Journal of Morphological Sciences
J Morphol Sci
Brazilian Society of Anatomy

Original Article
J Morphol Sci 2024;41:125-130

Evaluation of Factors Affecting the Visibility Of Mandibular Canal In CBCT - a Crossectional Radiographic Study

Prashanth Shenoy[1], Jeslin James[1], Veena K.M[1], Rachana V Prabhu[1], Prathima Shetty[1]

[1]Department of Oral Medicine and Radiology, Yenepoya Dental College and hospital, Yenepoya (deemed to be) university, Mangalore, Karnataka

Disclose and conflicts of interest: none to be declared by all authors

ABSTRACT

Introduction: To assess the visibility of the mandibular canal in CBCT images and to know if the visibility is affected by age, gender and bone density.

Materials and Methods: a total of 352 canals were screened for visibility of mandibular canal and the samples were equally divided based on age and gender. All sections of CBCT images were analyzed i.e the coronal, axial, sagittal and cross sectional views. The visibility of the MC was registered as either visible or not visible in each section of CBCT images, bone density was also checked according to Misch classification for bone density. The findings of the study were validated by a well experienced maxillofacial radiologist.

Results: The results showed that, mandibular canal exhibited good visibility in the cross sectional, coronal and sagittal sections with a slightly lesser visibility in the molar regions of the axial sections. Factors like age, gender and bone density also had significant effects on canal visibility.

Conclusion: the conclusion of this retrospective study was that the mandibular canal demonstrated an overall satisfactory visibility in the cross-sectional, coronal and sagittal sections however the axial sections showed a slightly lesser visibility in the molar regions. In evaluating factors affecting visibility, it was found that canals were better visualised in younger age groups and with regard to gender, males showed higher visibility than females. Bone densities of D1 and D2 demonstrated good visibility than D3 and D4.

Keywords: CBCT; Mandibular canal; Endosseous Implants; Spiral CT.

Introduction

The mandibular canal (MC) is located bilaterally within the internal aspect of the mandible and houses the inferior alveolar nerve, artery and the vein. It extends from the region of the mandibular foramen, on the lingual side of the ramus, continues through the buccal surface of body of the mandible to meet at the mental foramen, adjacent to the second mandibular premolar tooth.[1] The neurovascular bundle within the canal is responsible for giving the somatosensory innervations and blood innervations to the mandibular teeth.[2] The contents of the canal can be at risk specially during implant placement surgeries and can lead to several complications[3] like altered sensations associated with anesthesia and pain and also damage to the inferior alveolar artery and the lingual artery may cause excessive hemorrhage. Therefore, MC is considered to be an important anatomical landmark while performing procedures involving the mandible.[4]

Among various modalities used for mandibular canal visualisation, 3 D views in CBCT provide superior diagnostic accuracy because of its ability to visualize the canals at different sections and at different planes.[5] Several authors have suggested that even though CBCT images are suitable for appreciation of the canal, the identification of the MC is a delicate task and the radiographic appearance is usually a radiolucent zone with superior and inferior corticated margins.[6] However, the cortication of the canal is variable, owing to difficulties in visualization of the canal in some cases. The identification of MC has also been linked to the bone density of its walls and in some cases the radiopaque border is disrupted in radiographic images, and it is invisible in some other cases. The mandibular canal is usually formed by a thin trabecular bone with many circumferentially located voids, and these trabeculations may also vary among different locations within the mandible. A correlation between the alveolar bone quality and the existence of the mandibular canal wall has been indicated by radiological studies. Decreased visibility of the canal wall on radiographs could suggest lower integrity of the wall and decreased bone trabeculation.[6]

Miles *et al*[1] in his study also found that the visibility was also associated with certain factors like age and gender which was further affected by location. Furthermore, the structure is associated with frequent anatomic and radiographic variations

DOI: 10.51929/jms.41.125.2024
ISSN 2177-0298

which can also affect the visibility, depicted in several studies investigating the course of the mandibular canal. Therefore the aim of the present study was to assess the visibility of the mandibular canal in different sections of CBCT images and to know if the visibility is affected by factors like age, gender and bone density.

