Original Article

Inferior alveolar nerve canal position in relation to mandibular molars: A cone-beam computed tomography study

ABSTRACT

Objective: This study was carried out to prevent the risk of iatrogenic injuries to the inferior alveolar nerve (IAN) canal associated with various surgical interventions in the area of mandibular molars, by using cone-beam computed tomography (CBCT).

Materials and Methods: The present retrospective study was carried out by using CBCT of 100 patients between 18 and 40 years of age group. The linear measurements were made in relation to the 1st and 2nd mandibular molars on both the sides. Linear distances between buccal and lingual aspects to the mandibular, buccal, and lingual cortical bone thickness; IAN canal diameter; and the superior corticated border of the IAN canal from the periapex of the 1st and 2nd mandibular molars. The statistical evaluation was done using SPSS V.20 (SPSS: an IBM company), and $P < 0.05$ was considered statistically significant.

Results: Both genders of all age groups showed statistically significant result ($P < 0.00$). All the linear measurements were statistically significant in relation to both the 1st and 2nd mandibular molars ($P < 0.005$), and also the bilateral comparison of the linear measurements showed statistically significant difference in relation to the mandibular 2nd molar ($P < 0.03$) and 1st molar ($P < 0.04$) among both the sexes.

Conclusion: Clinicians should be aware of the proximity of root apices and cortical plates to the mandibular canal when performing surgical and root canal procedures in the posterior mandible to avoid serious nerve injuries.

Keywords: Buccal cortical plates, cone-beam computed tomography, inferior alveolar nerve, lingual cortical plates, mandibular canal, neurosensory disturbance

INTRODUCTION

Inferior alveolar nerve (IAN), the largest branch of the posterior division of trigeminal nerve, provides sensory supply to the lower teeth, lower lip, and chin. IAN dips down the mandibular foramen and exits through the mental foramen. Throughout its course, it is inside the mandibular canal (MC). Being closely related to the lingual plate near the mandibular foramen, the nerve turns from the lingual to the buccal plate toward the mental foramen inside the MC.[1] The morphology of well-corticated MC varies according to the dental status, ethnicity, and age.[2]

This main nerve of the mandible is vulnerable to iatrogenic injuries during the surgical procedures involving the third molar and mandibular deformity corrections such as bilateral sagittal split osteotomy (BSSO), implant procedures, monocortical screw fixation for mandibular fractures, surgery of the pathology, and endodontic procedures of the lower molars.[1] Because damage to IAN neurovascular bundle is a

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serious complication resulting in the numbness of lower lip and chin, it is associated with an overall risk of 0.4%–6% in case of third molar removal,[3] 9%–85% of operated sides in case of SSO,[4] and 17% in implant placements.[5] The injury might be due to compression, stretching of the nerve, laceration of the nerve trunk, during the osteotomies of the mandible, and during the fixation of osteotomized segments involving the mandibular posterior region.[4]

There are many radiographic techniques available to estimate the canal position and its relation to the surrounding structures which include digital periapical radiography, panoramic radiography, spiral computed tomography, and cone-beam computed tomography (CBCT) scanning.[6]

CBCT has several advantages over other X-ray methods such as low radiation dose, high resolution, low cost, better image quality of teeth and their surrounding structures,[3] fewer artifacts, high accuracy, and reproducibility.[7]

As the MC is an important landmark, this study was aimed to measure the linear distance from canal to the buccal and lingual cortex (inner and outer) and to the periapex of the 1st and 2nd lower molar teeth as well as to compare the difference in parameters in the apical region of the 1st and 2nd molars on both sides of the jaw.

MATERIALS AND METHODS

The present retrospective study was conducted in the Department of Oral Medicine and Radiology, Kalinga Institute of Dental Sciences, KIIT University, Bhubaneswar, Odisha, after obtaining the clearance from the Ethical Committee of KIIT University (KIMS/KIIT/IEC/026/2014). The archives of the CBCT images were taken from August 2014 to August 2016.

