Reliability of Cone Beam Computed Tomography in Comparison with Panoramic Radiography to Predict the Anatomical Relationship of Inferior Alveolar Nerve with Mandibular Third Molar: A Radiological and Clinical Study

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Objectives: The purpose of the study was to assess the precision of cone beam computed tomography (CBCT) in comparison with panoramic radiography in determining the anatomical relationship of inferior alveolar nerve (IAN) with the impacted mandibular third molar. Materials and Methods: Twenty patients diagnosed with the following panoramic radiographic markers: darkening of the root, interruption of white line of mandibular canal, diversion of mandibular canal, and narrowing of the roots suggesting a close relationship of roots with the mandibular canal were selected and underwent an additional CBCT to assess the proximity of IAN to mandibular third molar roots. All patients were assessed for loss of sensation or neurosensory deficit in the chin and lower lip during postoperative period by objective and subjective methods. Results: Twenty patients with an average age of 25.4 years (21–39 years) with 21 impacted mandibular third molars were included in this sample. It was found that after the removal of impacted third molars, IAN was not visible in any of the cases and postoperative objective and subjective neurosensory tests showed no signs of neurosensory disturbances. Conclusion: The study found that CBCT had limited usefulness in neurovascular bundle exposure prediction, prior to surgical removal of impacted mandibular third molars. The accuracy of radiographic markers in conventional panoramic radiography to predict neurovascular exposure was also limited.

Keywords: Cone beam computed tomography, inferior alveolar nerve, mandibular third molar

INTRODUCTION

Removal of third molar by surgical method forms the mainstay of day-to-day maxillofacial surgical practice. The most common risk factor following removal of third molar includes injury to inferior alveolar nerve (IAN) with an overall risk of temporary IAN injury ranging from 0.4% to 8.4%[1-3] and that of permanent injury approximately 0.2%–1%.[4] However, it was found that only 1% of the patients had permanent sensory impairment that lasted longer than 6 months.[5] The number of patients affected was high as the number of third molar’s removal was more. Moreover, the incidence of IAN damage has been found to increase up to 30% when the proximity between the mandibular third molar and the mandibular canal is...
closer as viewed radiographically.[4] Thus, assessment of the position and relationship of third molar with the mandibular canal was essential to minimize the risk of nerve injury preoperatively.[6]

Commonly used diagnostic tool for this purpose is panoramic radiography.[7] If any radiographic markers that suggest a close relationship between the third molar and the mandibular canal, which includes darkening of root, deflection of root, narrowing of root, diversion of canal, bifid root apex, narrowing of the canal, and interruption in white line of canal,[8-10] then a three-dimensional imaging modality can be used for a closer evaluation of the mandibular third molar and its relative position with respect to the mandibular canal.

If any of these factors are found on a pantomogram, indicating a close proximity of the canal to the tooth, it has been suggested that among the three-dimensional imaging modalities, cone beam computed tomography (CBCT) has been specifically introduced for use in dentistry in 1997 and has been considered to be more accurate in determining the relationship of mandibular third molar to the mandibular canal.[11,12] CBCT image voxels are same in all three dimensions. Thus, it is possible to reorient the images as well as perform real-time measurements.[13] Also, CBCT is found to reduce the level of metal artifact when related to conventional CT, especially in the reconstructed images of the mandibular and maxillary dentition. CBCT is superior in terms of image reproducibility, quality, validity, and reduced radiation exposure when associated with conventional CT.[13] A single panoramic radiograph provides an equivalent radiation dose of approximately 3–44 times that of CBCT.[14] The amount of radiation depends on the manufacturer, scan time, tube voltage, tube current radiation source, voxel size, and field of view.[13]

These higher three-dimensional imaging modalities require significantly higher radiation exposure, which may be unnecessary and unwarranted if conventional imaging modalities are of considerable diagnostic value.[15]

It is, therefore, necessary to justify the use of CBCT and to assess if CBCT can give more accurate and comprehensive details as compared to the conventional imaging technique to justify the additional radiation exposure.

