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Panoramic Radiograph and cone beam computed tomography- evaluation of Mandibular impacted third molar and Mandibular canal

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Abstract:

Aim: The aim of this study was to assess the reliability of high risk injury signs to inferior alveolar nerve on panoramic radiograph, both individually and in combination, in predicting the absence of corticalisation between the mandibular canal and the third molar and cortical plate perforation on cone beam computed tomographic (CBCT) images.

Methods: The sample consisted of 20 subjects (20 left and 20 right mandibular third molars) who underwent pre-operative radiographic evaluation before extraction of impacted mandibular third molars. On panoramic radiographs, the most common high risk injury signs of inferior alveolar nerve (darkening of roots, interruption of white line, deviation of mandibular canal, narrowing of mandibular canal and superimposition of mandibular canal on roots) and bucco-lingual position of mandibular canal, supero-inferior position of mandibular canal, presence or absence of corticalisation between the mandibular third molar and the mandibular canal and cortical plate perforation on cone beam computed tomographic (CBCT) images were evaluated.

Results: Darkening of roots, superimposition of roots on mandibular canal were significantly associated with presence of corticalisation of mandibular canal (P value < 0.05) and interruption of white line was significantly associated with absence of corticalisation of mandibular canal (P value < 0.05). Darkening of roots was significantly associated with cortical plate perforation (P value <0.05). No statistically significant association was observed for the other panoramic radiographic findings, either individually or in association (P value > 0.05).

Conclusion: Darkening of roots and interruption of white line observed on panoramic radiographs were effective in determining the risk relationship between the tooth roots and mandibular canal, cortical plate requiring further three dimensional evaluation.

Introduction:

Impaction is a pathological condition which is defined as "lack of eruption of a tooth in the oral cavity within the time and physiological limits of normal eruption process".[1] Management of impacted teeth requires accurate and precise diagnosis regarding location of an impacted tooth and its relationship with the surrounding anatomical structures. Neurological complications may occur because of inappropriate diagnosis of the neighbouring anatomic structures or the surgical approach in the cases, having close or intimate relationship between roots of mandibular third molar and mandibular canal and or mandibular lingual cortex. The removal of an impacted mandibular third molar can injure the inferior alveolar nerve (IAN) and cause dysesthesia.[2],[3] The root tip position of an impacted mandibular third molar is the very important and decisive factor for the nerve injury incidence. The incidence of inferior alveolar nerve damage is increased upto 30% in cases where the root of mandibular third molar is in direct contact with the inferior alveolar nerve.[4],[5],[6],[7] For preoperative diagnosis of routine cases, intraoral and panoramic radiographs are sufficient to determine the position of the third molar in relation to inferior alveolar canal. But additional information from other imaging modalities is needed in the second plane if the tip of root is on the level or inferior to the mandibular canal to identify the position of root tip in relation to mandibular canal.[8] Moreover conventional radiographs have their inbuilt drawbacks like superimposition, distortion of images, because of the projection of 3dimensional structures in 2-dimension hence the advanced imaging is necessary for the assessment of impacted molars. Some studies used panoramic radiographs as a guideline for deciding whether an axial CT (Computed tomography) was needed in addition to preoperative panoramic radiograph for patients to undergo third molar extraction.[9] CT provides good tissue contrast, eliminates blurring of image and overlapping of adjacent anatomical structures. CT requires thin slices and a resulting high radiation dose to get precise information of the very fine anatomic structures of the root tip and the surrounding structures.[10],[11],[12],[13] Despite its advantages, until now, the use of CT for the assessment of impacted teeth has been restricted because of issues related to cost, risk versus benefit, and access.[8] CBCT (cone beam computed tomography) is a recent technology initially developed for angiography in 1982 and subsequently applied to maxillofacial imaging.[14] It uses a divergent or "cone"-shaped beam of ionizing radiation and a two dimensional detector fixed on a rotating gantry to obtain multiple sequential projection images in one complete scan of the area of interest.[14] It is only since late 1990s that it has become possible to produce clinical systems that are both inexpensive as well as small enough to be used in the dental office. CBCT imaging has the benefit of lesser radiation exposure to the patient as compared to CT. With the advent of CBCT, it has become very convenient, simple and easy to determine the exact location of impacted tooth in the jaw and its relation to the adjacent teeth as well as anatomic structures. Many different radiographic projections were required for the localization of an impacted tooth traditionally. Although these projections were able to identify whether the tooth was buccal or lingual, it was still difficult to assess the proximity of impacted tooth to the roots of adjacent teeth and underlying anatomical structures. With CBCT, the diagnosis has become a simple illustrative task, viewing the entire dentition as well as the impacted teeth. Further additional information such as three dimensional orientation of an impacted tooth, and direction of path of eruption is best revealed with CBCT. The present study was aimed to evaluate the diagnostic utility of CBCT in assessment of relationship of mandibular canal with the impacted mandibular third molars where these two structures are closely related to each other bearing high risk chances of IAN injury.

