Original Research Paper

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A CBCT Based Evaluation of The Varying Location of Mandibular Canal and Mental Foramen: An Original Research Study

Abstract

Background and Aim: Iatrogenic injuries to inferior alveolar nerve (IAN) are a well known complication of implant placement, osteotomies and other surgical procedures. This study was at attempted to determine the most common position of the mental foramen and to estimate difference in position of mental foramen, occurrence of anterior loop and to evaluate the variation in the location of mandibular canal using cone-beam computed tomography (CBCT) radiographs. Materials & Methods: A total of 205 north Indian subjects were selected during a period of two years. Formerly exposed CBCT images of the selected subjects were studied by 'iCAT Vision' and 'Anatomage' Software. Measurements from the mandibular canal to the root apices of the first premolar, second premolar, first molar and second molar were obtained. Likewise the distance from the inferior alveolar canal to the buccal cortical plate (BCP) and lingual cortical plates (LCP) were also studied. The estimation of the horizontal and vertical positioning of mental foramen on the CBCT images was also done on both sides. Other inter-related dimensional parameters were also studied comprehensively. The incidence of Anterior Loop (AL) was also assessed and comparisons were done among both sides of the jaw and gender. Statistical Analysis and **Results:** A total of 205 subjects comprising of 108 (52.7%) males and 97 (47.3%) female participated in the study. The Unpaired t-test showed a statistically significant difference among males and females in the measurements of IAC. Among males Linear, Perpendicular and Anterior loop pattern was seen in 64 (59.3%), 34 (31.4%) and 10 (9.3%) subjects respectively. Among males prevalence of right sided anterior loop (Mental Foramen) was 10 (30.3%), left sided anterior loop was 10 (30.3%). The Unpaired t-test showed a statistically non-significant difference among males and females. ($p>0.5$) Anterior loop was seen on 17 (51.5%) occasions on the right side and 16 (48.5%) occasions on the left side. The Pearson's Chi-square test showed a statistically non-significant difference among the genders on the right side.

Conclusion: The most common configurations alveolar canal was the linear pattern followed by perpendicular pattern. Most frequent location of mental foramen was in continuity with second premolar in both the left and right sides as well as in both the genders. The anterior loop was the least common pattern of inferior alveolar canal.

Key-words : Inferior Alveolar Nerve, Dental Implant, Osteotomy, Neuropraxia, Cone-Beam Computed Tomography

Introduction

Dental implants have become a widely acceptable treatment modality as it restores esthetics and function equivalent to natural teeth. Despite its high success rate many complications have been encountered with its use.[1] Iatrogenic injuries to inferior alveolar nerve (IAN) are a well-documented complication of implant placement, osteotomies and other surgical procedures.[2] The incidence, varies from 0 to 40%, of implant related inferior alveolar nerve (IAN) injuries. The damage can result from the traumatic local anesthetic injections or during the dental implant site osteotomy or placement. This damage is one of the most unpleasant experiences, from mild paresthesia to complete anesthesia and/or pain, for both the patient and the dentist.[3] Implant placement in mandibular premolar region is one of the most complicated surgical procedures due to potential inadvertent complications of neuro-sensory alterations in the chin and

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NIVEDITA MALL[1], AMRITA PRITAM[2], VIDHI SRIVASTAVA[3], VASU SIDDHARTHA SAXENA[4]

[1]Department of Prosthodontics, Shree Bankey Bihari Dental College and Research Centre, Ghaziabad

[2]Prosthodontist and Implantologist, Aashray Nursing Home, Tilkamanjhi, Bhagalpur

[3]Department of Dentistry, T.S. Misra Medical College and Hospital, Lucknow

[4]Department of Oral Medicine and Radiology, Career Post Graduate Institute of Dental Sciences & Hospital, Lucknow

Address for Correspondence : Dr. Nivedita Mall, Senior Lecturer, Department of Prosthodontics, Shree Bankey Bihari Dental College and Research Centre, Ghaziabad, India

