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Title- A CBCT study of mandibular canal and its variations in Udaipur population

Running title- Radiographic localization of the position of mandibular canal at various sites: A CBCT study

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Abstract

Background: The Mandibular Canal (MC) has been documented to have different anatomic configurations in the dentulous and partially dentulous patients and completely edentulous individuals. Cone beam Computed tomography has allowed more accessible three dimensional assessment of the MC and its variations.

Aim and Objectives: To evaluate the role of Cone Beam Computed Tomography (CBCT) in analyzing the detailed anatomy of mandibular canal and its variations in Udaipur population. To study the mandibular canal and its variations like position using CBCT and to compare the parameters of MC and

its variations in completely dentulous (CD), partially edentulous (PE) and completely edentulous (CE) patients.
Materials and Methods: 90 CBCT scans of mandible were obtained for various treatment procedures were collected from various Implant and CBCT Centers in Udaipur, Rajasthan. The position of the MC was assessed at various locations and sites and the data analyzed through SPSS (7.0) software.
Results: The location of MC was assessed at various sites and the maximum and minimum distance of MC was fromcrest position (16.32 mm) and lingual position (3.86 mm). respectively in CD group. The assessment of site revealed maximum distance of MC was at 2nd premolar (Site B) and minimum distance was at 2nd molar region (Site D) in CD group.
Conclusion: The MC was more lingually positioned distal to 1st molar and buccally at premolar region in CD group and PE group. Also it was closer to crest and farther from base in CE group and more lingually placed in the edentulous.

Keywords: Canal, Mandibular, Bifid Mandibular Canal, Mental Foramina

Introduction
The Mandibular Canal (MC) is a canal within the mandible that is beginning in mandibular foramen on the medial surface of the ascending mandibular ramus. It runs obliquely downward and forward in the ramus, and then horizontally forward in the body till mental foramen.[1] The MC has different anatomic configurations in the dentulous and partially dentulous patients in the vertical plane.[2] The canal may run lower when it proceeds anteriorly, or may have sharp decline, or drape downward in catenary's fashion.[3] In edentulous patients, after the loss of teeth, the alveolar border is resorbed and mandibular canal and mental foramen lie close to the alveolar border.[4] Knowledge about the morphology and topography of the mandibular canal is important when carrying out interventions in the mandible, in order to preserve anatomical structures which pass through it.[4] Hence, the present study was carried out with the main aim to compare mandibular canal and its variations in dentulous, partially dentulous and completely edentulous.
Aims
The aim of our study was to evaluate the role of Cone Beam Computed Tomography in analyzing the detailed anatomy of mandibular canal and its variations in Udaipur population so as to aid in the management of various surgical procedures. Objectives were to determine to study the mandibular canal and its variations like position using Cone Beam Computed Tomography in completely dentulous, partially edentulous and completely edentulous patients.
Material and methods
Sample selection
The study was conducted in Department of Oral Medicine and Radiology on subjects older than 18 years were 90 CBCT scans were obtained from Dentium Co CBCT machine imaging. CBCT scans in which mandibular canal was clearly visualized along the entire course from mandibular foramen upto mental foramen were included in the study. The subjects with pathologic lesions in mandible were excluded from our study.[5]
Contiguous sectional images in three planes, axial, sagittal and coronal sections were reconstructed from the projection data with a slice width of 1 mm. The contiguous sectional images using CS-3D software are evaluated on a cathode ray tube (CRT) monitor.[5]
Assessment of Location of the MC:
The coronal cross- section was used to measure the distance of the external surface of the canal to all the four borders to calculate the location of mandibular canal in horizontal plane by measuring distance from outer margin of mandibular canal to buccal and lingual cortical plate in dentulous, partially dentulous subjects.

