Assessing the Variation in Course and Position of Inferior Alveolar Nerve among South Indian Population: A Cone Beam Computed Tomographic Study

Abstract
Background: Trauma to the inferior alveolar nerve (IAN) is one of the complications during surgical procedures in the posterior mandible. Most of the time, this is due to inaccurate assessment of an operator from conventional radiographs. Lately, with the availability of advanced imaging techniques such as cone beam computed tomography (CBCT), precise location of anatomic structures has become a reality. This study was designed to evaluate the course and position of IAN in relation to the alveolar crest, buccal cortical bone, lingual cortical bone, and inferior border of the mandible using CBCT in South Indian population. Materials and Methods: A total of 139 CBCT scans were assessed using sagittal section done at every 5-mm interval beginning 1 mm posterior to the mental foramen extending till the anterior border of the ramus. Measurements were made on sectional images as CN – alveolar crest to the nerve, BN – buccal cortex to the nerve, LN – lingual cortex to the nerve, and IN – inferior border to the nerve. Results: IAN showed a wavy pattern from posterior to anterior in relation to the alveolar crest and was positioned inferiorly in males when compared to females at Section one of CN1 (P = 0.004). IAN was more away from the lingual cortex in dentulous compared to partially dentulous group (P = 0.003). Females showed more bone present lingual to nerve near the first molar region. Gender and presence or absence of dentition had an influence on overall results. Conclusion: There is a considerable variation in the position of IAN throughout its course in the mandible. Henceforth, advanced diagnostic images such as CBCT should be strongly recommended in evaluating the position of IAN preoperatively before advanced implant surgical techniques, nerve repositioning, and any other surgical procedures.

Keywords: Cone beam computed tomography, implant guidance, inferior alveolar nerve, nerve repositioning

Introduction
Dental implant has become one of the most common procedures practiced to replace missing teeth. For placement of dental implants, locating and assessing the vicinity of various anatomical structures in relation to a planned surgical site play a crucial role. Among these structures, the location of mental foramen, inferior alveolar nerve (IAN), and its course need to be assessed to determine the available bone height for implant placement and also to avoid neurosensory disturbances.[1,2] Apart from the implant surgery, assessing the assorted anatomic structures is critical during different surgical procedures such as autogenous block grafts, nerve transposition, removal of impacted third molars, sagittal split osteotomies, and orthodontic mini-implants.[3,4] The current information available in the literature regarding the course and the location of IAN was mostly obtained from cadaver sections and by conventional radiography technique.[6-9] Gowgiel et al. on cadaver sections reported that external surface of the buccal plate has usually been half a centimeter in the molar and premolar regions from the nerve. In another survey, dentists were asked to assess the distance of the nerve to the crest using two-dimensional image; 47% of the subjects underestimated and 38% overestimated the distance, thus resulting in over- or under-estimating the implant size.[10]

There seems to be a lot of variation in the available data regarding the course of IAN. This could be due to the use of two-dimensional images such as intraoral periapical radiograph or orthopantomograph, which lack in precisely locating anatomic

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structures. To obtain three-dimensional view, initially, computed tomographic (CT) scans were used to assess the IAN and other anatomical structures in the mandible.\cite{11-13} Lee et al. in their study assessed the proximity between the mandibular third molar and IAN using CT and confirmed that it could be used as an effective diagnostic tool to prevent IAN damage during surgical procedures. A recent study also assessed the quantity of bone present surrounding the IAN canal using CT.\cite{14} Although CT provides sufficient information regarding the anatomical structures, it also invariably exposes patients to unnecessary excessive radiation. With the development of cone beam computed tomography (CBCT), the errors produced in conventional radiography can be eliminated and the excessive radiation produced in the CT could be reduced. To our knowledge, there were no data reported regarding the course of IAN, its comparison between genders, dentulous and partially dentulous group, and different age groups using CBCT in case of South Indian population. Thus, this study aims at assessing the variation in course and position of IAN among the South Indian population using CBCT.

**Materials and Methods**

A total of 139 CBCT scans (106 males and 33 females) were obtained from the Radiology Department, Saveetha Dental College, Chennai. The scans that are exclusively from South Indian population with one or two missing teeth in the mandible within the age group of 15–75 were included. Scans that demonstrate any pathologic defects in the bone, periodontal bone defects, and children were excluded. Ethical clearance was obtained from the institutional ethical committee and scientific review board holding a number STP/SDMDS15PER18.