Email: nim237159@gmail.com

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lower lip that are likely to occur if mental foramen (MF) is not properly identified and protected. Compression-related injuries (neuropraxia) can occur by encroaching on the inferior alveolar nerve (IAN) without actual contact or invasion of the mandibular canal. Bleeding and resultant hematomas have been shown to cause nerve damage because of finalized implant positioning too close to the neurovascular canal. Additionally, the IAN superior cortical bone can be compressed, thus causing pressure necrosis, with resultant nerve impairment.[3,4] That is why the better understanding of the intra-bony anatomy of the IAN and its relationship to mandibular molar (MM) anatomical landmarks, particularly with emphasis on the tooth may aid to decrease the risk of inadvertent IAN injury. This will also decrease the risk of unwanted and often avoidable iatrogenic trauma of IAN during various surgical procedures.[2] Localization of critical anatomic structures at the surgical site including an estimation of the location, size and configuration of the inferior alveolar nerve during mandibular surgery is usually difficult using conventional images. Superimposition of overlying anatomy, distortion and magnification, presence of acquisition and processing artifacts and lack of information in the third dimension are some of the known drawbacks of this type of imaging.[5,6,7] Cone Beam Computed Tomography (CBCT) is a relatively new technology to dentistry, used for the three-dimensional imaging of the teeth and jaws. Therefore, it is usually suggested that the clinicians should carefully identify these anatomical landmarks, by analyzing all influencing factors, as well as study the shape and dimension of bone, prior to any surgical intervention.8,9,10 For the reason the CBCT showed the great potential for proper pre-implant planning. Thus, in view of this, the present study was conducted among the North Indian sample population, to determine the most common position of the mental foramen and to estimate difference in position of mental foramen, occurrence of anterior loop and to evaluate the variation in the location of mandibular canal in a selected North Indian sample population using cone-beam computed tomography (CBCT) radiographs.

Materials and Methods:

The study was planned, outlined and conducted in the Department of Prosthodontics and Crown & Bridge, Shree Bankey Bihari Dental College & Research Centre, Ghaziabad, Uttar Pradesh. The study was presented and cleared from institutional ethical committee. For execution, a total of 205 north Indian subjects were selected during a period of two years. Sampling method used was non-probabilistic sampling wherein all the patients meeting the inclusion and exclusion criteria were recruited for the study. Previously exposed CBCT images of the selected subjects were obtained from Raydent i-CAT Dental & Maxillofacial Imaging Centre®, Lucknow, Uttar Pradesh. The images were acquired from iCAT (Imaging Sciences International, Hatfield, PA, USA, CB 500 Machine), 110KV, 15 mA. iCAT Vision™ and Anatomage™ Software were used for the study. Section slicing used were 1 mm and 2 mm. The images were reviewed by two independent subject experts including a board certified Oral and Maxillofacial Radiologist. To mark the exact location of the inferior alveolar canal, all the measurements were done from the line passing through the centre of the mandibular canal. Measurements from the mandibular canal to the root apices of the first premolar, second premolar, first molar (mesial and distal root) and second molar (mesial and distal root) were obtained from cross sectional reformatted images. Other measurements included the distance from the inferior alveolar canal to the buccal cortical plate (BCP) and lingual cortical plates (LCP), as well as distance of the IAC to the inferior borders of the mandible (IBM) as shown in Figure 1. Figure 2 depicts the location of Mental Foramen below 1st Molar. Figure 3 shows straight (right) emergence of mental foramen. The assessment of the horizontal and vertical positioning of mental foramen on the CBCT images was done on both sides. The distances from the upper and lower cortical areas of the mental foramen to the alveolar crest/cemento enamel junction of tooth in line with mental foramen and the mandibular basal bone respectively were analyzed, in coronal section. The distances from the upper edge of the mental foramen to the superior border of mandible and the distances from the lower edge of the mental foramen to the base of the mandible were also studied. Figure 4 shows the vertical position of mental foramen; Mental Foramen-Superior Border of Mandible (green), Mental Foramen–Inferior Border of Mandible (orange). The prevalence of Anterior Loop (AL) was assessed and comparisons were done among both sides of the jaw and gender (Figure 5). All images were reconstructed using 'Anatomage Software'. The Pearson chi-square tests were used to assess the relation between patients' demographic variables with mental foramen, emergence type. Data were analyzed with SPSS software version[21].