All the measurements were taken from the existing CBCT (MyRay Hyperion X9, field of view: 11 cm × 8 cm, operated at 85 kV and 12 mA) scans, which had been taken for diagnostic purposes such as implant placement, extraction of the third molar, or orthodontic treatment planning. A total of 100 CBCT images were obtained, having complete mandibular images in the age range of 18–40 years. Any images showing pathology or congenital deformities of the mandible with missing or malpositioned mandibular 1st or 2nd molars were excluded from the study.

After locating the Inferior Alveolar Canal, linear measurements were calibrated using the NNT viewer QR srl-Via Silvestrini Verona, 20-37135 Italy. The slice thickness of 0.3 mm was used, and images were evaluated in the coronal view.

All measurements were measured by an experienced radiologist and a surgeon, as per the pilot study done by Balaji *et al*.[8] The linear measurement parameters are shown in Table 1 and Figures 1-3.

Statistical analysis

The statistical evaluation was done using Statistical Package for the Social Sciences (SPSS) (SPSS: an IBM Company) V.20 IBM, Armonk, NY, United States of America. The measurements in relation to the mandibular 2nd and 1st molar were analyzed by Mann–Whitney U-test.

$P < 0.05$ was considered statistically significant, $P < 0.001$ as highly significant, while $P > 0.05$ was considered statistically insignificant.

RESULTS

In the study samples of 100 images, 42 were of males and 58 were of females. Age-wise distributions of the samples were done in the four groups [Table 2], namely Group I (18–24 years), Group II (25–30 years), Group III (30–35 years), and Group IV (36–42 years). The mean age of the study population was 30.94 years. Mean and standard deviation of males were 27.68 and 3.28 and that of females were 32.69 and 5.88, respectively, which were statistically highly significant [Table 3].

Gender-wise comparison of MC position in relation to the roots of the 1st and 2nd mandibular molars showed the statistically significant result in the point A of the 1st molar and the point F of the 2nd molar of both sexes [Table 4].

Table 1: Linear measurement parameters

Points	Linear measurements
Point A	Shortest distance between the lingual inner and outer cortex
Point B	Inner cortex to outer surface of the IAN canal along the lingual side
Point C	Inner cortex to outer surface of the IAN canal along the buccal side
Point D	Shortest distance between buccal inner to outer cortex
Point E	Inner cortical width of the IAN canal
Point F	Outer cortex to outer cortex width along the center of the IAN canal
Point G	Shortest distance between the periapex to the superior surface of IAN canal

IAN: Inferior alveolar canal

Table 2: Age and sex cross tabulation

Sex	Age group				Total
	18-24	25-30	30-35	36-40	
Male	3	26	6	7	42
Female	7	8	19	24	58
Total	10	34	25	31	100

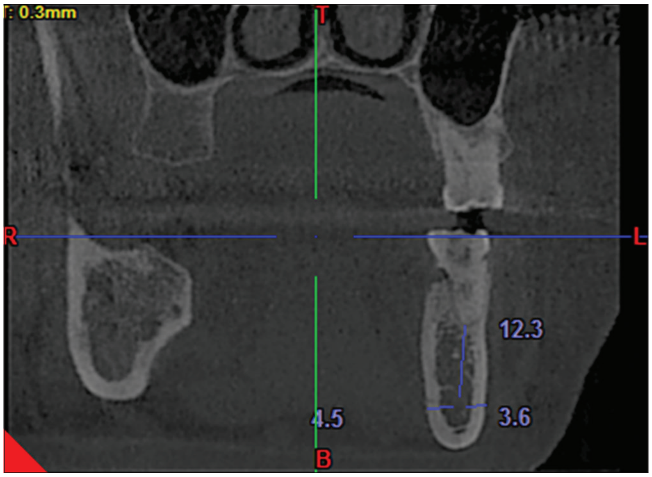

Figure 1: The measurements points B, C, and G in relation to the mandibular molar