The measurements in vertical plane were being calculated by measuring distances from outer margin of mandibular canal to alveolar crest and inferior border of mandible in dentulous.[7,8]
For partially and completely edentulous, measurement in vertical plane was being calculated by measuring distances from outer margin of mandibular canal to crest of edentulous alveolar ridge and inferior border of mandible in edentulous span region.[9,10]
For completely dentulous, completely edentulous and partially edentulous (CD, CE& PE):
The following four measurements were recorded at each coronal cross-sectional image were takenas follows:[5,6]
(1) CN – from the alveolar crest to the bone directly superior to Inferior alveolar canal (IAN);
(2) BN – from the buccal cortex to the bone directly lateral to the IAN;
(3) LN –from the lingual cortex of the bone directly medial to the IAN;
(4) IN – from the inferior border of the mandible to the bone directly inferior to the IAN.
The location of MC was assessed at various sites:
For CD and PE group: 1st premolar (Site A), 2nd premolar (Site B), 1st molar (Site C) and 2nd molar (Site D).
For CE group: The slices were marked as follows:
(i) Site A was taken from 1mm below the mandibular foramen and parallel to the inferior margin of the body of the mandible.
(ii) Site B was taken perpendicular to the anterior end of site A.
(iii) Site C was taken midway between site B and the mental foramen.
(iv) Site D was taken 1mm posterior to the mental foramen. And the position of MC was calculated at each slice region by the outermost margin of mandibular canal and outermost cortical margins and final mean was taken.[4]
All the measurements obtained were entered into the Excel sheets and were subjected to statistical analysis. Statistical analysis were done using Student Pair T test using SPSS (Statistical Package of Social Science) software SYSTAT version 7.0.The p value > 0.05 was considered as statistically significant, <0.005 as non-significant and 0.000 as highly significant.[11]
Results
The final study group was 90 CBCT scans which contain 30 CBCT scan each for CD, PE & CE groups. The mean distance of mandibular canal was recorded at buccal, lingual, crest and base in all the three groups at various sites in right and left side.
Comparison of position of mandibular canal within completely dentulous (CD), partially edentulous (PE) and completely edentulous (CE) groups.
The maximum and minimum mean distance was derived for buccal, lingual, crest and base positions for each group separately for right and left side. The standard deviation of mean distances of mandibular canal from buccal, lingual, crest and base in all the three groups and p value was derived. The p value derived from comparison between PE&CE in crest, CE&CD in buccal and base was significant in right side and CE&CD in base was significant in left side whereas, all the p values were non-significant as depicted in Table 1.

Table 1: Comparison of position of mandibular canal within completely dentulous (CD), partially edentulous (PE) and completely edentulous (CE) patients

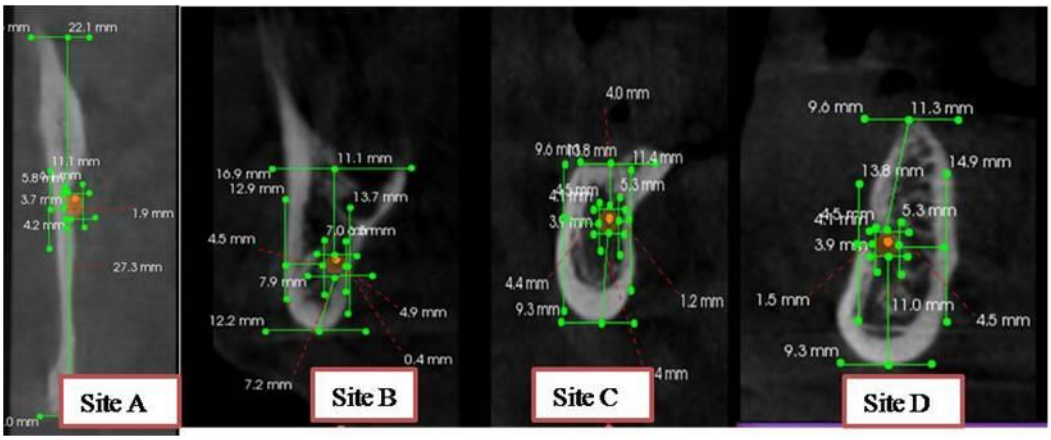
		BUCCAL			LINGUAL			CREST			BASE		
		CD	PE	CE	CD	PE	CE	CD	PE	CE	CD	PE	CE
MEAN	RIGHT	4.69	3.93	3.62	2.6	3.5	3.37	16.32	14.53	9.4	6.7	7.74	8.71
MEAN	LEFT	3.42	4.14	3.74	3.86	3.55	3.4	15.92	14.22	9.91	6.97	8.42	8.88

Comparison of mean position in completely edentulous (CE) at various sites.