Materials and Methods

The present study was conducted in the Department of Oral Medicine and Radiology, Yenepoya Dental College, Mangalore. The samples were selected from the archives of the patients coming to department of oral medicine and radiology for CBCT scanning with any indication from any department. The selection of images was taken to fit in the inclusion criteria, that is mandibular CBCT images of patients aged 18-70 years and CBCT images without any artifacts. CBCT images with artifacts, images of patients having any known systemic disorder and with any bone disorders were excluded from the study. The CBCT scans were acquired using Planmeca Promax Proface 3D mid that uses Romexis software 3.8.3R for image reconstructions. The CBCT images included in this study were high quality images, free of artifacts, taken in various field of views. The parameter for exposure in acquiring these images were 90kV, 10mA, 12sec, bit depth of image being 12. Ethical clearance was obtained from the Ethical Committee, Yenepoya deemed to be University before the onset of the study. Based on 5% level of significance, 80% power and an effect size of 0.3 the sample size required was 176 that is 88 in each gender, i.e. (males = 88, females = 88). Each gender group was then equally sub-divided into 4 sub groups based on the age. Each sub-group included 22 males and 22 females. Sub-group A: 18 – 31 years of age, Sub-group B: 32-44 years, Sub-group C: 45 – 57 y ears and sub-group D: 58- 70 years of age. The included samples were interpreted and evaluated for visibility of Mandibular canal in the premolar and molar region, that is a total of 352 canals were screened and selected for evaluation by an oral medicine and radiology resident. All sections of CBCT images were analyzed i.e the coronal, axial, sagittal and cross sectional views. The visibility of the MC was registered as either visible if it was undoubtedly differentiated from the surrounding marrow spaces. (FIG- 1) It was registered as not visible if it cannot be differentiated between the surrounding marrow spaces (FIG-2) in each section of the CBCT images. In addition to evaluation of visibility of the mandibular canal, bone density was also checked. Evaluation of bone density was done and it was categorized into 4 classes according to Misch classification for bone density. Each case was assigned a single value of 'D' depending upon the radiographic appearance and MDCT HU value as described by the classification. The findings of the study were validated by a broad- certified well experienced maxillofacial radiologist. Data was expressed in terms of frequency and percentage and Chi square test was used to check the association between the canal visibility with that of age, gender and bone density. A p-value of <0.05 was considered to be statistically significant.

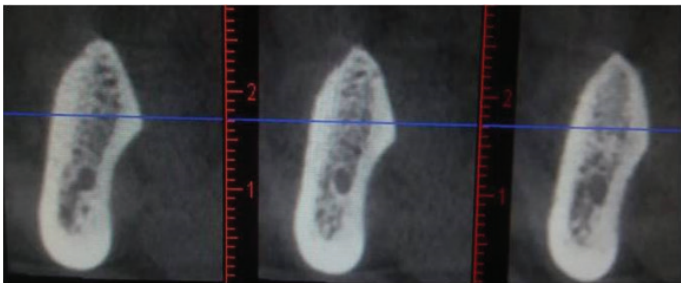


Figure 1. clearly visible canal.

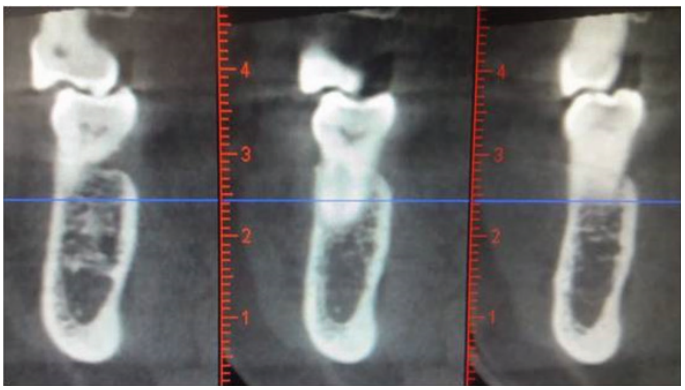


Figure 2. canal not clearly appreciable.

Results

The results of the present study demonstrated that out of 352 canals evaluated, 321 (91.2%) canals showed better detectability in the premolar regions and 315 (89.5%) canals showed good visibility for molar regions in all sections of CBCT images. However the visibility was found to be slightly lesser in the axial sections, for the molar regions that is 311 (88.4%) canals showed good visibility. Hence, mandibular canal exhibited an overall satisfactory visibility in cross sectional, coronal and sagittal sections however the canal visibility was slightly lesser in the axial sections (Table 1).