CBCTs were categorized into three groups based on patient’s age. Group I is of age between 15 and 35 years, group II is of age between 36 and 55 years, and group III is of age between 55 and 75 years. Scans were also subcategorized to account for individuals with missing teeth in the posterior mandible \((n = 100)\) and those without missing teeth \((n = 39)\). Patients were considered to have missing in the event that they had \(\geq 1\) tooth missing posterior to the mental foramen and no missing teeth if they had all posterior teeth in that sextant, except the third molars. Among total number of patients, 79 fall under Group I, 35 under Group II, and 25 under Group III.

All the CBCTs were obtained from a single source using the following acquisition parameters with a tube volume of 85 kV and tube current of 13 mA. Initially, the images were viewed on the screen and checked for the presence or visibility of the canal on both the sides. In each patient’s CBCT, sagittal sections of the mandible were done on both sides at 5 mm intervals, beginning 1 mm posterior to the mental foramen extending till the anterior border of the ramus. These sections were taken on each right and left side of the mandible.

Due to variable anteroposterior dimensions of the mandibular segment, the first six sagittal sectional images were obtainable from all the 139 CBCTs. These sagittal sectional images correspond to the location extending from 1 mm posterior to the mental foramen to a location of the second molar posteriorly. Only these six sagittal sectional images are taken into consideration since it represents the most common sites for the placements of dental implants [Figure 1].

The images were analyzed and the measurements were done using the tools given in the proprietary software (Sirona Galaxis Galileos Viewer Version 1.9, Sirona dental systems, GmbH, Bensheim, Germany). A single examiner performed all the measurements to eliminate error in measuring. To gain expertise in measuring the sections, measurements were drawn initially on 15 CBCT scans before the start of the study.

The following four measurements were recorded at each sagittal sectional image as follows: (1) CN – from the alveolar crest to the bone directly superior to 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 sagittal section was used to measure the distance of the external surface of the canal to all the four borders [Figure 2].

The obtained data were analyzed using two-way analysis of variance (ANOVA). The dependent variables were CN, BN, LN, and IN. Independent categorical variables were age, sex, and missing teeth.

**Statistical analysis**

A computer software program IBM SPSS version 16 was used to do a statistical test for the study. The tests that were conducted were one-way ANOVA, post hoc test, and independent \(t\)-test. Confidence interval (95%) was calculated in a two-tailed manner for CN, BN, LN, and IN and included measurements for sagittal sectional images 1–6. Statistical significance was determined using \(\alpha = 0.05\).

**Results**

In all the 139 CBCT scans, the mandibular canal and mental foramen were clearly identified. The average of all the parameters such as CN, BN, LN, and IN showed the position and course of the IAN in relation to alveolar crest, buccal cortex, lingual cortex, and inferior border of the alveolar bone, respectively. The results from our study showed that the average value of CN was \(15.14 \pm 3.21\) mm at 6th section and then dropped to \(14.89 \pm 2.91\) mm at 5th section, and there was a gain in the value at 4th section which was \(15.38 \pm 5.37\) mm with sudden decrease observed at section 3 as \(14.75 \pm 3.02\) mm. Since then, it showed a steady rise across 2nd and 1st section as \(14.93 \pm 2.72\) mm and \(15.14 \pm 2.70\) mm, respectively [Figure 3]. When CN was compared between genders, interestingly, significant
difference was observed, where the IAN was positioned inferiorly in males when compared to females at section 1 \( (P = 0.004) \). However, when compared between different age groups (Group I, II, and III) as well as between dentulous and partially dentulous patients, there was no statistically significant difference observed.

On evaluating BN, it was \( 4.47 \pm 1.39 \) mm at section 6 and demonstrated a gradual increase at section 5 \( (4.94 \pm 1.21 \) mm) and at section 4 \( (5.31 \pm 1.28 \) mm) after which it reduced to \( 5.09 \pm 1.27 \) mm, \( 4.65 \pm 1.22 \) mm, and \( 4.12 \pm 1.66 \) mm at consecutive sections, respectively [Figure 3]. BN showed no statistically significant difference between different age groups, genders, as well as between dentulous and partially dentulous patients.