It was observed that the maximum mean distance of mandibular canal at Site A was not assessable while the maximum mean distance of MC at Site B (perpendicular to anterior end of Site A) in crest position (10.55 mm) in right side and in left side at Site D (1 mm posterior to mental foramen) in crest position (10.53 mm) respectively. The minimum mean distance of mandibular canal was seen at Site B (perpendicular to anterior end of Site A) in buccal position (2.35 mm) in right side and in left side at Site C (midway between Site B and mental foramen) in lingual position (2.70 mm) respectively. All the p values were mostly non-significant. It was highly significant for buccal & lingual in right side and significant for buccal &lingual, lingual & crest, crest & base in right side and in left side buccal & lingual, buccal &base, lingual & crest respectively. (Table 2& Image 1)

Table 2: Comparison of position of mandibular canal within completely edentulous (CE) at various sites

	Site	SITE A				SITE B				SITE C				SITE D			
		B	L	C	BASE	B	L	C	BASE	B	L	C	BASE	B	L	C	BA
MEAN	RIGHT	NA	NA	NA	NA	2.35	4.63	10.55	9.95	4.71	2.85	8.43	7.73	3.83	2.65	9.54	8.
MEAN	LEFT	NA	NA	NA	NA	3.09	3.99	9.16	9.90	4.84	2.70	8.09	8.13	3.47	3.55	10.53	8.



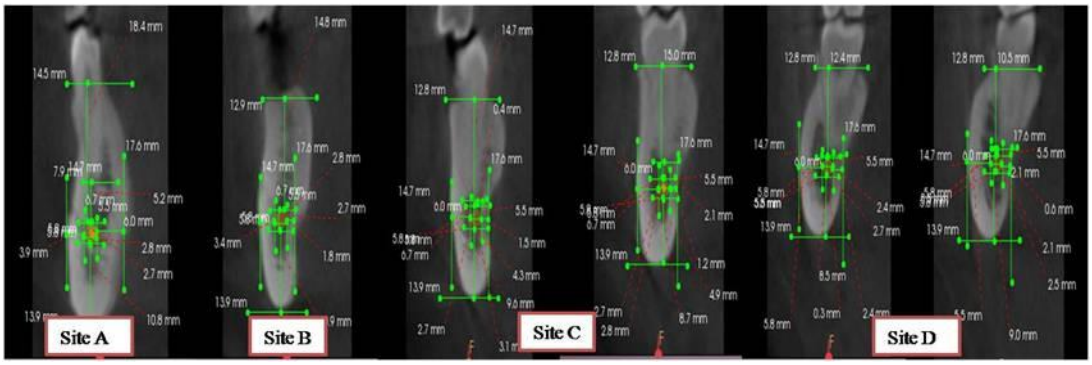
Measurement of mc atposition (buccal, lingual, crest and base) of mc in completely edentulous at various sites (site a-d).

Comparison of mean position in partially edentulous (PE) at various sites.

It was observed that the maximum mean distance of mandibular canal was seen at Site C (1st molar) in crest position (14.6 mm) in right and left side respectively. The minimum mean distance of mandibular canal was seen at Site A (1st premolar) in buccal position (2.75 mm) in right and left side respectively. All the p value were non-significant in Site A and C. All the p values were non-significant expect the p value between Buccal & crest was significant in Site B and D. (Table 3& Image 2)

Table 3: Comparison of position of mandibular canal within partially edentulous (PE) at various sites

	Site	SITE A				SITE B				SITE C				SITE D			
		B	L	C	BASE	B	L	C	BASE	B	L	C	BASE	B	L	C	BASE
MEAN	RIGHT	2.75	5.7	12.75	11.05	3.57	4.03	14.19	9.22	4.71	2.98	14.6	8.11	4.41	3.35	13.69	7.73
MEAN	LEFT	2.75	5.7	12.95	11.05	3.57	4.03	14.19	9.22	4.71	2.98	14.6	8.11	4.41	3.35	13.69	7.73



