Original Article - Comparative Study

Orthopantomography and Cone-Beam Computed Tomography for the Relation of Inferior Alveolar Nerve to the Impacted Mandibular Third Molars

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Abstract

Context: Relation of inferior alveolar nerve to the impacted mandibular third molars (IMTMs). **Aims:** The aim of this study was to assess the reliability of seven specific radiographic signs of mandibular third molar root that are observed on orthopantomography (OPG) and to predict the proximity and the absence of corticalization between the mandibular canal and IMTM root on cone-beam computed tomography (CBCT) images. **Settings and Design:** The present study was conducted in the Department of Oral and Maxillofacial Surgery, Raja Rajeswari Dental College and Hospital. **Subjects and Methods:** Data set of 30 panoramic images was retrieved between the year of 2015 and 2016 indicated for extraction of lower third molars. The sample consisted of 30 individuals, who underwent preoperative radiographic evaluation before the extraction of impacted mandibular third molars (IMTM). Patients aged above 18 years with any of the seven specific signs observed on the panoramic radiograph which includes darkening, deflection, narrowing of roots, bifid root apex, diversion, narrowing of canal and interruption in the white line of the canal were included in the study. If any of the above mentioned seven specific sign were present, the patient was subjected to CBCT. On the CBCT images, the canal was traced in three planes. The acquired images were assessed for the presence or absence of corticalization. **Statistical Analysis Used:** Descriptive and inferential statistical analyses were used. Proportions were compared using the Chi-square test and Student's *t*-test. **Results:** Among the 4 subjects, diagnosed with an absence of corticalization, patients with isolated darkening of root $P = 0.001$ and patients with isolated interruption in white line $P = 0.69$. Patients with darkening of root in association with interruption in white lines on OPG showed the absence of corticalization on CBCT findings $P = 0.001$, respectively. **Conclusions:** This study showed the poor reliability of radiographic signs seen on OPG on predicting the proximity of third mandibular root with mandibular canal related to CBCT finding. Four were diagnosed with the absence of corticalization in CBCT findings.

Keywords: Cone-beam computed tomography, impacted mandibular third molar, inferior alveolar canal, orthopantomography, paraesthesia

Introduction

Surgical extraction of the third molar is a routine practice in oral and maxillofacial surgery for prophylactic, therapeutic, and orthodontic reasons.[1] Damage to the inferior alveolar nerve (IAN) during mandibular third molar extraction surgery is a significant and common complication, which can result in postoperative paraesthesia in patients.[2] IAN paraesthesia is characterized by prolonged sensory deficit and/or abnormal sensation in the lower jaw, mental region, and lower lip of the affected side, and may be transient or permanent in nature.[3] The incidence of IAN paraesthesia following surgery is reported to be between 0.4% and 8%.[4] Permanent paraesthesia may lead to functional deficits and a decreased quality of life. To enhance surgical planning and evade complications, such as paraesthesia, and precise identification of the mandibular canal are essential.[5]

The topographic relationship between the mandibular third molar roots and the mandibular canal is the most predictable

Access this article online

Quick Response Code:

Website: www.amsjournal.com

DOI: 10.4103/ams.ams_138_18

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How to cite this article: Saha N, Kedarnath NS, Singh M. Orthopantomography and cone-beam computed tomography for the relation of inferior alveolar nerve to the impacted mandibular third molars. Ann Maxillofac Surg 2019;9:4-9.

risk factor leading to IAN damage.[6] Exposure of the IAN on extraction is indicative of a close relationship between the nerve and the roots of the mandibular third molar. The literature reveals a 15-25% increased risk of postoperative paraesthesia following IAN exposure and research indicates high-anatomical variability between individuals.[7]

Radiological imaging is a vital tool for diagnosis and surgical management. Therefore, accurate preoperative radiographic examination is considered indispensable before extraction of the mandibular third molar. Ideally, this examination should help the surgeon to evaluate the difficulty of the operation and to choose the most appropriate surgical techniques, for example, where to remove bone, how to split the tooth, and in what direction roots can be lifted.[8,9]

There are several diagnostic tools and imagining techniques to measure the proximity of impacted mandibular third molar (IMTM) roots to mandibular canal, which includes intraoral periapical radiography (IOPAR), orthopantomography, computed tomography (CT), cone-beam CT (CBCT), etc.