Materials and methods:

This prospective study was approved by institutional ethical committee and informed consent was obtained from all the subjects. Total of 20 right and 20 left impacted mandibular third molars in 20 patients were assessed. Inclusion criteria were age group from 22-30 years, patients having one or both impacted third molar and are willing to participate in the study. Exclusion criteria were uncooperative patients, patients with maxillofacial trauma and suffering from any physical and mental disability, and pregnant patients. On panoramic radiograph, most common signs associated with high risk injury to inferior alveolar nerve (IAN) which are darkening of roots (DR) (Figure 1), interruption of white line (IWL) (Figure 2), superimposition of mandibular canal on roots (SMC) (Figure 3), narrowing of mandibular canal (NMC) (Figure 4), deviation of mandibular canal (DMC) and combination of these findings were only included in the study.[15],[16],[17] Only one case was there of combination finding as deviation of mandibular canal along with interruption of white line (Figure 5). Kodak 8000C digital panoramic system was used to obtain panoramic radiograph and scanning parameters were 12mA, 73kV and 13.9 seconds scanning time. Further, all these patients were subjected to CBCT evaluation. The panoramic findings were also evaluated and confirmed in CBCT reformatted panoramic images. Cross sectional CBCT images were evaluated for bucco-lingual (B-L) position of mandibular canal, supero-inferior (S-I) position of mandibular canal, absence or presence of corticalisation of mandibular canal, and cortical plate perforation (Figure 6,7). B-L position and S-I position of mandibular canal were assessed as buccal, lingual, or at the level of roots in horizontal plane and inferior, superior, or at the level of roots in vertical plane respectively at the level of root tip. KODAK 9500 cone beam 3D Extraoral imaging system with a reconstruction volume of 50x37mm and a reconstructed matrix voxel of 76.5x76.5x76.5µm was

used to obtain the CBCT images. The equipment has CMOS sensor technology. Exposure parameters for the patients varied from 90 kV, 10 mA with a scan time of 10.8 seconds. Patients were positioned in standing position while taking the scan. The total image acquisition time was less than 2 minutes. The impacted teeth were assessed by the 3-dimensional volumetric image and 1 mm tomographic sections in sagittal, axial and coronal planes. The field of view (FOV) was 9 x 15cm (from the bottom of the chin to the top of the jaw). Tomographic sections were taken in curved planar reformation (panorex), a series of multiplanar reconstructions (cross sections).

Results

The statistical analysis was done using the computer software program SPSS version18. Values were analyzed using descriptive and analytical statistics. Fisher's Exact test was used to evaluate the correlation between various panoramic findings and CBCT findings. In the present study, P-value <0.05 was considered as the level of significance. Total of 40 impacted mandibular third molars were assessed in the study and most common type of impaction was mesioangular (50%) shown in table 1. On panoramic radiographs most commonly found high risk injury sign to IAN was IWL (57.5%) followed by DR (20%) depicted in table 2. All these panoramic findings were evaluated in reformatted CBCT panoramic image and all the findings were consistent. In the CBCT cross sectional images, the position of mandibular canal was at the level of roots (50%), buccal (27.5%), and lingual (22.5%) in horizontal plane shown in table 3 where as in vertical plane, the position of mandibular canal was inferior (80%), at the level of roots (15%), and superior (5%) shown in table 4. DR and SMC on panoramic radiograph were significantly correlated with presence of corticalisation on CBCT images (P value <0.05) and IWL on panoramic radiograph was significantly correlated with absence of corticalisation on CBCT images (P value <0.05) shown in table 5. Only DR on panoramic radiograph was significantly correlated with cortical plate perforation in CBCT images (P value <0.05) shown in table 6. All the cases with positive cortical plate perforation showed lingual plate perforation. No statistically significant association was observed for the other panoramic radiographic signs, either as isolated findings or in association with each other (P>0.05).