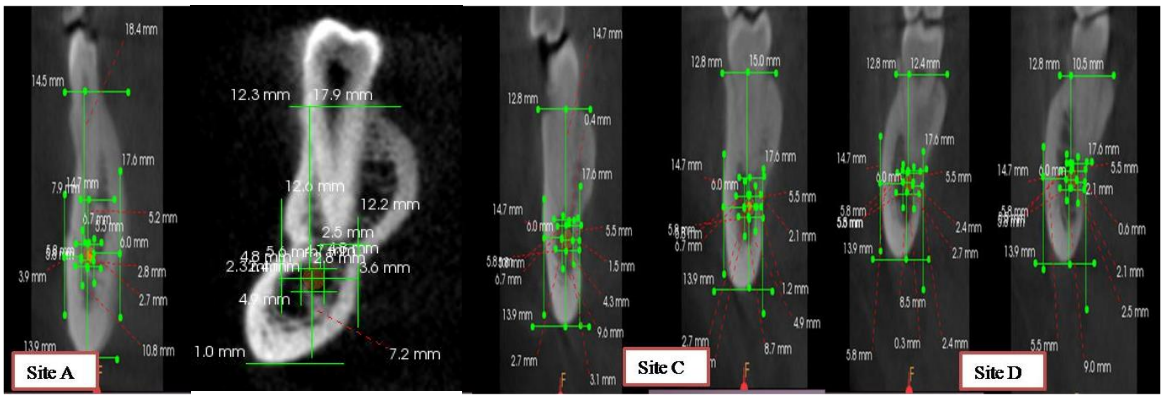
Measurement of mc atposition (buccal, lingual, crest and base) of mc in partially edentulous at various sites (site a-d).

Comparison of mean position in completely dentulous (CD) at various sites.

It was observed that the maximum mean distance of mandibular was at Site A (1st premolar) in crest position (17.50 mm &15.08 mm) in right and left side. The minimum mean distance of mandibular canal was at Site C (1st molar) in lingual position (1.92 mm) in right side and Site D (2nd molar) in lingual position (1.39 mm) in left side respectively. The p value for Site A, B was non-significant for lingual & crest and crest & base, while the p value was significant for buccal & lingual and lingual & base and the p value was highly significant for buccal & lingual and buccal & base for right side. For Site C, The p value was non-significant for buccal &lingual, buccal & crest and lingual &crest, while the p value was significant for buccal & base, lingual &base and crest & base for right side and for left side all the p value were non-significant in Site A,B &C. All the p values were non-significant in right and left side for Site D. (Table 4 & Image 3)

Table 4: Comparison of position of mandibular canal within completely dentulous (CD) at various sites

	Site	SITE A				SITE B				SITE C				SITE D			
		B	L	C	BASE	B	L	C	BASE	B	L	C	BASE	B	L	C	BASE
MEAN	RIGHT	2.99	4.19	17.50	6.71	4.46	2.48	16.99	6.39	5.38	1.92	16.80	6.39	5.83	1.95	14.38	7.09
MEAN	LEFT	4.02	2.04	15.08	6.32	3.45	3.95	14.79	7.61	3.30	3.24	14.98	6.44	3.26	1.39	13.95	6.56



Measurement of mc atposition (buccal, lingual, crest and base) of mc in completely dentulous at various sites (site a-d).