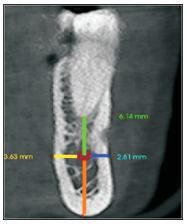


Figure 1: Cross section showing linear measurement from Inferior Alveolar Canal to Buccal Cortical Plate (blue), Lingual Cortical Plate (yellow), Inferior Border of Mandible (orange), and tooth apex (green) respectively.

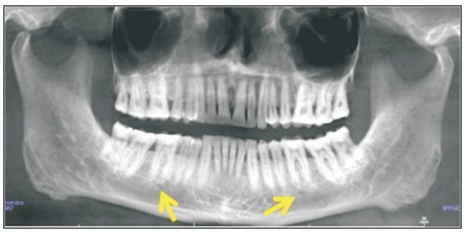


Figure 2: Location of Mental Foramen below 1st Molar

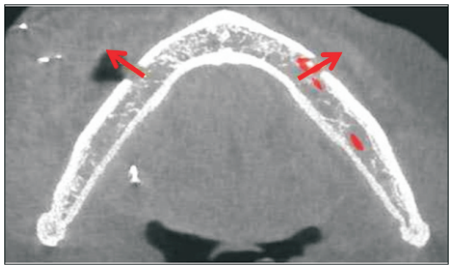


Figure 3: Straight (Right) Emergence of Mental Foramen

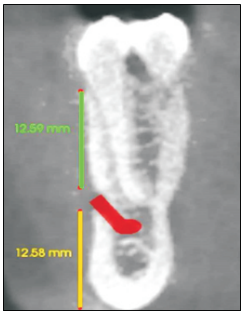


Figure 4: Vertical position of mental foramen; Mental Foramen-Superior Border of Mandible (green), Mental Foramen –Inferior Border of Mandible (orange)

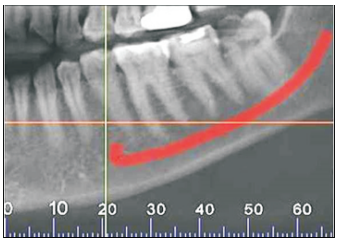
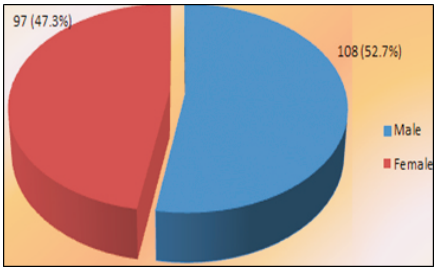


Figure 5: Anterior Loop pattern of Inferior Alveolar Canal

Statistical Analysis And Results:

A total of 205 subjects comprising of 108 (52.7%) males and 97 (47.3%) female participated in the study (Graph 1). The configuration of 1st premolar, 2nd premolar, 1st molar mesial (MM) root, 1stmolar distal (MD) root, 2nd molar mesial (MM) root and 2ndmolar Distal (MD) root in relation to inferior alveolar canal was measured and compared among gender and sides. The Unpaired t-test showed a statistically significant difference among males and females in the measurements. ($p<0.5$, Graph 2). Comparison of Position of IAC – Right & Left Side has been shown in table 1. The Unpaired t-test showed a statistically significant difference among sides in the measurements ($p<0.5$). The pattern of inferior alveolar canal was seen on panoramic view and compared among gender and side (Table 2). Among males Linear, Perpendicular and Anterior loop pattern was seen in 64 (59.3%), 34 (31.4%) and 10 (9.3%) subjects respectively. Among females Linear, Perpendicular and Anterior loop pattern was seen in 58 (59.8%), 32 (32.9%) and 7 (7.3%) subjects respectively. The Pearson's Chi-square test showed a statistically non-significant difference among the genders on the right side ($p=0.723$). Among males Linear, Perpendicular and Anterior loop pattern was seen in 63 (58.3%), 35 (32.4%) and 10 (9.3%) subjects respectively. Among females Linear, Perpendicular and Anterior loop pattern was seen in 58 (59.7%), 33 (34.1%) and6 (6.2%) subjects respectively. The Pearson's Chi-square test showed a statistically non-significant difference among the genders on the left side. ($p=0.843$) (Table 3) Among right side Linear, Perpendicular and Anterior loop pattern was seen in 122 (59.5%), 66 (32.2%) and 17 (8.3%) subjects respectively. Among left side Linear, Perpendicular and Anterior loop pattern was seen in 121 (59.1%), 68 (33.1%) and 16 (7.8%) subjects respectively. The Pearson's Chi-square test showed a statistically non-significant difference among the sides. ($p=0.631$ & Table 4). Comparison of Location of Mental Foramens of Right & Left side has been illustrated in table 5. Among males prevalence of right sided anterior loop was 10 (30.3%), left sided anterior loop was 10 (30.3%). Among females prevalence of right sided anterior loop was 7 (21.2%), left sided anterior loop was 6 (18.2%). The Unpaired t-test showed a statistically non-significant difference among males and females. ($p>0.5$) Comparison of Emergence of Mental Foramen of both sides has been shown in table 6. Anterior loop was seen on 17 (51.5%) occasions on the right side and 16 (48.5%) occasions on the left side. The Pearson's Chi-square test showed a statistically non-significant difference among the genders on the right side ($p=0.215$, Table 7).