CBCT scanners have recently been developed for dentomaxillofacial imaging. Three-dimensional (3D) images of CBCT are becoming more readily available for use in maxillofacial applications. CBCT provides better image quality of teeth and their surrounding structures, compared with conventional CT.[10,11] It reduces the radiation dose as compared with conventional CT and offers high spatial resolution.[12,13] Thus, it seems that the relationship of the mandibular third molar to the mandibular canal is assessed more accurately with CBCT imaging modality. CBCT examination has been found to be useful in the preoperative diagnosis of lower third molars and CBCT examination is highly reliable in locating the mandibular canal.

Studies suggest that seven specific signs are observed on panoramic radiograph which includes darkening of roots, deflection of roots, narrowing of roots, bifid root apex, diversion of the canal, narrowing of canal, and interruption in the white line of the canal. These specific signs indicate the risk of injury to the IAN during the IMTM surgery.[14]

Panoramic radiography is a two-dimensional technique and the specific signs observed on orthopantomogram (OPG) may vary when compared to CBCT. CBCT can provide 3D information about the buccolingual configuration and the curvature of IAN to the IMTMs along with cortical loss of the inferior alveolar canal, number of roots, and the distance between the IAN and the IMTM.[14]

In the present study, panoramic radiograph and CBCT images have been utilized to asses proximity of mandibular canal and mandibular third molar root and evaluate the reliability of seven specific signs that are observed on panoramic radiograph and compare it with CBCT in predicting the proximity of impacted third molar root with mandibular canal and to assess for the similarities and differences in the findings of panoramic radiographs and CBCT.

Subjects and Methods

Data set of 30 panoramic images taken during 2015-2016 for the extraction of lower third molars was retrieved from the archives of our institution. The sample consisted of 30 individuals, and informed consent was obtained from all patients, who underwent preoperative radiographic evaluation before the extraction of IMTMs. Digital panoramic radiographs were obtained using an orthopantomography (Sirona Orthophos XG 5 DS/Ceph digital), operating at 64 kVp/8 mA and an exposure time of 14.1 s. 3D images were obtained using a SCANORA 3D (SOREDEX), operating at 90 kVp/12.5 mA, 15 s. Patients >18 years irrespective of gender, any of the seven specific signs observed on the panoramic radiograph which includes darkening of roots, deflection of roots, narrowing of roots, bifid root apex, diversion of canal, narrowing of canal, and interruption in the white line of the canal were included in the study. Patients with bifid and trifid mandibular canals, pregnant patients, and individuals with radiological evidence of intraosseous pathologies (e.g., cysts or tumors) associated with the third molars were excluded from the study. Under dim lighting conditions, on a computer monitor (21-inch liquid crystal display monitor with 128061024 resolution), the panoramic radiographs and CBCT images were evaluated independently by two expertise in radiology with a minimum of 3 years of experience in CBCT diagnosis. The interpretation of OPG was done using radiographic viewing box. The radiograph was checked for the following seven specific signs that are-darkening of roots [Figure 1], deflection of roots, narrowing of roots, bifid root apex, diversion of canal, narrowing of canal, and interruption in the white line of the canal [Figure 2], according to the criteria by Rood and Shehab.[15] If any of the above-mentioned seven specific sign were present, the patient was subjected to CBCT. Any differences were fixed following the initial observation by the observers. On the CBCT images, the canal was traced, and the image formed was seen in 3D view, i.e., sagittal, coronal, and axial planes. The acquired images were assessed for the occurrence of presence and absence of corticalization [Figures 3 and 4], and were calculated for the distance, i.e., proximity of the root tip from mandibular canal. Data were evaluated using SIDEXIS software considering the magnification factor of the equipment.