Discussion

The mandibular nerve is the third and inferior most division of the trigeminal nerve, or the fifth cranial nerve. The trigeminal nerve is predominantly a sensory nerve, innervating most of the face. The upper branch of the trigeminal nerve is called the ophthalmic nerve and innervates the forehead.[1] The middle branch is called the maxillary nerve and innervates the maxilla and the midface. Gosling in 1985 stated that the lower branch is called the mandibular nerve and innervates the teeth and the mandible, the lateral mucosa of the mandible, and the mucosa and skin of the cheek, lower lip and chin.[2]

Certain variations in the anatomy of mandibular canal and its course are not uncommon. Acquaintance with the morphology and topography of the inferior alveolar neurovascular bundle is essential for various surgical procedures including dental implant placement, third molar surgery, dental anesthesia, mandibular osteotomy, bone harvesting procedure from the ramus and body of mandible, bone plating in angle and body region of mandible, or any other surgical procedure involving the mandible.[3]

Buccolingual orientation is an important parameter to analyze before surgical procedure. In a study by Komal A et al[12] in fully dentate individuals the canal was found to be at mean distance of 4.3 mm from lateral aspect of buccal cortical plate and 1.8 mm in medial aspect of lingual cortical plate in third molar region which was similar our study where the mean distance of mandibular canal from buccal position was 4.69 mm in completely dentulous in right side which was similar to our study. Comparatively similar were the mean maximum distance of mandibular canal from lingual cortical plate was 3.86 mm in completely dentulous on the left side. This variation can be due to the site variations between the studies.

It was also inferred by Balaji et al[13] that as the age increases the interval between mandibular canal and lingual cortical plate increases which is contradictory to our completely edentulous group where the maximum mean distance of MC from lingual cortex was 3.55 mm on both right and left side which was similar to that of the buccal cortex distance in completely edentulous groups.

Similar CBCT study of 150 patients (of 69 completely edentulous and 41 completely dentulous patients) done by Haghanifer. S et al[14] concluded that the mean distance from the crest, buccal, lingual and inferior border was 10.67 mm, 4.4mm, 2.23 mm and 5.75 mm on right side respectively and the mean distance was 10.38 mm, 4.31 mm, 2.42 mm and 5.63 mm on left side respectively which suggested that the mandibular canal was lingually inclined in buccolingual dimension and more inclined to crest position rather than inferior border of mandible. These were similar to completely edentulous in our study suggesting the resorption of the bone at the crestal area to be more in the patients with advanced age. This was also correlative by the study by Yashar et al[15].

Previous studies done by Levine et al[16], Kamburoglu et al[17], Koivisto et al[18] and Uppal et al[19] had revealed that the distance of MC from the lingual cortex as 1.7-4.35 mm and from buccal cortex to be 2.6-3.5 mm. Also this study suggested the mean values of 7-7.94 mm and 10.92 mm from the basilar edge. Similar to our study in which the mean distance of MC from inferior border as 6.97 mm, 8.47 mm & 8.88 mm in left side in CD, PE &CE groups respectively.

Also the study by Levine et al[16] measured the distance from edentulous alveolar crest to superior aspect of mandibular canal in 50 patients as 17.4 mm. Similarly Watanabe el al[20] analyzed the CT data of 79 Japanese patients found a similar result of 15.3-17.4 mm. These results were similar to completely dentulous group 16.32 mm and 14.53 mm in partially edentulous in right side.

Khorsidhi et al[21] stated that mandibular canal was located at a mean distance of 8.5 mm from the inferior margin of the mandible which increased to 9.73 mm at the mental foramen as the mandibular canal slightly ascended to the mental foramen.

Arias et al[22] done on CBCT samples in dentate patients had described descendant trajectory in 1st and 2nd molar region and ascending trajectory in premolar region suggesting a oblique downwards course in dentate mandibles similar to completely dentulous group.

Kilic et al[23] where he had suggested that nerve was placed more lingually in premolar region and buccally in molar region.

In a study by Shaikh KV et al[24], the mean distance of outer surface of buccal cortex to the lateral surface of the canal at mandibular body at second molar was 5.934 mm and from lower border was 6.92 mm similar to that of results obtained in partially edentulous group (4.41 mm,7.75 mm from the buccal cortex) also a study by Yu wang et al had a mean distance of 7.2 mm from the buccal cortex and 7.6 mm from the lower border of the mandible at second molar region similar to that of our study in completely dentulous (5.83 mm from buccal cortex) and in partially edentulous (7.73 mm from inferior border of mandible).