The average value of LN was \( 2.21 \pm 1.01 \) mm at section 6 and decreased to \( 2.14 \pm 0.82 \) mm at section 5, and then, there was a steady increase from section 4 \( (2.32 \pm 1.65 \) mm) till section 1 \( (3.24 \pm 1.12 \) mm) [Figure 3]. At section 5, the IAN was more away from lingual cortex in dentulous group when compared to partially dentulous group which was statistically significant \( (P = 0.003) \). However, there was no statistically significant difference observed between genders and between different age groups.

With respect to IN, the average value at section 6 was \( 7.44 \pm 1.93 \) mm and there was a steady decrease till section 3 \( (6.82 \pm 1.42 \) mm). Since then, there is a steep increase from section 2 to section 1 as \( 7.21 \pm 1.63 \) mm and \( 7.64 \pm 1.93 \) mm, respectively [Figure 3]. At 2\textsuperscript{nd} section \( (P = 0.001) \) and 5\textsuperscript{th} section \( (P = 0.005) \), the dentulous group showed the position of the IAN at a higher level which was statistically significant when compared to the partially dentulous group. Similar to LN, IN also showed no significant difference between different age groups, genders when compared.

The lower bound of 95% confidence interval was determined for males and females in sextants with and without missing teeth and is tabulated [Tables 1 and 2]. This was done to assess the risk of injury to the IAN associated with surgical procedures in the posterior mandible. The values obtained were quite low, suggesting

**Table 1: Lower bound 95% class interval for alveolar crest to the nerve**

|          | CN1  | CN2  | CN3  | CN4  | CN5  | CN6  |
|----------|------|------|------|------|------|------|
| Males    |      |      |      |      |      |      |
| missing  | 4.43 | 4.88 | 5.24 | 5.38 | 5.01 | 4.42 |
| teeth    |      |      |      |      |      |      |
| Females  |      |      |      |      |      |      |
| missing  | 4.71 | 4.42 | 4.59 | 5.10 | 4.73 | 4.77 |
| teeth    |      |      |      |      |      |      |
| Males    |      |      |      |      |      |      |
| nonmissing | 3.45 | 4.33 | 4.81 | 5.21 | 4.93 | 4.55 |
| teeth    |      |      |      |      |      |      |
| Females  |      |      |      |      |      |      |
| nonmissing | 3.86 | 4.48 | 5.08 | 5.21 | 4.83 | 4.39 |

The bone directly lateral to the IAN to the CN. Missing teeth \( \geq 1 \) missing teeth posterior to mental foramen excluding third molars. IAN=Inferior alveolar nerve, CN=Alveolar crest to the nerve

**Table 2: Lower bound 95% class interval for buccal cortex to the nerve**

|          | BN1  | BN2  | BN3  | BN4  | BN5  | BN6  |
|----------|------|------|------|------|------|------|
| Males    |      |      |      |      |      |      |
| missing  | 15.54| 14.89| 14.54| 14.74| 14.89| 15.38|
| teeth    |      |      |      |      |      |      |
| Females  |      |      |      |      |      |      |
| missing  | 12.95| 13.57| 13.5 | 13.88| 15.4 | 16.82|
| teeth    |      |      |      |      |      |      |
| Males    |      |      |      |      |      |      |
| nonmissing | 15.7 | 16.15| 15.89| 15.87| 15.35| 16.05|
| teeth    |      |      |      |      |      |      |
| Females  |      |      |      |      |      |      |
| nonmissing | 14.29| 14.02| 14.19| 14.31| 14.2 | 14.46|

The bone directly lateral to the IAN to the BN. Missing teeth \( \geq 1 \) missing teeth posterior to mental foramen excluding third molars. IAN=Inferior alveolar nerve, BN=Buccal cortex to the nerve
Discussion

CBCT technology offers a sophisticated imaging modality that clinicians utilize as an adjunct to conventional dental radiography. It can be used to determine the status of the various anatomic structures in the proposed implant site and how to best advance the implant placement considering the prosthetic needs. In this study, measurements were made from the outer surface of the IAN canal to the crest, inferior border, buccal, and lingual cortical plates of the mandible, and a comparison was made among genders, dentulous and partially dentulous areas, and different age groups. There have been numerous studies in the literature depicting the course of the IAN in the mandible. To our knowledge, this is the first study to assess the course and the quantity of bone present surrounding the inferior alveolar canal using CBCT in South Indian population.