Thus, this study was designed to determine the accuracy of CBCT in comparison to panoramic radiography in studying the close relationship of IAN with the impacted mandibular third molar.

**Materials and Methods**

The study was approved by our institutional ethical committee.

**Patients and data collection**

This was a prospective study conducted on patients aged between second and fourth decades with impacted mandibular third molar on one or both sides. Twenty patients (11 women and 9 men) with an average age of 25.4 years (ranging from 21 to 39 years) were chosen from the group diagnosed of having the following characteristics: darkening of the root, interruption of the white line of mandibular canal wall, diversion of the mandibular canal, and narrowing of the roots on panoramic radiographs suggesting a close relationship of the tooth root with the mandibular canal. These patients underwent an additional three-dimensional evaluation using CBCT. Radiographic suggestion of cyst and those who exceeded the time interval of 6 months between imaging and third molar removal were not included in the study.

All patients were educated about the procedure, the probable difficulties that can occur after removal of third molar, and an informed written consent along with detailed case history was obtained.

The study purpose was explained to the operating surgeon and the presence or absence of neurovascular bundle exposure at the end of the surgical procedure was asked to be noted.

Under local anesthesia (lignocaine hydrochloride 1:200,000), removal of third molar by a single oral and maxillofacial surgeon was performed. After raising the mucoperiosteal flap, buccal and distal bones were removed with a bur, and the sectioning of tooth was carried out if necessary. Thorough examination of the surgical site was carried out after proper rinsing and isolation of surgical site to check whether IAN was exposed. The socket was sutured following the procedure using 3-0 black silk sutures. Following the procedure, postoperative instructions were given and possibility of various complications was explained.

All patients were assessed for the sensation in the lip and chin during postoperative appointment after 7 days during suture removal by subjective and objective methods for the occurrence of postoperative dysesthesia. Unoperated mucosal and cutaneous areas were chosen as control areas.

The following tests were used for determining the neurosensory deficit:

*Two point discrimination test:* With controlled pressure on the skin, a caliper device was placed on the patient
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and asked if he or she could sense one or two points. The minimum separation that was consistently reported as two points was termed as two-point discrimination threshold. The normal distance that can be perceived as two separate points is 6 mm.

Pin prick test: A 23-gauge needle was used to test for pressure sensation and the level of anesthesia or paresthesia was noted. Pain perception was evaluated by using needle to the skin by fast pricking movements. The patient was asked if any change was felt bilaterally after pricking both sides.

Direction of movement test: With patient’s eyes closed, a Von Frey's filament was used to stroke the region of the chin left and right and the patient’s ability to feel the sensation and judge the direction of movement was recorded.

Light-touch assessment: A gentle touch was made randomly with a wisp of cotton and the area was mapped moving outside in small steps.

Imaging system specifications
Digital panoramic radiographs were obtained with Kodak 9000 system (Care Stream Health, Rochester, New York) and CBCT with Kodak digital imaging system.

Evaluation of images
CBCT and panoramic images were shown to two trained oral and maxillofacial surgeons in an arbitrary order; both the images were evaluated independently.

Panoramic radiographs and its radiographic markers were looked into and CBCT images were assessed in three dimensions using Kodak software to see if there is a breach in cortical layer between third molar and mandibular canal.

Results
Twenty-one impacted mandibular third molars from 20 patients (11 women and 9 men) with an average age of 25.4 years (ranging from 21 to 39 years) were included in the study.

Following removal of all the 21 impacted third molars, IAN exposure was not exposed in any of the cases immediately following the procedure and postoperative neurosensory disturbance assessed using various objective and subjective neurosensory tests showed no signs of neurosensory disturbance.

The $\kappa$ value in the assessment of contact between the third molar root and the mandibular canal on CBCT images was 0.78.

On CBCT, 60% of the cases did not show any bone between root of third molar and mandibular canal, but none of these cases as predicted resulted in the postoperative neurosensory deficit [Table 1].