In a study by Juozdalzbys et al[3] had suggested that with advancing age the mandibular atrophy at dental ridge is seen distal to second molar area similar to our study where completely dentulous (18.7 mm) and completely edentulous (13.5 mm) group had minimum distance of the superior aspect of MC from the crest at second molar region (Site D & Site B) respectively as compared to other site within this group. The partially edentulous group because of variable sampling didn't show similar results.

A study by Alrahaimi SF et al[25] done on CBCT patients on missing tooth in posterior segment of mandible had concluded the average distance of superior margin of MC at premolar, 1st and 2nd molar to be 15.19 mm, 14.53 mm and 14.19 mm respectively.

Sekerci et al[26] reported the distance of mandibular canal from buccal cortex on both right and left side to be in the range of 6.3-6.66 mm, lingual cortex was in the range of 2.632.70 mm and from the superior border 15.6 mm-11.1 mm as taken at the sites between 1st and 2nd molar and 2nd and 3rd molar and distal to 3rd molar which was similar to our study.

Haghanifer and Yashar et al[14,15] had concluded that the mandibular canal is located in the most inferior position at a distance of 1mm from the mental foramen and gradually move upwards from 1st molar to the 3rd molar area having the maximum distance from the alveolar crest in this region till it reaches the anterior border of the ramus, similar to our study in all the three groups.

A study by Hsu JT et al[27] had suggested that no statistical difference in the maximum measurement of MC to the upper border of mandible which was 15.88 mm for 2nd premolar and 16.15 in 1st molar thus concluding that similar length implant bodies can be used at this site. Also the lowest distance of MC from the alveolar crest in the above study was 10.56 mm and 11.25 mm for lower 2nd premolar and 1st molar respectively. Similar measurement were seen in our study where in complete dentulous the premolar and molar had (14.79 mm and 16.8 mm respectively) and in partially edentulous (14.19 and 14.6 mm) respectively, and dissimilar to completely edentulous group in these regions reason being uneven ridge resorption.Also the study had stated the distance of MC from buccal cortex was smaller 4.08 mm in 1st molar 4.68 mm. Thus suggesting the proper selection of the screws for the length and thickness when doing mono-cortical bone plating to prevent IAN injuries.

A study by Chaudhary ML et al[28] done on 378 CBCT images it was noted that the IANC was closest to buccal cortical plate in the region of premolars on both side with the mean distance of 2.83 mm on both side and from there onwards the canal courses towards the lingual cortical plate (2.7 mm) and inferior border of the mandible as it moves posterior towards the distal of 2nd molar roots.

A study by Ylikontiola et al[29] the distance of MC to the buccal cortex was 3.5 mm in 1st and 2nd molar and 2.5 mm distal to2nd molar where as the mean distance of MC from inferior border 8.8 mm to 6.8 mm at various reference points was going from posterior to anterior. Similar to study of Rajchel et al57 who found that greatest distance of MC in buccal cortex was at 1st and 2nd molar and least at 3rd molar similar to our study in completely dentulous group.

Tsu JI and Yammimoto et al[30,31] had suggested the close proximity of MC to this region as the reason of fractures occurring at medial aspect of ramus above the inferior border of the canal.thus stating the 2nd molar to be the safe site considering the maximum thickness of the cortical plates in this region. Contradictory to our study as the maximum thickness of buccal, lingual and crest in 1st premolar rather than 2nd molar expect inferior border in completely dentulous group.

Conclusion

In our study, it was concluded that the buccolingual dimension, the MC was closer to lingual cortex in molar area and in premolar area; the MC takes a sharp turn from lingual to buccal and exits through the mental foramen. Due to the catenary fashion of MC, the available bone in buccolingual dimension is approximately 6mm which suggests that dental implants can be placed without injuring MC and the preferred location is 2nd premolar in any dentition status with surgical guidance with the use of angled abutment. The base position from MC was taken into consideration as when the MC descends from Mandibular foramen it was minimum at 2nd molar region and gradually ascended when it approached mental foramen. These information is helpful in bone harvesting, bone plating in angle and body regions.

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