The data obtained from the present study demonstrated high level of variability found in CN values, which concurs well with other studies. In our study, IAN is positioned inferiorly in relation to alveolar crest at the posterior region (representing 1st and 2nd molar region) of the mandible that presents a wavy pattern as it courses anteriorly. A study by Yashar et al. supports our results where they showed that the nerve position is most inferiorly placed at the most posterior segment and moved into a superior position of the adjacent segment and then maintained a steady straight course till it enters the mental foramen. Contradicting to these, Ulm et al. reported that the course of the nerve does not follow a wavy pattern; instead, it shows a steady rise in the position of nerve in relation to the alveolar crest from posterior to anterior segment. The results obtained in our study could be as a result of assessing less number of CBCT scans. From our results, it could be suggested that, in case of full-mouth rehabilitation with all on six implants, the posterior implants can be placed preferably at first molar region and also it could be used as a site for procuring the autogenous bone graft using the trephine. There seems to be high risk of injury to IAN in females than males where the crestal bone was less in females. This is in agreement with the earlier studies.

When buccal cortex was evaluated, the nerve is positioned more lingually in relation to the second premolar and first molar region where more amount of buccal bone was present. This is similar to other studies, where more buccal bone was reported near the second premolar and first molar in both cadaver and CT sections. However, a recent study contradicts with this results, where more amount of bone was present near the second molar region.

In case of compromised ridges where there is a chance of impingement of IAN during implant placement, nerve repositioning procedure is commonly done. The knowledge of the position of IAN in relation to the buccal cortex ensures the surgeon to adequately plan the surgical entry through buccal cortex to reach IAN without injuring the nerve. Thus, CBCT could be a valuable tool in planning for such surgical procedure.

With respect to the lingual cortex, the nerve is positioned more buccally in relation to premolars and first molar where more amount of bone was present. This probably could be due to consistent remodeling owing to the oral musculature attachments in that region. The results of this study are in correlation with the previous study.

When dentulous and partially dentulous was compared, females with missing teeth show a greater width from lingual cortical plate to the outer surface of mandibular canal in all the scans. This can be due to either a shift in the position of the canal to the buccal side or more bone deposition had taken place in patients with missing posterior teeth.

In current circumstances, two-dimensional imaging techniques are still being used widely to evaluate the position of IAN, yet the disadvantage being that the exact position of anatomic structures cannot be perceived in a two-dimensional image and the measurement of available bone above the nerve for accurately choosing an implant is difficult. Therefore, three-dimensional imaging techniques such as CT and CBCT should be used to assess the quantity of bone present surrounding the IAN. The reason behind not using the three-dimensional imaging modality widely could be either due to the nonaccessibility of CT and CBCT in the places where the clinics are situated or absence of knowledge for a dental practitioner in analyzing the anatomic structures using these advanced imaging aids. Although CT produces three-dimensional images, it results in more radiation exposure when compared to CBCT which suggests CBCT should be a better option for planning implant placement.

Conclusion

Due to the fact that the CBCT images were reformatted slices, they were free of magnification errors, superimposition of neighboring structures, and other problems inherent to panoramic radiographs. This may result in very clear images that best depict the anatomical structures. Within the limitations of the study, it shows that CBCT is a reliable imaging modality to analyze IAN and other anatomical structures during surgical procedures. It is wise to conclude that CBCT should be recommended for planning advanced implant surgical procedures on a routine basis. We further suggest an evaluation of IAN in different races using CBCT to assess for the change in course and position of these anatomic structures.

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Conflicts of interest

There are no conflicts of interest.

References

1. Kieser J, Kieser D, Hauman T. The course and distribution of the inferior alveolar nerve in the edentulous mandible. J Craniomaxillofac Surg 2005;16:6-9.

2. Wadu SG, Penhall B, Townsend GC. Morphological variability of the human inferior alveolar nerve. Clin Anat 1997;10:82-7.

3. Juodzbalys G, Wang HL, Sabalys G. Injury of the inferior alveolar nerve during implant placement: A Literature review. J Oral Maxillofac Res 2011;2:e1.

4. Hassani A, Kalantar Motamedi MH, Saadat S. Inferior alveolar nerve transpositioning for implant placement. A Textbook of Advanced Oral and Maxillofacial Surgery. Ch. 25. Iran: InTech; 2013.