Statistical analysis

Descriptive and inferential statistical analyses have been carried out in the present study. Results on continuous measurements are presented on a mean ± standard deviation (SD) (minimum–maximum), and results on categorical measurements are presented in number (%). Significance is assessed at 5% level of significance. Proportions were compared using the Chi-square test and Student's *t*-test. The Student's *t*-test was used to determine whether there was a statistical difference between male and female participants in the parameters measured. In all above test, values of $P < 0.05$ were taken to be statistically significant. The data were analyzed using the SPSS software (version 20.0, IBM Corp. Armonk, New York, United States).

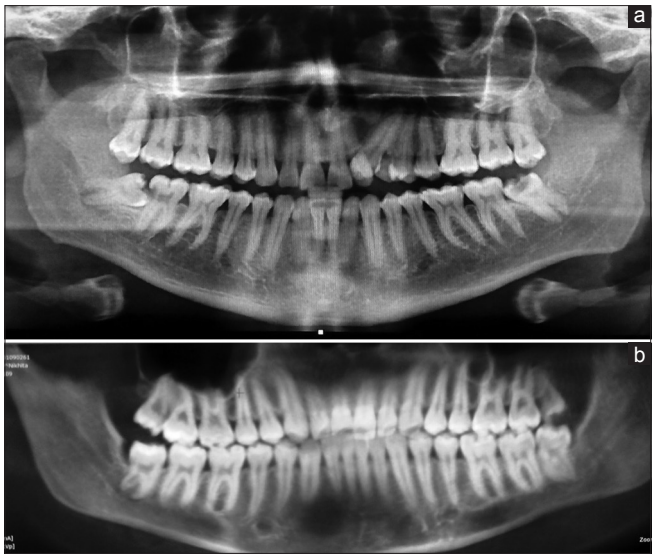

Figure 1: (a and b) Orthopantamography showing darkening of root

Figure 3: Cone-beam computed tomography coronal section view showing the presence of corticalization

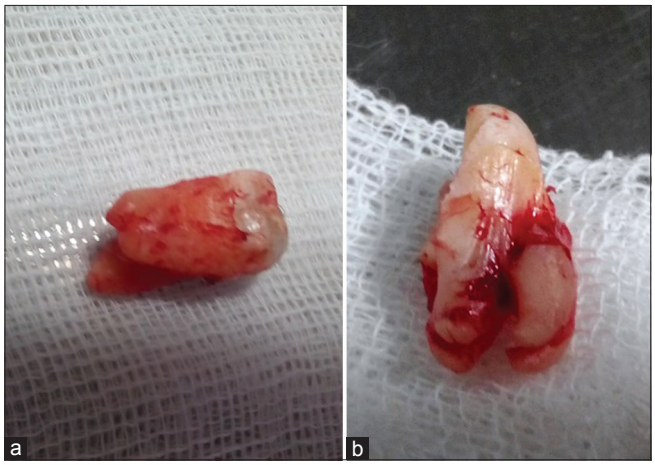

Figure 5: (a) Groove on the apical end of a single rooted extracted mandibular third molar tooth nearing to the inferior alveolar nerve canal. (b) Groove on the apical end of a multi rooted extracted mandibular third molar tooth nearing to the inferior alveolar nerve canal

Figure 2: OPG showing interruption in white line

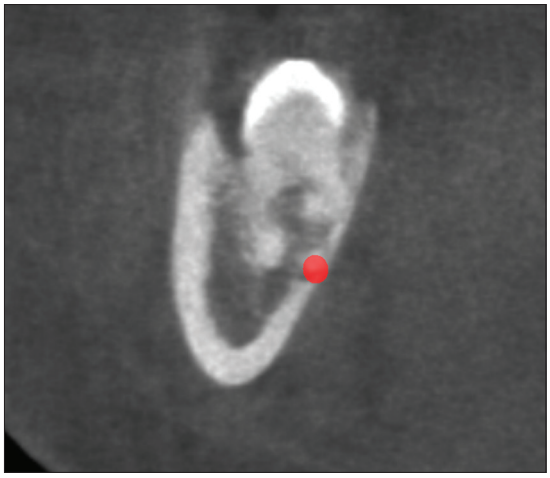

Figure 4: Cone-beam computed tomography coronal section view showing the absence of corticalization