The radiographic signs, darkening of the root, interruption of the mandibular canal wall, change in radiomorphology of mandibular canal, and change in radiomorphology of root were found in 40%, 100%, 35%, and 30% cases, respectively [Table 2], but none of the cases showed IAN exposure and neurosensory deficit representing that none of these radiographic signs could predict nerve exposure.

For CBCT, Kodak digital imaging system was used. In total, 60% of the cases on CBCT had no layer of cortical bone tissue between third molar root and mandibular, and none of these cases during surgical procedure showed an exposed neurovascular bundle [Graph 1] as well as postoperative dysesthesia [Graph 2] indicating the limited accuracy in predicting IAN exposure; however, it is highly reliable in determining the buccolingual position of the mandibular third molar.

Discussion
Most mandibular third molars can be safely removed without causing injury to the nerve; however, when a close relationship exists between the tooth and the canal, patients' needs to be informed prior about the possibility of nerve injury to both inferior alveolar and lingual nerve. A surgeon should be able to establish the risk and inform the patient prior to the procedure.[10] On the basis of the radiological observations, Rood and Shehab[8] have already identified the risk using a combination of periapical radiographs and panoramic radiographs.

| Table 1: Cone beam computed tomography results of mandibular third molar with mandibular canal |
|---|---|---|---|
| CBCT parameters | Positive | Negative |
| | $n$ | % | $n$ | % |
| Contact | 12 | 60 | 8 | 40 |
| No contact | 7 | 35 | 13 | 65 |
| CBCT = cone beam computed tomography |

| Table 2: Orthopantomogram results of mandibular third molar with mandibular canal |
|---|---|---|---|
| OPG | Positive | Negative |
| | $n$ | % | $n$ | % |
| Darkening of roots | 8 | 40 | 12 | 60 |
| Interruption of the mandibular canal wall | 20 | 100 | 0 | 0 |
| Change in radiomorphology of Mandibular canal | 7 | 35 | 13 | 65 |
| Change in radiomorphology of roots | 6 | 30 | 14 | 70 |
| OPG = orthopantomogram |
It is a known fact that a three-dimensional picture cannot be obtained using panoramic radiography; various studies have been performed to establish the relationship of panoramic radiographic signs, exposure of neurovascular bundle, or postoperative nerve dysfunction.

Studies on 1560 mandibular third molars were conducted by Rood and Shehab, who found that radiographic signs on pantomogram had significant chance of occurrence of postoperative dysesthesia. Tantanapornkul et al. reported that first four

Graph 1: Cone beam computed tomography (CBCT) results for nerve exposure

Graph 2: Cone beam computed tomography (CBCT) results for neurosensory evaluation
radiographic signs had a high risk of developing dysesthesia following extraction, which was similar to the studies reported by Sedaghatfar et al. However, Gomes et al. and Bell in their respective studies, reported limited usefulness of panoramic radiography. It has to be accepted that all these studies in common indicate that absence of radiographic signs provides a consistent conclusion but presence of these signs cannot be used as a reliable marker for prediction of nerve injury.

It is reported to have an injury incidence of 0.4%–8.4% after surgical removal of mandibular third molar and the presence of intact neurovascular bundle increases the chance of paresthesia to 20%–40%.

However, Susarala et al. found that no damage happened even on nerve exposure. Few studies have shown IAN exposure as an important risk factor for the occurrence of a postoperative IAN damage. Tay and Go found that nerve dysfunction was observed in 20% of the cases where IAN was exposed during surgery.

In his study, not find any postoperative loss of sensation in his study.

Tantanapornkul et al. showed a sensitivity of 93% and a specificity of 77%. When using CBCT in comparison to panoramic radiography, Ghaeminia et al. in their study, found a high sensitivity (96%) but a lower specificity (23%) for i-CAT CBCT.

According to this study, four panoramic features such as darkening of the root, interruption of mandibular canal wall, diversion of the canal, and narrowing of the root were found in 40%, 100%, 35%, and 35%, cases, respectively, but none of these signs as predicted was associated with IAN exposure or postoperative dysesthesia suggesting that these panoramic features may not contribute to prediction exposure.