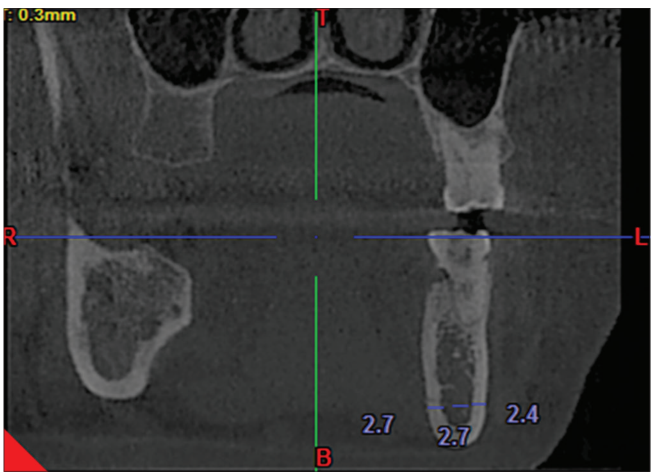

Figure 2: The measurements points A, D, and E in relation to the mandibular molar

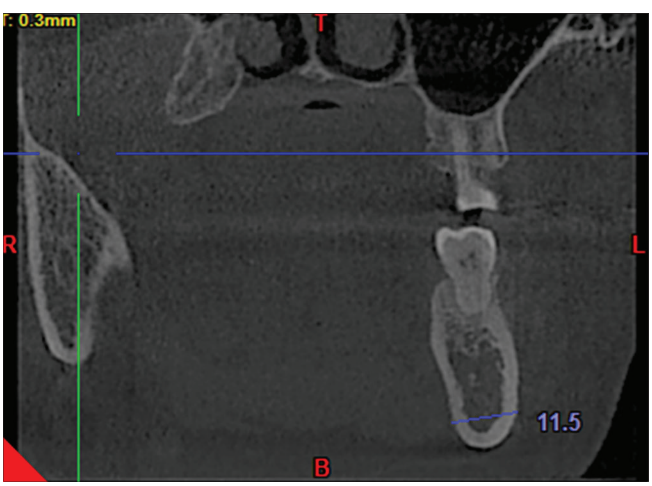

Figure 3: The measurement point F in relation to the mandibular molar

Bilateral comparison of all the linear measurements in relation to the 1st and 2nd mandibular molars showed statistically significant result in the point E of the 2nd molar [Table 5].

Table 3: Mean and standard deviation of age and sex cross tabulation

	Mean	SD	*T*	*P*
Age overall	30.94	5.64	4.65	0.00
Male	27.68	3.28		
Female	32.69	5.88		

SD: Standard deviation

Among all the linear measurements in the study population for the 1st and 2nd mandibular molars, results were statistically highly significant with $P < 0.005$, whereas measurements of point F were insignificant [Table 6].

DISCUSSION

The anatomic relationships between the MC, cortical plates, and apices of mandibular molars should be known, in order to prevent injury to the IAN because it might result in short- or long-term altered sensation of the lower lip and chin. With the emergence of three-dimensional imaging, CBCT is being increasingly used for the diagnosis and treatment planning of both surgical and nonsurgical cases.[9]

In CBCT, the MC appears as a well-defined radiolucent zone, surrounded by a radiopaque line. However, the radiographic densities of the lucent and radiopaque borders are variable, depending on the canal's cortification. Hence, the cases are reported with the radiologically invisible IAN canals.[8]

Studies by Yu *et al*.[10] and Koivisto *et al*.[11] showed no statistically significant change in the location of MC in patients in the age group of 18–40 years, which was in contradiction to our study, where we obtained a statistically significant result ($P < 0.00$) in the above age group of both genders. Similarly, significant statistical result of ($P < 0.04$) increase in the distance between the MC and buccal cortical bone (point C) was seen in the study done by Levine *et al*.[12] They concluded that, as the age increases, the distance between MC and buccal cortical bone decreases. The study by Kawashima *et al*.[13] showed statistically significant decrease in point G (distance from the apex of distal root of the mandibular second molar to MC) in both the genders ($P < 0.05$ in males and $P < 0.01$ in females) in the age group of <21 years.