Graph 1: Gender Distribution



Graph 2: Comparison of Position of Right 1st PM IAC – Gender based

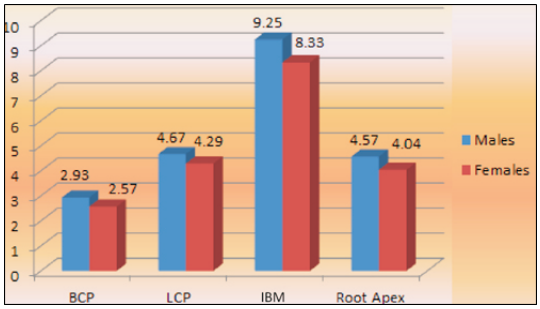


Table 1: Comparison of Position of IAC – Right & Left Side

Position	Right	Left	Probability of "t"	p-value
	Mean ±SD (mm)			
	1st Premolar			
BCP	2.71 ± 0.87	2.61 ± 0.85	1.382	0.028*
LCP	4.42 ± 1.32	4.31 ± 1.28	2.166	0.032*
IBM	8.93 ± 2.04	8.81 ± 2.01	2.632	0.043*
Root Apex	4.14 ± 1.29	4.11 ± 1.26	2.123	0.041*
	2nd Premolar			
BCP	2.98 ± 0.89	2.92 ± 0.83	1.042	0.049*
LCP	4.12 ± 0.69	4.05 ± 0.57	0.188	0.032*
IBM	9.25 ± 2.23	9.19 ± 2.17	1.038	0.043*
Root Apex	3.83 ± 1.35	3.77 ± 1.28	1.055	0.001**
	1st Molar Mesial			
BCP	4.69 ± 1.15	4.62 ± 1.09	0.034	0.242#
LCP	3.86 ± 0.77	3.81 ± 0.72	0.016	0.033*
IBM	7.87 ± 2.22	7.82 ± 2.17	1.725	0.028*
Root Apex	4.95 ± 1.21	4.88 ± 1.15	2.632	0.006*
	1st Molar Distal			
BCP	5.27 ± 1.55	5.19 ± 1.38	1.084	0.019*
LCP	3.22 ± 0.82	3.17 ± 0.76	0.049	0.332#
IBM	7.14 ± 2.03	7.11 ± 2.01	0.038	0.593#
Root Apex	4.78 ± 1.27	4.66 ± 1.16	1.038	0.018*
	2nd Molar Mesial			
BCP	6.36 ± 2.33	6.31 ± 2.28	0.234	0.018*
LCP	2.49 ± 0.67	2.43 ± 0.62	0.354	0.032*
IBM	7.93 ± 1.88	7.85 ± 1.77	1.342	0.043*
Root Apex	3.64 ± 0.36	3.55 ± 0.31	1.137	0.001**
	2nd Molar Distal			
BCP	5.96 ± 2.44	5.93 ± 2.34	0.198	0.015*
LCP	2.23 ± 0.72	2.17 ± 0.64	1.097	0.039*
IBM	8.71 ± 3.27	8.63 ± 3.21	0.188	0.043*
Root Apex	3.23 ± 0.75	3.19 ± 0.69	1.275	0.024*