Results

In the present study, panoramic radiograph and CBCT images have been utilized to assess proximity of mandibular canal and mandibular third molar root and evaluate the reliability of seven specific signs that are observed on panoramic radiograph and compare it with CBCT in predicting the proximity of impacted third molar root with mandibular canal and to assess for the similarities and differences in the findings of panoramic radiographs and CBCT. Table 1 depicts the age distribution in the study sample presenting with 20% (6) of patients with age <20 years, 66.7% (20) of patients with the age group of 21–30 years, 3.3% (1) of patients with the age group of 31–40 years, 3.3% (1) of patients with the age group of 41–50 years, and 6.7% (2) of patients with the age group of 51–60 years. In total sample, mean age was 26.8 and SD was 8.9. Table 2 represents gender distribution in the study sample consisting of 50% (15) males and 50% (15) females. Table 3 depicts the comparison of OPG findings in the study sample (7 specific signs that are-darkening of roots, deflection of roots, narrowing of roots, bifid root apex, diversion of the canal, narrowing of the canal, and interruption in the white line of the canal) with CBCT findings. Darkening of root was present in 30.0% (9) on OPG and the presence of corticalization in 15.4% (4) on CBCT with the Chi-square and

Table 1: Age distribution in studied patient

Distribution of demographic characteristics in the study sample		
Variables	**Categories**	***n* (%)**
Age group (years)	<20	6 (20.0)
	21-30	20 (66.7)
	31-40	1 (3.3)
	41-50	1 (3.3)
	51-60	2 (6.7)
Age, mean±SD (range)	26.8±8.9 (19-60)	

SD: Standard deviation

Table 2: Gender distribution of patients studied

Gender	Number of patients (%)
Female	15 (50.0)
Male	15 (50.0)
Total	30 (100.0)

Table 3: Comparison of the distribution of OPG signs of inferior alveolar canal with cone-beam computed tomography findings among the study sample using Chi-square goodness of fit test

Parameters	OPG, *n* (%)	CBCT (corticalization), *n* (%)	χ^2	*P*
Darkening of roots	9 (30.0)	4 (15.4)	10.769	0.001*
Deflection of roots	2 (6.7)	0	0.330	0.56
Narrowing of roots	0	0	.	.
Bifid root apex	1 (3.3)	1 (3.8)	0.159	0.69
Diversion of canal	0	0	.	.
Narrowing of canal	0	0	.	.
Interruption in white line	29 (96.7)	4 (15.4)	0.159	0.69

CBCT: Cone-beam computed tomography, OPG: Orthopantomography. *P* < 0.001*

P value as 10.769 and 0.001. Deflection of roots was present in 6.7% (2) on OPG and the presence of corticalization in 0% on CBCT with Chi-square and *P* value as 0.330 and 0.56. Bifid root apex was present in 3.3% (1) on OPG and presence of corticalization in 3.8% (1) on CBCT with the Chi-square and *P* value as 0.159 and 0.69. Interruption in white line was present in 96.7% (29) on OPG and presence of corticalization in 15.4% (4) on CBCT with the Chi-square and *P* value as 0.159 and 0.69. Narrowing of roots, diversion of the canal, and narrowing of the canal were absent on OPG in the present study. Table 4 represents the CBCT findings in the study sample. The presence of corticalization was seen in 86.7% (26) and absence of corticalization was seen in 13.3% (4) on CBCT with Chi-square and *P* value as 16.133 and <0.001. The mean and SD of distance measured from the mesial root tip to the mandibular canal is 1.81 and ±0.96. The mean and SD of distance measured from distal root tip to the mandibular canal is 1.61 and ±0.90. The *t* value and *P* value of distance measured on CBCT between the roots of the mandibular third molar to the mandibular canal is 1.106 and 0.28, which is not statistically significant. Table 5 depicts the presence of corticalization for darkening of roots in association with interruption in white line was seen in 55.6% (5) and absence of corticalization was seen in 44.4% (4) on CBCT with Chi-square and *P* value as 10.769 and <0.001.