The present study also showed that factors like age , gender and bone density also had significant effects on canal visibility. Chi square test was used to check the association between the factors and the canal visibility. It was found that when considering age as one of the factor, better canal visibility was observed for sub group A (18-31 yrs of age) in the premolar region (97%) when compared to molar regions (95%) in all sections of CBCT images. However in the axial sections, there was a

Table 1. frequency distribution for each sections.

Sections	PM		M	
	NV	V	NV	V
CS	31 (8.8 %)	321 (91.2%)	37 (10.5%)	315 (89.5%)
Coronal	31 (8.8%)	321 (91.2%)	37 (10.5%)	315 (89.5%)
Sagittal	31 (8.8%)	321 (91.2%)	37 (10.5%)	315 (89.5%)
Axial	31 (8.8%)	321 (91.2%)	41 (11.6 %)	311 (88.4%)

*PM - premolar
*M - molar
*NV - non visible
*V - visible
*CS - cross -sectional

slight variation in visibility and the visibility was slightly lesser in the molar regions (93%) when compared to the premolar regions. The visibility was found to be the least for sub group D that is (58-70 years) in all sections of CBCT images. Table 2 & 3, graphs 1 & 2 .

Table 2. comparison between the age groups and visibility in cs , coronal, sagittal sections.

Age Groups	PM		M	
	NV	V	NV	V
A (18-31 yrs)	2 (2.3%)	86 (97.7%)	4 (4.5%)	84 (95.5%)
B (32-44yrs)	9 (10.2%)	79 (89.8%)	5 (5.7%)	83 (94.3%)
C (45- 57 yrs)	5 (5.7%)	83 (94.3%)	7 (8%)	81(92%)
D (58-70 yrs)	15 (17%)	73 (83%)	21(23.9%)	67 (76.1%)
P Value		0.004		< 0.001

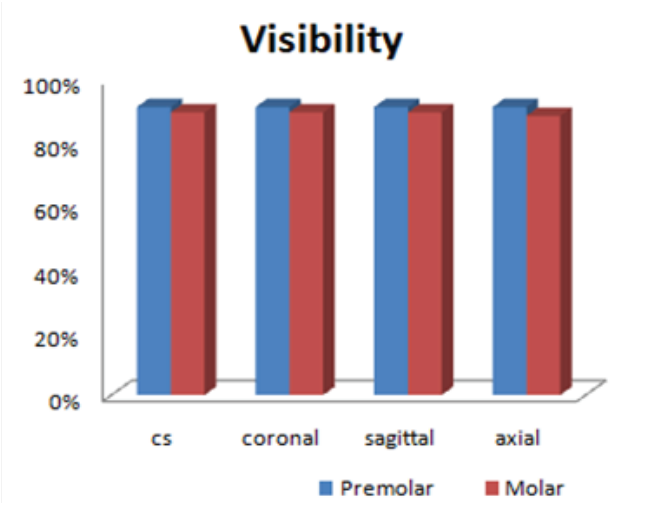
*PM - premolar
*M - molar
*NV - non visible
*V - visible
*CS - cross -sectional

Table 3. comparison between the age groups and visibility in axial section.

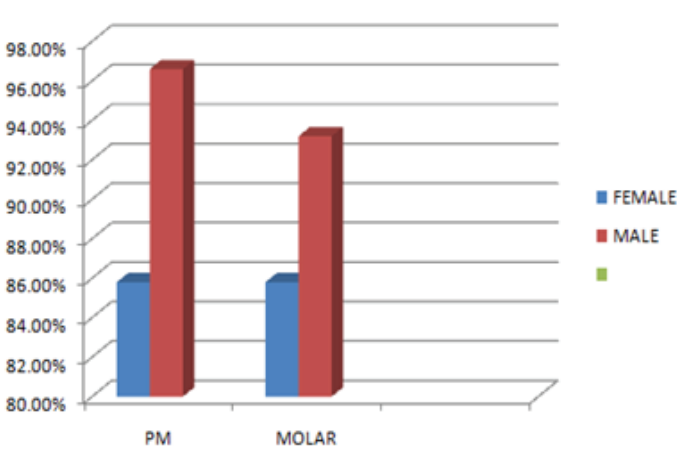
Age Groups	PM		M	
	NV	V	NV	V
A (18-31 yrs)	2 (2.3%)	86(97.7%)	6 (6.8%)	82 (93.2%)
B (32-44yrs)	9 (10.2%)	79(89.8%)	7 (8%)	81 (92%)
C (45- 57 yrs)	5 (5.7%)	83(94.3%)	7 (8%)	81(92%)
D (58-70 yrs)	15 (17%)	73 (83%)	21 (23.9%)	67 (76.1%)
P Value		0.004		0.001