5. Teerijoki-Oksa T, Jääskeläinen SK, Forssell K, Forssell H, Vähätalo K, Tammisalo T, et al. Risk factors of nerve injury during mandibular sagittal split osteotomy. Int J Oral Maxillofac Surg 2002;31:33-9.

6. Gowgiel JM. The position and course of the mandibular canal. J Oral Implantol 1992;18:383-5.

7. Ulm CW, Solar P, Blahout R, Matejka M, Watzek G, Gruber H, et al. Location of the mandibular canal within the atrophic mandible. Br J Oral Maxillofac Surg 1993;31:370-5.

8. de Morais JA, Sakakura CE, Loffredo Lde C, Scaf G. A survey of radiographic measurement estimation in assessment of dental implant length. J Oral Implantol 2007;33:186-90.

9. Ramesh AS, Rijesh K, Sharma A, Prakash R, Kumar A, Karthik, et al. The prevalence of mandibular incisive nerve canal and to evaluate its average location and dimension in Indian population. J Pharm Bioallied Sci 2015;7:S594-6.

10. Lee B, Park Y, Ahn J, Chun J, Park S, Kim M, et al. Assessment of the proximity between the mandibular third molar and inferior alveolar canal using preoperative 3D-CT to prevent inferior alveolar nerve damage. Maxillofac Plast Reconstr Surg 2015;37:30.

11. Schwartz MS, Rothman SL, Rhodes ML, Chafetz N. Computed tomography: Part I. Preoperative assessment of the mandible for endosseous implant surgery. Int J Oral Maxillofac Implants 1987;2:137-41.

12. Rothman SL, Chafetz N, Rhodes ML, Schwartz MS. CT in the preoperative assessment of the mandible and maxilla for endosseous implant surgery. Work in progress. Radiology 1988;168:171-5.

13. Yashar N, Engeland CG, Rosenfeld AL, Walsh TP, Califano JV. Radiographic considerations for the regional anatomy in the posterior mandible. J Periodontol 2012;83:36-42.

14. Lee CI, Haims AH, Monico EP, Brink JA, Forman HP. Diagnostic CT scans: Assessment of patient, physician, and radiologist awareness of radiation dose and possible risks. Radiology 2004;231:393-8.

15. Jacobs R, Mraiwa N, vanSteenberghe D, Gijbels F, Quirynen M. Appearance, location, course, and morphology of the mandibular incisive canal: An assessment on spiral CT scan. Dentomaxillofac Radiol 2002;31:322-7.

16. Agthong S, Huanmanop T, Chentanez V. Anatomical variations of the supraorbital, infraorbital, and mental foramina related to gender and side. J Oral Maxillofac Surg 2005;63:800-4.

17. Hausmann E. Radiographic and digital imaging in periodontal practice. J Periodontol 2000;71:497-503.

18. Klinge B, Petersson A, Maly P. Location of the mandibular canal: Comparison of macroscopic findings, conventional radiography, and computed tomography. Int J Oral Maxillofac Implants 1989;4:327-32.

19. Lindh C, Petersson A. Radiologic examination for location of the mandibular canal: A comparison between panoramic radiography and conventional tomography. Int J Oral Maxillofac Implants 1989;4:249-53.

20. Kieser JA, Paulin M, Law B. Intrabony course of the inferior alveolar nerve in the edentulous mandible. Clin Anat 2004;17:107-11.

21. Stella JP, Tharanon W. A precise radiographic method to determine the location of the inferior alveolar canal in the posterior edentulous mandible: Implications for dental implants. Part 1: Technique. Int J Oral Maxillofac Implants 1990;5:15-22.

22. Massey ND, Galil KA, Wilson TD. Determining position of the inferior alveolar nerve via anatomical dissection and micro-computed tomography in preparation for dental implants. J Can Dent Assoc 2013;79:d39.

23. Massey ND, Galil KA, Wilson TD. Determining position of the inferior alveolar nerve via anatomical dissection and micro-computed tomography in preparation for dental implants. J Can Dent Assoc 2013;79:1-7.

24. Balaji SM, Krishnaswamy NR, Kumar SM, Roobhan T. Inferior alveolar nerve canal position among South Indians: A cone beam computed tomographic pilot study. Ann Maxillofac Surg 2012;2:51-5.

25. American Dental Association Council on Scientific Affairs. The use of cone-beam computed tomography in dentistry: An advisory statement from the American Dental Association Council on Scientific Affairs. J Am Dent Assoc 2012;143:899-902.