For CBCT, Kodak digital imaging system was used. CBCT showed that 50% of the cases had no cortical layer between the mandibular canal and third molar root, but none of these cases during surgical procedure showed an exposed neurovascular bundle as well as postoperative dysesthesia indicating that CBCT when used as a predictor for ruling out nerve injury has limited usefulness in the selected high risk cases, but it was found to high reliability in determining the buccolingual position of the mandibular third molar. It is thus important to identify and avoid any pressure or unnecessary movements using instruments or elevators, also the decision to remove or perform coronectomy to prevent nerve injury. The patient can be more adequately informed about his or her risk profile. In this study, mandibular canal was more often positioned buccally (75%) to third molar root than lingually. This is in accordance with some studies, whereas others have found more mandibular canals positioned lingually to the third molar root. The position of the third molar in relation to mandibular canal was another factor for the absence of IAN exposure.

The study also showed limited accuracy of radiographic markers in conventional panoramic radiography. However, reliability of CBCT was high in predicting markers in conventional panoramic radiography. The study also showed limited accuracy of radiographic markers in conventional panoramic radiography. However, reliability of CBCT was high in predicting the buccolingual position of the mandibular canal with respect to third molar, which can identify cases in which a lingually placed IAN can have an injury. Panoramic radiography could thus be considered more reliable in excluding the close relationship between the third molar root and the nerve in the absence of these radiographic markers than in confirming the presence of a true relationship in the presence of these radiographic findings. The results of this study have to be considered primary, as the number of cases was limited and more detailed studies will be needed to authenticate its clinical usefulness.

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**Conflicts of interest**

There are no conflicts of interest.
REFERENCES

1. Güllicher D, Gerlach KL. Sensory impairment of the lingual and inferior alveolar nerves following removal of impacted mandibular third molars. Int J Oral Maxillofac Surg 2001;30:306-12.

2. Bataineh AB. Sensory nerve impairment following mandibular third molar surgery. J Oral Maxillofac Surg 2001;59:1012-7; discussion 1017.

3. Cheung LK, Leung YY, Chow LK, Wong MC, Chan EK, Fok YH. Incidence of neurosensory deficits and recovery after lower third molar surgery: a prospective clinical study of 4338 cases. Int J Oral Maxillofac Surg 2010;39:320-6.

4. Mela OA, Tawfik MA-M, Mansour NA. Assessment of the relationship between the mandibular canal and impacted third molars using cone beam computed tomography. Mans J Dent 2014;1:49-55.

5. Gomes AC, Vasconcelos BC, Silva ED, Caldas AF Jr, Pita Neto IC. Sensitivity and specificity of pantomography to predict inferior alveolar nerve damage during extraction of impacted lower third molars. J Oral Maxillofac Surg 2008;66:256-9.

6. Ghaeminia H, Meijer GJ, Soehardi A, Borstlap WA, Mulder J, Bergé SJ. Position of the impacted third molar in relation to the mandibular canal. Diagnostic accuracy of cone beam computed tomography compared with panoramic radiography. Int J Oral Maxillofac Surg 2009;38:964-71.

7. Palma-Carrió C, García-Mira B, Larrazabal-Morón C, Peñarrocha-Diago M. Radiographic signs associated with inferior alveolar nerve damage following lower third molar extraction. Med Oral Patol Oral Cir Bucal 2010;15:e886-90.

8. Rood JP, Shehab BA. The radiological prediction of inferior alveolar nerve injury during third molar surgery. Br J Oral Maxillofac Surg 1990;28:20-5.

9. Blaeser BF, August MA, Donoff RB, Kaban LB, Dodson TB. Panoramic radiographic risk factors for inferior alveolar nerve injury after third molar extraction. J Oral Maxillofac Surg 2003;61:417-21.

10. Bell GW. Use of dental panoramic tomographs to predict the relation between mandibular third molar teeth and the inferior alveolar nerve. Radiological and surgical findings, and clinical outcome. Br J Oral Maxillofac Surg 2004;42:21-7.