*PM - premolar
*M - molar
*NV - non visible
*V - visible

When comparing the visibility with that of the gender, it was found that better canal visibility was observed for the male gender when compared to the female gender in the cross sectional, coronal , sagittal and the axial sections. However slight variations were observed in percentages for the molar regions of the axial sections where the visibility was found to be slightly lesser. Table 4 & 5, graphs 2 & 3.



Graph 1. Visibility in each sections.



Graph 2. Visibility for males and females in cs, coronal and sagittal sections.

Table 4. comparison between the gender and visibility in cs, coronal, sagittal sections.

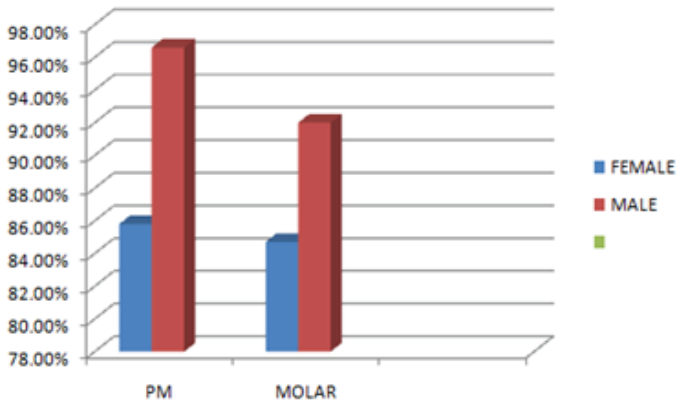
Gender	PM		M	
	NV	V	NV	V
Female	25 (14.2%)	151 (85.8%)	25 (14.2%)	151 (85.8%)
Male	6 (3.4%)	170 (96.6%)	12 (6.8%)	164 (93.2%)
P value		< 0.001		0.024

*PM - premolar
*M - molar
*NV - non visible
*V - visible
*CS - cross sectional

Table 5. comparison between the gender and visibility in axial section.

Gender	PM		M	
	NV	V	NV	V
Female	25 (14.2%)	151 (85.8%)	27 (15.3%)	149 (84.7%)
Male	6 (3.4%)	170 (96.6%)	14 (8%)	162 (92%)
P value		< 0.001		0.031

*PM - premolar
*M - molar
*NV - non visible
*V - visible

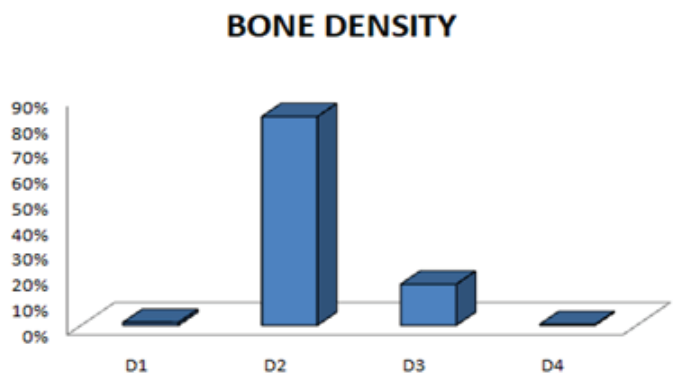


Graph 3. Visibility in axial section for males and females.

Bone density also had a considerable effect on canal visibility in this study. The highest percentage of bone density was found to be D2 (82.4%) followed by D3 (16.2%) , D1 (1.1%) and D4 with (0.3%). Table 6 and graphs 4.