Discussion

The incidence of IAN injury from surgical removal of mandibular third molar varies from 0.4% to 8.4%.[15] Injury of the IAN is a worrisome consequence following mandibular third molar removal, since the symptoms associated with the nerve injury may persist for several months or in serious case the patient may end up with permanent paraesthesia.[6,16] In most cases, the presence of numbness from a nerve injury will resolve within or <6 months. Sedaghatfar *et al*. stated that the incidence rate is commonly reported to be <1% in cases of permanent paraesthesia.[17,18]

The proximity of the root apex of the mandibular third molar to the inferior alveolar canal predisposes a patient to nerve injury following surgical removal of the tooth.[16] Therefore, in the preoperative assessment of the mandibular third molar, accurate diagnostic assessment is important to achieve precise evaluation of the relationship of the root apex to the canal. Knowing the exact position of the root apex to the inferior alveolar canal will help the surgeon to determine the risk associated with the surgical procedure and to decide the most appropriate treatment plan [Figure 5a and b].

Tantanapornkul *et al*. and Ghaeminia *et al*. proved in their study, the diagnostic accuracy of CBCT in predicting neurovascular bundle exposure before IMTM removal.[6,19] However, due to the higher dose and cost of this imaging modality, many dental settings only rely on conventional radiographs in the assessment of IMTM.

In the SEDENTEXCT guideline,[20] the proximity of a mandibular third molar to the inferior alveolar canal indicates the use of CBCT to evaluate the situation precisely.

However, regardless of being film-based or digital, orthopantomography has many inherent limitations. A fundamental one is that it causes superimposition of anatomical structures. Features of diagnostic interest may, therefore, be obscured and diagnostic accuracy is decreased. Therefore, assessment of IMTM is paramount in determining the need for CBCT in selected cases and avoid unnecessary radiation exposure to the patient.[20]

OPG is commonly acceptable for the assessment of the proximity of lower third molar to the mandibular canal in the absence of overlap between the mandibular canal and a lower third molar, as suggested by Flygare and Ohman.[9,21]

Table 4: Distribution of cone-beam computed tomography finding (corticalization) of inferior alveolar canal

Comparison of the distribution of CBCT finding (corticalization) of inferior alveolar canal among the study sample using Chi-square goodness of fit test

CBCT findings of inferior alveolar canal	Present, *n* (%)	Absent, *n* (%)	χ^2	*P*
Corticalization	26 (86.7)	4 (13.3)	16.133	<0.001*

*Statistically significant. CBCT: Cone-beam computed tomography

Table 5: Comparison of distribution of OPG signs (2 specific) with cone-beam computed tomography findings

Relationship between the corticalization and OPG characteristics using Chi-square test

OPG characteristics	Corticalization		χ^2	*P*
	Absent, *n* (%)	Present, *n* (%)		
Darkening of roots + interruption in white line	4 (44.4)	5 (55.6)	10.769	<0.001*

Significant figures: suggestive significance (P<0.005), *moderately significant (0.001≤P 0.05), OPG: Orthopantomography

The present study consisted of 30 individuals who comprised 15 males and 15 females in the age group of 19–40 years and above. Using OPG signs and CBCT findings, the relationship of impacted mandibular third molar with inferior alveolar canal was assessed. Seven specific radiographic signs, i.e., darkening of roots, deflection of roots, narrowing of roots, bifid root apex, diversion of the canal, narrowing of canal, and interruption in the white line of canal seen on OPG for impacted mandibular third molar with the mandibular canal, were correlated for the proximity and involvement with CBCT findings for the same.