Discussion:

Impaction is the cessation of eruption of a tooth caused by a physical barrier or ectopic positioning of a tooth. Dental impactions have been reported to affect as many as 25-50 per cent of the population with the third molars and maxillary canines bearing the highest incidence.[18] Three-dimensional views acquired by cone beam computed tomography (CBCT) have been introduced because of the improbability and limitations of 2-dimensional plain radiography.[18] Also the prognosis of an impaction can be assessed accurately only when the exact position of an impacted tooth and its relationship with the surrounding anatomical structures is well known. The present study was done to evaluate the various signs in panoramic radiograph which depicts the intimate relationship between mandibular canal and impacted mandibular third molar such as darkening of roots, interruption of white line, narrowing of mandibular canal, deviation of mandibular canal, and superimposition of roots on mandibular canal and correlation of these findings with CBCT findings of presence or absence of corticalisation of mandibular canal, and cortical plate perforation. In this study most common type of impaction based on angulation was mesioangular which was in concordance to some studies and non-concordance to some studies and this variation may be due to variation in sample population and sample size. In this study most common finding was interruption of white line (57.5%) (table 2) and all these findings were also consistent in reformatted CBCT panoramic radiograph. These findings on panoramic radiograph were consistent to the observations of Monaco et al [9] and Tantanapornkul et al.[19] In the present study, the position of mandibular canal in horizontal plane was most common at the level of roots (50%) whereas in vertical plane the most common position was inferior (80%) (table 3,4). These results were not consistent with previous studies. Monaco et al [16] found in their study that highest number of mandibular canal was positioned buccal to the third molar. On the other hand, Tantanapornkul et al [19] found that maximum number of mandibular canal was positioned lingual to the third molar. Neugebauer J et al [20] found that in maximum cases mandibular canal was located buccal in horizontal plane and at the level of roots in vertical plane. These variations may be present due to both sample size as well as variation of study population. This study revealed that the interruption of white line in panoramic radiograph demonstrated significant association with absence of corticalisation between mandibular canal and mandibular third molar in CBCT with statistically significant value (P value < 0.05) and darkening of roots, superimposition of roots on mandibular canal in panoramic radiograph showed significant association with presence of corticalisation of mandibular canal in CBCT with statistical significance (P value <0.05) (table 5). The results of present study were partially consistent with a study done be F Sampaio Neves et al [21] according to which darkening of roots and interruption of white line associated with the absence of cortical lining between the mandibular third molar and the mandibular canal on CBCT images were statistically significant. Cortical plate perforation was also assessed in CBCT cross sectional images. This study demonstrated that darkening of roots in panoramic radiograph showed statistical significant association with cortical plate perforation in CBCT with P value < 0.05 (table 6). A study done by W Tantanapornkul et al [22] stated that the darkening of the root may represent thinning of the cortical plate. Obtaining information about cortical plate perforation is very important and it might serve to lower the risk of injury

to lingual nerve, and dislocation of bone or tooth in adjacent structures like floor of mouth or sublingual space. Further studies are needed to be carried out to correlate other parameters with larger sample size to determine significant association. Blaeser BF et al [23] and Sedaghatfar M et al [24] said that panoramic findings of diversion of the inferior alveolar canal, darkening of the third molar root, and interruption of the cortical white line are statistically associated with inferior alveolar nerve injury. Park W et al [25] in their study said that loss of mandibular canal cortical integrity is associated with an increased risk of paresthesia following mandibular third molar extraction. So, panoramic radiograph plays very vital role as the routine screening procedure for preoperative evaluation of mandibular third molars, such as position and the angulation of impacted tooth and its proximity to inferior alveolar nerve. Further topographic evaluation of inferior alveolar canal in relation to tooth in all the planes is required by means of advanced imaging such as CT, CBCT in cases showing intimate relationship between tooth and nerve though use of CT is limited due to cost, access, radiation exposure so it is not justified for localisation of mandibular canal.

Conclusion:

Conventional radiography remains basic imaging modality for most of the impacted teeth. Until recent, advanced imaging option was somewhat limited to the medical conventional fan-beam CT. But invention of CBCT 3-D imaging system exclusively for maxillofacial region brought revolution in the field of imaging in dentistry to reduce exposure. Also commercially available CBCT equipments have been shown to provide diagnostic information almost equal to CT. CBCT imaging technology provides the adequate diagnostic information for various indications with lower cost, less device maintenance, and reduced exposure of radiation to the patient. CBCT determines precise tooth position to visualize impaction with in alveolar bone, inclination of impacted tooth, location relative to adjacent teeth and proximity to vital structures such as nerve canal, and cortical borders.