Table 6. frequency of bone density.

Bone Density	Frequency
D 1	4 (1.1%)
D 2	290 (82.4%)
D 3	57 (16.2%)
D 4	1 (0.3%)



Graph 4. Frequency of bone density.

Canal visibility of 100% was observed when the bone density was D1 and D2, however a decline in the visibility was noted with the bone densities of D3 and D4. Table 7 & 8.

Discussion

The MC is an anatomical structure that is located bilaterally within the mandible and extending from the mandibular foramen to the mental foramen carrying the inferior alveolar nerve, artery and vein.[8] For endosseous implant surgeries, the portrayal of MC on imaging tests is a prerequisite, because the available bone height of the edentulous site is determined by the distance between the

Table 7. comparison between the bone density and visibility in cs, coronal, sagittal sections.

Bone Density	PM		M	
	NV	V	NV	V
D 1	0	4 (100%)	0	4 (100%)
D2	0	290 (100%)	1 (0.3%)	289 (99.7%)
D3	30 (52.6%)	27 (47.4%)	35 (61.4%)	22 (38.6%)
D4	1 (100%)	0	1 (100%)	0
P value		< 0.001		< 0.001

*PM - premolar
*M - molar
*NV - non visible
*V - visible
*CS - cross sectional

Table 8. comparison between the bone density and visibility in axial section.

Bone Density	PM		M	
	NV	V	NV	V
D 1	0	4 (100 %)	0	4 (100%)
D2	0	290 (100%)	3 (1%)	287 (99%)
D3	30 (52.6%)	27 (47.4%)	37 (64.9%)	20 (35.1%)
D4	1 (100%)	0	1 (100%)	0
P Value		< 0. 001		< 0.001

*PM- premolar
*M – molar
*NV – non visible
*V – visible

alveolar ridge and the MC. The implant length is greatly influenced by the location of mandibular canal, therefore the visibility of the canal on CT or CBCT scans is paramount to prevent operative complications at mandibular implant sites.[9] The identification of the MC on imaging tests is a delicate process as the radiographic appearance usually involves a radiolucent zone lined by superior and inferior corticated borders. The cortication of the canal may be variable even within the same individual giving a possible explanation of difficult visualization in some cases. Even though, the MC has been identified as a radiolucent zone lined by radiopaque borders on radiographs, distinct bony-walled channels having definite borders do not seem to be a regular feature. The MC walls are typically not composed of compact bone. Instead, they are formed by a coalescence of trabecular bone,[10 11 12 13] ranging from dense to very delicate structures. In addition, the trabeculation can also differ among individuals and also among different locations within the mandible.

Previous researches have examined the visibility of the mandibular canal using panoramic radiography, computed tomography, or cone-beam computed tomography (CBCT). CBCT was found to be superior

to panoramic images for the identification of the mandibular canal because of its ability to visualize the canals at different sections and at different planes. The quality of the image and the contrast between adjacent structures are one of the essential factors in the recognition of various landmarks. The precision of multi-slice CT in the analysis of significant anatomical landmarks, such as the mandibular canal pathway, has been shown. CBCT has been attested as well suited for imaging of the maxillofacial area, displaying high contrast, thus extremely useful for evaluation of bone. Cancellous bone is more sharply visualized in the Cross-sectional images of CBCT than Spiral CT.

Angelopoulos *et al*[14] compared digital and conventional panoramic radiographs and CBCT - reformatted panoramic images in the visibility of the MC in various regions of the mandible. CBCT imaging was considered superior to other modalities for evaluating visibility of the MC, despite the location.

An overall satisfactory visibility of the canal was observed for cross sectional, coronal and sagittal sections however the canal visibility was slightly lesser in the axial sections. The result of the study was supported by a study conducted by Oliveira-Santos et al[6] in which CBCT cross-sectional images of 58 patients (116 hemi-mandibles) were analyzed, and the visibility of the MC in different regions was assessed. The results of the study showed that MC was clearly visible in 53% of the hemi-mandibles. However the identification of the canal was not readily feasible in 47% of the canals. This may indicate that deciding which hypodense area that may correspond to the actual MC on CBCT images might be a difficult task.