Table 2: Comparison of Pattern of Right IAC – Gender based

Pattern	Male		Female		Total	
	n	%	n	%	n	%
Linear	64	59.3	58	59.8	122	59.5
Perpendicular	34	31.4	32	32.9	66	32.2
Anterior Loop	10	9.3	7	7.3	17	8.3
Total	**108**	**100**	**97**	**100**	**205**	**100**
Pearson's Chi square test value = 0.0032					p = 0.723#	
*Significant p < 0.05					#Non-Significant	

Table 3: Comparison of Pattern of Left IAC – Gender based

Pattern	Male		Female		Total	
	n	%	n	%	n	%
Linear	63	58.3	58	59.7	121	59.1
Perpendicular	35	32.4	33	34.1	68	33.1
Anterior Loop	10	9.3	6	6.2	16	7.8
Total	**108**	**100**	**97**	**100**	**205**	**100**
Pearson's Chi square test value = 0.0087					p = 0.843#	
Significant p < 0.05					#Non-Significant	

Table 4: Comparison of Pattern of IAC – Right & Left side

Pattern	Right		Left	
	n	%	n	%
Linear	122	59.5	121	59.1
Perpendicular	66	32.2	68	33.1
Anterior Loop	17	8.3	16	7.8
Total	**205**	**100**	**205**	**100**
Pearson's Chi square test value = 0.1016			p = 0.631#	
Significant p < 0.05			#Non-Significant	

Table 5: Comparison of Location of Mental Foramen – Right & Left side

	Right		Left	
	n	%	n	%
Below 1st PM	16	7.8	14	6.8
Between 1st PM & 2nd PM	60	29.3	64	31.2
Below 2nd PM	115	56.1	119	58.1
Between 2nd PM & 1st M	13	6.3	7	3.4
Below 1st M	1	0.5	1	0.5
Total	**205**	**100**	**205**	**100**
Pearson's Chi square test value = 0.0063			p = 0.497#	
Significant p < 0.05			#Non-Significant	

Table 6: Comparison of Emergence of Mental Foramen – Right & Left side

Emergence	Right		Left	
	n	%	n	%
Posterior	128	62.4	128	62.4
Anterior	17	8.3	16	7.8
Right (Straight)	60	29.3	61	29.8
Multi	0	0	0	0
Total	**205**	**100**	**205**	**100**
Pearson's Chi square test value = 0.0093			p = 0.883#	
*Significant p < 0.05			#Non-Significant	

Table 7: Comparison of prevalence of Anterior Loop Gender based

Anterior Loop	Male		Female		Total		Probability of "t" (Gender)	p-value
	n	%	n	%	n	%		
Right Side	10	30.3	7	21.2	17	51.5	0.0056	0.127#
Left Side	10	30.3	6	18.2	16	48.5	0.0043	0.138#
Total	**20**	**60.6**	**17**	**39.4**	**33**	**100**	*Significant p<0.05 #Non-Significant	
Probability of "t" (Side)					0.0034			
p-value					0.215#			

Discussion:

