, the current study found that the distance in the age group of <41 years was lesser than those >41 years, but the difference was not statistically significant. Oliveira et al. found that age did not significantly influence the proximity between the root apex and the mandibular canal ($p > 0.05$), but the patients aged 36-45 years had root apices closer to the mandibular canal.[24] Burklein et al. found that in subjects aged <25 years, the distances of root apices to the nerve canal were significantly shorter compared to other age groups.[23] Studies have also reported that the distance from root apices to the mandibular canal increases with age.[9,16,23] The increase in the distance could be attributed to the continued eruption of mandibular teeth.[25] This suggests that the growth of facial skeleton may also occur in late phases of adolescence in both genders. Such growth may take place in ages 36-45 years.[23] Kawashima et al. suggests that the increase in this distance is due to increased bone deposition after tooth eruption or inferior migration of the IAN.[16]

The single-centre orientation is a limitation of the current study. A multi-centre study should be conducted to overcome the limitation.

Conclusions

There existed a high chance of injury to the nerve when performing dental procedures apical to second premolar. Females were most prone to such injuries. The patients aged <41 years were found to be more at risk of iatrogenic nerve injuries compared to the older individuals.

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