Lofthag- Hansen, et al[15] in the year 2008 evaluated the visibility of the mandibular canal in CBCT cross sectional images and found that in a predetermined cross sectional image, the MC was found to be clearly visible in only one-third of the cases. The visibility also increased when the canals were assessed in more images. Hence the results points out the need to assess every sequential images in order to improve the localization of the MC.

In another study done by Carter & Keen,[16] it was found that the neurovascular components within the mandibular canal may spread out and a distinct bony- walled channel with a definite border might not seem to be regular feature. These results point out that some degree of difficulty might be experienced in the identification of the mandibular canal on imaging exams.

When determining the factors that affect the visibility of the mandibular canal, age was considered as one of the factor and the results demonstrates that canal visibility was observed highest for the younger age groups and the least for sub group D that is (58-70 years) in all sections of CBCT images. The results of the present study can be supported by the fact that with advancing age the overall bone quality subsequently decreases causing reduction in the visibility of canal walls.

When comparing the visibility with that of the gender, it was found that better canal visibility was observed for the male gender when compared to the female gender in the cross sectional, coronal, sagittal and the axial sections. Miles *et al*[1] conducted a similar study in which CBCT images were evaluated for the visibility o f the MC. 360 total CBCT cross-sectional images were examined, with the MC identified in 204 sites. Age and gender had a significant effect on MC visibility. For age 65+ molar regions showed lower visibility than premolar region and females had lower visibility compared to males thus concluding MC was visualized only in just over half of the CBCT images. Age, gender and location had significant effects on the visibility which was in accordance with the results of our study. The overall reduction in canal visibility for the female gender can also be attributed to the fact that generally in females the overall bone quality decreases with increasing age mainly due to the physiological osteoporotic effect of estrogen and due to other hormonal influences. Females show estrogen related bone loss starting at menopause predominantly affecting the trabecular pattern of bone leading to overall decrease in bone quality.

Bone density also had considerable effect on canal visibility in the present study, canal visibility of 100% was observed when the bone density was D1 and D2, however a decline in the visibility was noted with the bone densities of D3 and D4. A correlation between the alveolar bone quality and canal walls have been indicated in radiological studies. In a study conducted by Wadu *et al*[7] it was found that the mandibular canal is usually formed by a thin trabecular bone with many circumferentially located voids. The radiopaque border of the canal can be disrupted in radiographic images. Decreased visibility of the canal wall on radiographs could suggest lower integrity of the wall and decreased bone trabeculation. These trabeculations can also vary within different locations in the same mandible.

In conclusion, the visibility of the mandibular canal exhibited good visibility in the cross sectional, coronal and sagittal sections with a slightly lesser visibility in the molar regions of the axial sections. Furthermore factors like age, gender and bone density also had significant effects on canal visibility.

Conclusion

The present study was done to assess the visibility of the mandibular canal in CBCT images and to know if the visibility is affected by factors

like age, gender and bone density. The conclusion of this retrospective study was that the mandibular canal demonstrated an overall satisfactory visibility in the cross-sectional, coronal and sagittal sections however the visibility was lesser in the axial sections. Considering the visibility of the mandibular canal in our study sample, one should take into account the visualization and identification of the mandibular canal preoperatively so as to avoid any neurosensory disturbances and careful evaluation of the implant site is necessary to avoid impingement or violation of vital structures.

Factors like age, gender and bone density had significant effects on canal visibility. Canals were visualised more for younger age groups that is 18-31 years of age and visibility was observed least for age groups of 58-70 years. With regard to gender, better canal visibility was observed for the male gender than that of female gender. Visibility was also affected by bone densities. Bone densities of D1 and D2 demonstrated good visibility than D3 and D4.