Understanding the proximity of the mandibular canal and Inferior alveolar nerve to the overlying structures is very crucial in Oral Implantology. Accurate knowledge of inferior alveolar nerve location is essential for the prevention of iatrogenic errors. These observations in our study were similar to the study done by Nair UP and co-researchers using Cone Beam Computed Tomography.5 Nkenke and associates reported that the distance from the upper alveolar crest to the inferior alveolar nerve canal in the retromolar area was 11.0 ± 2.2 mm.11 Levine et al. measured 17.4 mm around the mandibular second molar area. In the above mentioned studies, the root apex was not considered as in our study.12 In our study the lingual cortex was thicker at the first molar level, while the buccal cortex is much thicker at the second molar level. This probably could be due to consistent remodeling owing to the oral musculature attachments in the region. The distance of IAC from root apex in our study was similar to the results obtained from a recent study by Nair UP et al.5 using CBCT scans in 44 patients in the age group of 18-70 years. Our study found that the distance between the Inferior alveolar canal and the root apices of mandibular first molars is significantly shorter in females than in males. This could be attributed to the fact that dimension of the jaws is larger in males. Similar study was also done by Chong BS et al. in which 50% of the mandibular second molar evaluated, there was an intimate relationship between the roots and the Inferior alveolar nerve. The results suggested that second molar is the tooth most prone for nerve injury.[13] Based on the distance of inferior alveolar canal from buccal cortical plate, lingual cortical plate and inferior border of mandible; the observed pattern is the canal running close to lingual cortical plate in the region of second molar and first molar and it moves buccally just anterior to mesial root of first molars. Similar findings were observed by Kim et al.[14] The dimensions of Right inferior alveolar canal from buccal cortical plate, lingual cortical plate and inferior border of mandible and root apex were found to be slightly more than their left counterpart. Our results were at par with results obtained from study by Balaji SM et al.[2] The inferior alveolar canal pattern in the present study was categorized into linear, perpendicular and anterior loop patterns. Our results were at par with results obtained from study by Al-Mahalawy H et al. whereas; the most common pattern detected was linear in nature (46.2%).[15] Iyengar AR et al. also suggested that linear/straight pattern was most commonly observed (79%).16 In the current study emergence of mental foramen on the right side was 62.9% for posterior type, 27.9% for straight or right angled and 9.2% for anterior direction. On the left side the posterior emergence of mental foramen was 61.9% way ahead of straight emergence of 31.9% and anterior emergence of 6.2%. Out results were at par with results obtained from studies conducted by Srivastava S et al.[17] In the present study, out of 205 CBCT scans evaluated, anterior looping of inferior alveolar nerve was identified in 17 (8.3%) CBCT scans. Results of our study were in accordance to results obtained by Jacobs et al.18 Our results were at par with that obtained by Nakib et al.[19] Thakare and associates evaluated the position of mental foramen for clinical and forensic significance in terms of gender in dentate subjects by digital panoramic radiographs.8 They noticed no difference in position of mental foramen in horizontal and vertical planes based on gender. Their methodologies and results were very much comparable and contrasting with that of ours. So, keeping the proposed guidelines, this study will be helpful to get rid of iatrogenic injuries which tend to occur during the implant surgeries and other surgical procedure, therefore careful and detailed planning is required to identify mandibular vital structures as well as the shape and dimensions of the bone prior to commencement of implant surgery. As the presence of anatomical variation in the location and course of the mandibular canal in relation to other anatomical structures in the jaw bone including the apex of the tooth is frequently neglected, so proper understanding of the important landmarks through CBCT images which is more appropriate and accurate, is very useful in preoperative assessment and planning prior to implant surgeries.[20,21,22] Recently, Cone-Beam computerized tomography technology has gained popularity in the dentistry community, particularly in the area of implantology, because of the image quality along with the possibility of taking precise measurements of anatomical and pathological findings.[23,24] This suggests the need and importance of studies involving the anatomical characteristics of the mental foramen, mandibular canal which provides clinicians a tool in proper identifying the important mandibular vital structures thus minimizing the potential complications during implant surgery, permits procedures to be performed more safely on the mandible.[25,26,27] Limitation was sample size (number of images) taken for this study was small and that too from a single private CBCT centre. Also, results were correlated on the basis of gender and side but they were not correlated with occlusal load and habits of patients, as the patients were not contacted primarily. Both these factors could have affected the alveolar height and mandibular cortical width by

activating the periodontal ligament and musculature involved. Systemic conditions of any patient also were not known. Hence, further studies could be done in this direction for more refinements of the results.

Conclusion:

Within the limitations of the study, the authors concluded that the mean distance from inferior alveolar canal to buccal cortical plate and lingual cortical plate were significantly larger in males. Moreover, the mean distance from inferior alveolar canal to inferior border of mandible and root apex were significantly larger in males. Mean distance between inferior alveolar canal to inferior border of mandible and root apex were significantly larger on right side. It was also concluded that the most common location of mental foramen was below the second premolar and the most common emergence type of the mental foramen was posterior. Anterior loop was illustrated as the least common pattern of inferior alveolar canal in the studied subjects.

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