11. Scarfe WC, Farman AG, Sukovic P. Clinical applications of cone-beam computed tomography in dental practice. J Can Dent Assoc 2006;72:75-80.

12. Peker I, Sarikir C, Alkurt MT. Panoramic radiography and cone-beam computed tomography findings in preoperative examination of impacted mandibular third molars. BMC Oral Health 2014;14:71.

13. Adibi S, Zhang W, Servos T. Cone beam computed tomography in dentistry: what dental educators and learners should know. J Dent Educ 2012;76:1437-42.

14. Ludlow JB, Ivanovic M. Comparative dosimetry of dental CBCT devices and 64-slice CT for oral and maxillofacial radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106:106-14.

15. Shahidi S, Zamiri B, Bronoosh P. Comparison of panoramic radiography with cone beam CT in predicting the relationship of the mandibular third molar roots to the alveolar canal. Imaging Sci Dent 2013;43:105-9.

16. Sedaghatfar M, August MA, Dodson TB. Panoramic radiographic findings as predictors of inferior alveolar nerve exposure following third molar extraction. J Oral Maxillofac Surg 2005;63:3-7.

17. Tantanapornkul W, Okouchi K, Fujiwara Y, Yamashiro M, Maruoka Y, Obayashi N, et al. A comparative study of cone-beam computed tomography and conventional panoramic radiography in assessing the topographic relationship between the mandibular canal and impacted third molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;103:253-9.

18. Szalma J, Lempel E, Jeges S, Olasz L. Darkening of third molar roots: panoramic radiographic associations with inferior alveolar nerve exposure. J Oral Maxillofac Surg 2011;69:1544-9.

19. Tay AB, Go WS. Effect of exposed inferior alveolar neurovascular bundle during surgical removal of impacted lower third molars. J Oral Maxillofac Surg 2004;62:592-600.

20. Maegawa H, Sano K, Kitagawa Y, Ogasawara T, Miyauuchi K, Sekine J, et al. Preoperative assessment of the relationship between the mandibular third molar and the mandibular canal by axial computed tomography with coronal and sagittal reconstruction. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003;96:639-46.

21. de Melo Albert DG, Gomes AC, do Egito Vasconcelos BC, de Oliveira e Silva ED, Holanda GZ. Comparison of orthopantomographs and conventional tomography images for assessing the relationship between impacted lower third molars and the mandibular canal. J Oral Maxillofac Surg 2006;64:1030-7.

22. Ohman A, Kivijärvi K, Blombäck U, Flygare L. Pre-operative assessment of the relationship between the mandibular third molar and alveolar canal by axial computed tomography with coronal and sagittal reconstruction. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;69:1544-9.

23. Omae A, Shono K, Kitagawa Y, Ogasawara T, Miyauuchi K, Sekine J, et al. Preoperative assessment of the relationship between the mandibular third molar and the mandibular canal by axial computed tomography with coronal and sagittal reconstruction. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003;96:639-46.

24. de Melo Albert DG, Gomes AC, do Egito Vasconcelos BC, de Oliveira e Silva ED, Holanda GZ. Comparison of orthopantomographs and conventional tomography images for assessing the relationship between impacted lower third molars and the mandibular canal. J Oral Maxillofac Surg 2006;64:1030-7.

25. Ohman A, Kivijärvi K, Blombäck U, Flygare L. Pre-operative assessment of the relationship between the mandibular third molar and the mandibular canal by axial computed tomography with coronal and sagittal reconstruction. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;69:1544-9.

26. de Melo Albert DG, Gomes AC, do Egito Vasconcelos BC, de Oliveira e Silva ED, Holanda GZ. Comparison of orthopantomographs and conventional tomography images for assessing the relationship between impacted lower third molars and the mandibular canal. J Oral Maxillofac Surg 2006;64:1030-7.

27. Ohman A, Kivijärvi K, Blombäck U, Flygare L. Pre-operative assessment of the relationship between the mandibular third molar and the mandibular canal by axial computed tomography with coronal and sagittal reconstruction. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003;96:639-46.