Our study can be compared to the studies done by Yu *et al*.,[10] Koivisto *et al*.,[11] and Ozturk *et al*.[14] in relation to the MC location to the cortical plates and thickness of cortical plates and to the root apices of posterior teeth in both the genders, showing no statistically significant value. Whereas studies done by Promma *et al*.,[2] Yoshioka *et al*.,[15] and Huang *et al*.[16] showed thicker buccal cortices (point D)

Table 4: Gender-wise comparison of linear measurements in the study population

	Sex	*n*	Mean	SD	SEM	*t*	Significance (two tailed)	95% CI of the difference		Mann-Whitney U	Asymptotic significance (two tailed)
								Lower	Upper		
First molar A	Male	35	1.93	0.19	0.03	2.08	0.04	0.00	0.16	867.5	0.043578
	Female	65	1.85	0.18	0.02						
First molar B	Male	35	2.30	0.22	0.04	0.40	0.69	−0.08	0.12	1096.5	0.76297
	Female	65	2.28	0.25	0.03						
First molar C	Male	35	3.33	0.22	0.04	−1.13	0.26	−0.17	0.05	1042	0.480727
	Female	65	3.40	0.27	0.03						
First molar D	Male	35	2.90	0.42	0.07	−1.21	0.23	−0.26	0.06	988	0.274631
	Female	65	3.00	0.37	0.05						
First molar E	Male	35	2.33	0.22	0.04	0.01	0.99	−0.09	0.09	1120	0.897212
	Female	65	2.33	0.22	0.03						
First molar F	Male	35	11.51	0.32	0.05	−0.23	0.82	−0.13	0.10	1130.5	0.959237
	Female	65	11.53	0.26	0.03						
First molar G	Male	35	6.36	0.25	0.04	−1.59	0.11	−0.19	0.02	915	0.104191
	Female	65	6.44	0.25	0.03						
A second molar	Male	35	1.74	0.23	0.04	−1.15	0.25	−0.17	0.05	1037	0.460609
	Female	65	1.80	0.28	0.03						
B second molar	Male	35	2.05	0.28	0.05	−0.18	0.86	−0.14	0.11	1136	0.991238
	Female	65	2.06	0.31	0.04						
C second molar	Male	35	3.13	0.36	0.06	−0.44	0.66	−0.16	0.10	1042	0.487651
	Female	65	3.16	0.28	0.03						
D second molar	Male	35	3.20	0.34	0.06	0.94	0.35	−0.07	0.20	1014	0.357749
	Female	65	3.13	0.31	0.04						
E second molar	Male	35	3.33	0.28	0.05	−0.88	0.38	−0.19	0.07	1047	0.507102
	Female	65	3.39	0.33	0.04						
F second molar	Male	35	11.42	0.34	0.06	−2.92	0.00	−0.30	−0.06	758.5	0.005526
	Female	65	11.60	0.26	0.03						
G second molar	Male	35	5.39	0.46	0.08	1.21	0.23	−0.07	0.31	943	0.155427
	Female	65	5.27	0.45	0.06						

CI: Confidence interval, SD: Standard deviation, SEM: Standard error of mean

in males than in females, except the study done by Balaji *et al.*,[8] wherein the point D was more in females than males, but the thickness of mandible (point F) was more in males. This difference may be due to the smaller sample size in the study by Balaji *et al.*[8] Neurosensory disturbance in females is more because of their smaller and fragile bone than those of men.[15] Shorter distance from the root apices of the 1st and 2nd molars to MC (point G) in females was seen with statistically significant *P* value ($P < 0.005$ and $P < 0.001$, respectively); similar results were obtained by the study done by Kovisto *et al.*,[5] Kawashima *et al.*,[13] and Burklein *et al.*[17]