References

1. Miles MS, Parks ET, Eckert GJ, Blanchard SB. Comparative evaluation of mandibular canal visibility on cross-sectional cone-beam CT images: a retrospective study. Dentomaxillofacial Radiology.2016,Nov;45:1-7.
2. Haas LF, Dutra K, Porporatti AL, Mezzomo LA, De Luca Canto G, Flores-Mir C, *et al*. Anatomical variations of mandibular canal detected by panoramic radiography and CT: a systematic review and meta-analysis. Dentomaxillofac Radiol 2016;
3. Kilic C, Kamburoglu K, Ozen T, Balcioglu HA, Kurt B, Kutoglu T, *et al*. The position of the mandibular canal and histologic feature of the inferior alveolar nerve. Clin Anat 2010; 23: 34–42.
4. Kobayashi K, Shimoda S, Nakagawa Y, Yamamoto A. Accuracy in measurement of distance using limited cone-beam computerized tomography. Int J Oral Maxillofac Implants. 2004;19:228-31.
5. Kassebaum DK, Nummikoski PV, Triplett RG, Langlais RP. Crosssectional radiography for implant site assessment. Oral Surg OralMed Oral Pathol 1990.
6. Oliveira-Santos C, Capelozza ALÁ, Dezzoti MSG, Fischer CM, Poleti ML, Rubira-Bullen IRF. Visibility of the mandibular canal on CBCT cross-sectional images. J Appl Oral Sci. 2011,Jun;19(3):240–3.
7. Wadu SG, Penhall B, Townsend GC. Morphological variability of the human inferior alveolar nerve. Clin Anat 1997; 10:82-7.
8. Juodzbalys G, Wang H, Sabalys G. Anatomy of mandibular vital structures. Part I: mandibular canal and inferior alveolar neurovascular bundle in relation with dental implantology. J Oral Maxillofac Res 2010.
9. Mehra A, Pai KM. Evaluation of dimensional accuracy of panoramic cross-sectional tomography, its ability to identify the inferior alveolar canal, and its impact on estimation of appropriate implant dimensions in the mandibular posterior region. Clin Implant Dent Relat Res.2012.
10. Denio D, Torabinejad M, Bakland LK. Anatomical relationship of the mandibular canal to its surrounding structures in mature mandibles. J Endod. 1992;18:161-5.
11. Gowgiel JM. The position and course of the mandibular canal. J Oral Implantol. 1992;18:383-5
12. Monsour PA, Dudhia R. Implant radiography and radiology. Aust Dent J. 2008.
13. Naitoh M, Katsumata A, Kubota Y, Hayashi M, Ariji E. Relationship between cancellous bone density and mandibular canal depiction. Implant Dent. 2009;18:112-8.
14. Angelopoulos C, Thomas SL, Hechler S, Parissis N, Hlavacek M. Comparison between digital panoramic radiography and cone-beam computed tomography for the identification of the mandibular canal as part of presurgical dental implant assessment. J Oral Maxillofac Surg. 2008 Dec;66(12):2657.
15. Lofthag-Hansen S, Gröndahl K, Ekestubbe A. Cone-beam CT for preoperative implant planning in the posterior mandible: visibility of anatomic landmarks. Clin Implant Dent Relat Res.2009;11.
16. Carter RB, Keen EM. The intramandibular course of the inferior alveolar nerve. J Anat. 1971;108:433-40.

Mini Curriculum and Author's Contribution

1. Prashanth Shenoy K MDS, Professor and Head of the Department, Department of Oral Medicine and Radiology, Yenepoya dental College, Yenepoya (deemed to be University) Mangalore Karnataka India ORCID ID: 0000-0002-3693- 9963.

2. Jeslin James MDS, Assistant Professor, Department of Oral Medicine & Radiology , Annoor Dental College & Hospital, Kerala, India. ORCID ID: 0009-0006-7808-0778.

3. Veena KM MDS, Professor, Department of Oral Medicine and Radiology , Yenepoya dental College, Yenepoya (deemed to be University) Mangalore Karnataka, India ORCID ID: 0000-0003- 3395- 7848.

4. Rachana V Prabhu MDS, Additional Professor, Department of Oral Medicine and Radiology , Yenepoya dental College, Yenepoya (deemed to be University) Mangalore Karnataka, India ORCID ID: 0000-0001-5801-6732.

5. Prathima Shetty MDS, Additional Professor, Department of Oral Medicine and Radiology, Yenepoya dental College, Yenepoya (deemed to be University) Mangalore Karnataka, India ORCID ID: 0000-0003-2695-7700.

Received: November 30, 2023
Accepted: December 23, 2023

Corresponding author
Jeslin James
E-mail: drjeslinjames.09@gmail.com