Results showed that patients presented with isolated darkening of root was 30.0% (9) on OPG and the presence of corticalization in 15.4% (4) on CBCT with Chi-square and *P* value as 10.769 and 0.001 (statistically significant) and patients presented with isolated interruption in white line was 96.7% (29) on OPG and presence of corticalization in 15.4% (4) on CBCT with Chi-square and *P* value as 0.159 and 0.69. Patients showed darkening of root in association with interruption in white lines on OPG, showed the absence of corticalization on CBCT findings, *P* value as 0.001 and patients presented within 44.4% (04) patients with Chi square test and *P* value for darkening of root in association with interruption in white line was measured as 0.001 respectively.

Neves *et al*. found that darkened roots and interruption of white line observed on panoramic radiographs, as both isolated findings and in association with each other, are effective in determining the risk relationship between the tooth roots and the mandibular canal, requiring 3D evaluation of the case.[14]

It was found in this study, that of 30 patients, only 13.3% (04) were diagnosed with the absence of corticalization on CBCT with mean and SD of distance measured from mesial root tip to mandibular canal is 1.81 and ±0.96 and mean and SD of distance measured from distal root tip to mandibular canal is 1.61 and ±0.90 for the same patients with mean difference of both root tip was 0.20 and *P* value as 0.28. Among these four patients with the absence of corticalization, everyone showed both darkening of roots and interruption in white line.

Tantanapornkul *et al*.[19] showed that CBCT was superior to OPG in predicting neurovascular bundle exposure following assessment of the relationship of the mandibular third molar root tip to the mandibular canal. The relative sensitivity and specificity of CBCT and OPG in predicting the nerve exposure was 93%, 77% and 70%, 63%, respectively.

Numerous studies have been performed using OPG and CBCT or CT which have proven to have a positive correlation of interruption in white line and darkening of root indicating the higher risk of IAN injury[14,19] which is in accordance with our study. Ghaeminia *et al*.[6] observed that three signs, interruption of white line, darkening of the root, and diversion of the mandibular canal were significantly associated with IAN exposure. Szalma *et al*.[22] confirmed the finding of Ghaeminia *et al*. in their study.

OPG serves as a valuable initial screening test to investigate the proximity of IMTM to the IAN and the seven radiographic criteria's (darkening of roots, deflection of roots, narrowing of roots, bifid root apex, diversion of canal, narrowing of canal, interruption in the white line of the canal). However, if any of these specific signs are positive on OPG, it is advised to do further investigation by way of CBCT where 3D relationship of IMTM and IAN can be studied. In the present study, two radiographic signs on OPG (darkening of roots, Figure 1a and b and interruption in white line, Figure 2) were of significance correlating to the absence of corticalization on CBCT [Figure 4]. Among the two, darkening of roots was statistically more significant. Therefore, due to the limited sample size, the results cannot be generalized. However, despite these limitations, the present study provides valuable information.

Therefore to conclude, this study showed the poor reliability of radiographic signs of OPG on predicting the involvement of mandibular third molar root with the mandibular canal. Four patients were diagnosed with the absence of corticalization and with the presence of contact in CBCT findings among 30 patients. This creates the controversy and questions regarding the reliability of OPG signs with CBCT findings which were found far more precise and accurate. However,

the two radiographic signs, interruption in the white line and darkening of roots have shown significant association indicating the higher risk of IAN injury. Also owing to its easy availability and less radiation exposure to the patient it can be taken as primary diagnostic tool for evaluating the proximity of mandibular canal and mandibular third molar root.

The present study, therefore, gave adequate insight to maxillofacial surgeons who need to decide whether CBCT is required in addition to OPG in mandibular third molar extractions. Further studies requiring the larger sample size using both OPG and CBCT with proper surgical planning will prove constructive.

Conclusion

The present study concluded that there was poor reliability of radiographic signs of OPG on predicting the involvement of mandibular third molar root with the mandibular canal. However, the two radiographic signs, interruption in the white line and darkening of roots have shown significant association indicating the higher risk of IAN injury. The present study, therefore, gave adequate insight to maxillofacial surgeons who need to decide whether CBCT is required in addition to OPG in mandibular third molar extractions.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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