Bilateral comparison of linear measurements was not statistically significant in our study, which was in consistent with the study done by Yu *et al.*,[10] whereas remarkable difference was noticed in the study done by Balaji *et al.*,[8] with the right half values higher than the left halves ($P = 0.001$ [point A], 0.035 [point B], and 0.001 [point D]) with respect to point C, shorter on the right side than the left side with the significant $P = 0.001$ in the study by Kawashima *et al.*[13]

The lingual cortical plate thickness (point A) in our study can be compared to that of the study done by Balaji *et al.*[8] with a highly significant $P = 0.001$, indicating the thicker lingual cortical plate at the 1st molar than at the 2nd molar due to the oblique course of mylohyoid line and the consistent remodeling of muscle attachments in this region.[8] However, Burklein *et al.*[17] and Koivisto *et al.*[11] in their study showed thinner lingual bone over the distal roots of the first molar.

According to Nair *et al.*,[18] the distance from the inner plate of cortex to MC along lingual side (point B) was less in the region of molars, which was similar to our study.

The distance from the inner cortex to outer MC along buccal side (point C) in the 1st and 2nd molars was statistically significant in our study, which is comparable to the studies done by Yu *et al.*[10] and Koivisto *et al.*[11] Other studies done

Table 5: Bilateral comparison of linear measurements in the study population

	n	Mean	SD	SEM	t	Significance (two tailed)	95% CI of the difference		Mann-Whitney U-test	Asymptotic significance (two tailed)
							Lower	Upper		
First molar A										
Right	57.00	1.88	0.20	0.03	0.09	0.93	−0.07	0.08	1195	0.826155
Left	43.00	1.87	0.17	0.03						
First molar B										
Right	57.00	2.27	0.20	0.03	−0.81	0.42	−0.14	0.06	1176.5	0.728406
Left	43.00	2.31	0.28	0.04						
First molar C										
Right	57.00	3.38	0.28	0.04	0.14	0.89	−0.10	0.11	1184	0.767831
Left	43.00	3.37	0.23	0.04						
First molar D										
Right	57.00	2.99	0.40	0.05	0.96	0.34	−0.08	0.23	1063	0.252612
Left	43.00	2.92	0.39	0.06						
First molar E										
Right	57.00	2.33	0.22	0.03	−0.24	0.81	−0.10	0.08	1191	0.806176
Left	43.00	2.34	0.23	0.03						
First molar F										
Right	57.00	11.52	0.28	0.04	−0.30	0.77	−0.13	0.09	1223.5	0.988775
Left	43.00	11.53	0.27	0.04						
First molar G										
Right	57.00	6.43	0.23	0.03	0.56	0.58	−0.07	0.13	1088	0.333341
Left	43.00	6.40	0.28	0.04						
A second molar										
Right	57.00	1.82	0.27	0.04	2.08	0.04	0.01	0.21	965	0.065391
Left	43.00	1.72	0.24	0.04						
B second molar										
Right	57.00	2.08	0.34	0.05	1.01	0.31	−0.06	0.18	1179	0.742931
Left	43.00	2.02	0.24	0.04						
C second molar										
Right	57.00	3.19	0.30	0.04	1.34	0.18	−0.04	0.21	1031.5	0.1721
Left	43.00	3.10	0.31	0.05						
D second molar										
Right	57.00	3.14	0.30	0.04	−0.43	0.67	−0.16	0.10	1212.5	0.925692
Left	43.00	3.17	0.35	0.05						
E second molar										
Right	57.00	3.43	0.31	0.04	2.27	0.03	0.02	0.26	926.5	0.03473
Left	43.00	3.29	0.30	0.05						
F second molar										
Right	57.00	11.57	0.31	0.04	1.01	0.32	−0.06	0.18	1028.5	0.164686
Left	43.00	11.50	0.30	0.05						
G second molar										
Right	57.00	5.34	0.48	0.06	0.69	0.50	−0.12	0.25	1062	0.249928
Left	43.00	5.28	0.44	0.07						

CI: Confidence interval, SD: Standard deviation, SEM: Standard error of mean

by Nagadia *et al*.,[1] Promma *et al*.,[2] Huang *et al*.,[7] Al-Jandan *et al*.,[19] and Massey *et al*.[20] also revealed the thickest buccal cortical bone surrounding the MC, indicating that the osteotomy depth should be similar to the width of fissure bur for less chances of IAN damage. Our study was in contradiction to the study done by Yamauchi *et al*.,[21] Sato *et al*.,[22] and Huang *et al*.,[16] who showed the lesser distance from MC to buccal cortex. Additionally, Yamauchi *et al*.[21] suggested that neurosensory disturbance is more in patients with shorter point C and long mandibular angle. Point C was shorter in patients of prognathism than retrognathism.[21]

The buccal cortical plate thickness (point D) was more in the present study similar to that of Balaji *et al*.[8] ($P < 0.000$). This might be due to the masseter attachment in the posterior region of the 2nd molar.

Table 6: Comparison of linear measurements of the first and second molars

	First molar							Second molar						Mann-Whitney U
	n	Mean	SD	95% CI for mean		Minimum	Maximum	Mean	SD	95% CI for mean		Minimum	Maximum	
				Lower	Upper					Lower	Upper			
A	100	1.87	0.19	1.83	1.91	1.60	2.30	1.78	0.26	1.73	1.83	1.40	2.30	0.00
B	100	2.29	0.24	2.23	2.33	1.90	2.80	2.06	0.30	1.99	2.11	1.70	2.80	0.00
C	100	3.37	0.26	3.32	3.42	3.10	3.80	3.15	0.31	3.08	3.21	2.70	3.70	0.00
D	100	2.96	0.39	2.88	3.04	2.30	3.60	3.16	0.32	3.09	3.21	2.80	3.90	0.00
E	100	2.33	0.22	2.28	2.37	2.10	2.80	3.37	0.31	3.30	3.42	2.90	3.90	0.00
F	100	11.52	0.28	11.46	11.57	10.90	11.90	11.54	0.31	11.47	11.60	10.90	11.90	0.19
G	100	6.41	0.25	6.36	6.46	6.10	6.90	5.31	0.46	5.22	5.40	4.20	5.90	0.00

CI: Confidence interval, SD: Standard deviation

The linear measurement of point E, that is the inner cortical width of MC in our study at the 1st and 2nd molars, was 2.33 and 3.37, respectively, which was consistent with the studies by Balaji *et al*.[8] and Tsuji *et al*.[23]

The linear measurement of point F (distance from the outer cortex of lingual side to the outer cortex of buccal side along the MC) was not statistically significant, which is similar to the study done by Balaji *et al*.,[8] but the thickness of mandible increased toward the mandibular body as compared to the mandibular foramen.[23]

The distance between the root apices of mandibular teeth and MC (point G) was shorter in relation to the 2nd molar and has been reported in the study done by Kovisto *et al*.,[5] Balaji *et al*.,[8] Sato *et al*.,[22] and Nair *et al*.,[18] which was similar to our study, whereas Wang *et al*.[9] showed shorter distance from the 1st molar root apices. This distance changes through bone remodeling and increases with the age.

The variations in our study as compared to that of others could be because of type of radiographic method used, thickness of slices, image quality, and measurement tools used.

Limitations

Only few of the images used in the study have undergone various surgical procedures. Surgical skills, extent of surgical corrections in BSSO, patients' sensitivity, and other anatomical factors which cause neurosensory disturbance were not taken into consideration. Hence, we could assess the risk of damage only theoretically and followed neurosensory disturbance.

Strength

This is one of the rare studies and had not been reported earlier among Bhubaneswar population.

CONCLUSION

Despite the smaller sample size (100 images), all the linear measurements in relation to point A, point B, point C, point D, point E, and point G showed statistically significant values, indicating higher chances for damage to IAN in relation to mandibular 1st and 2nd molar areas. Hence, the surgeon should take at most care to avoid neurosensory disturbance.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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