Figure legends

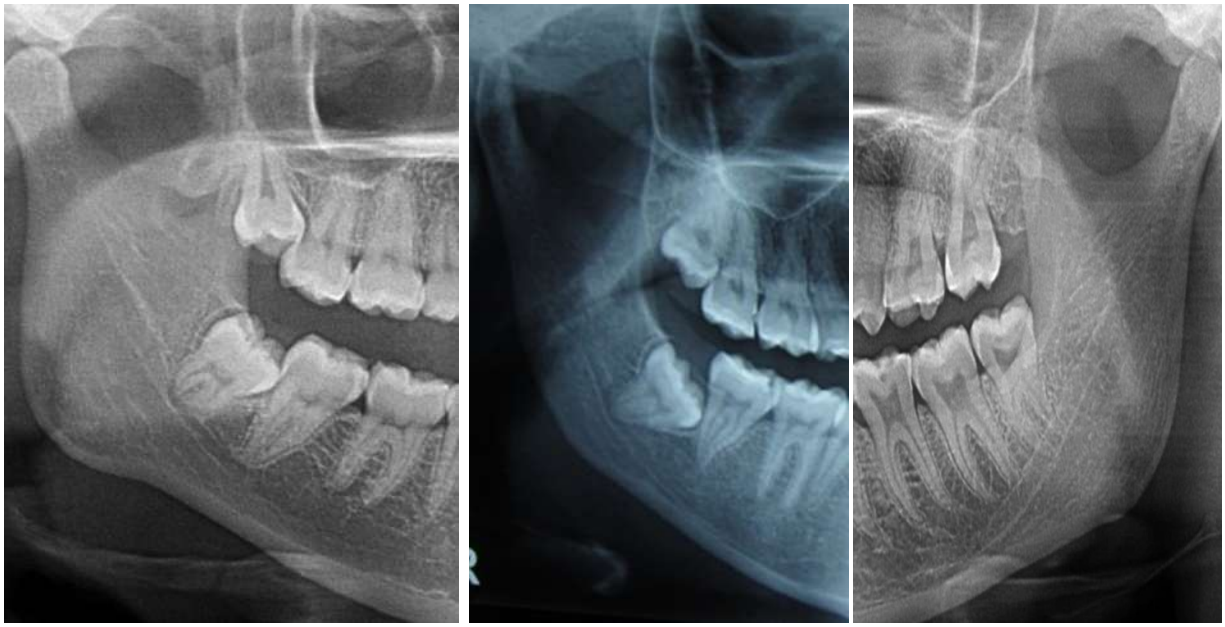

Figure.1 **Figure.2** **Figure.3**

Figure 1: Cropped panoramic radiograph showing darkening of roots

Figure 2: Cropped panoramic radiograph showing interruption of white line

Figure 3: Cropped panoramic radiograph showing superimposition of mandibular canal on roots

Figure.4

Figure.5

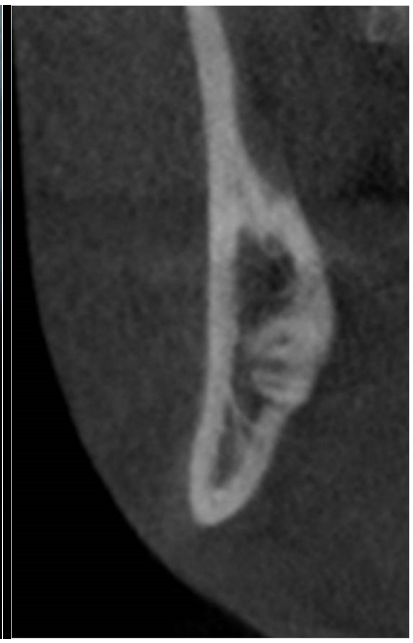

Figure.6

Figure4: Cropped panoramic radiograph showing narrowing of mandibular canal

Figure5: Cropped panoramic radiograph showing deviation of mandibular canal and interruption of white line

Figure 6: Cross sectional cone beam computed tomographic image showing absence of corticalisation of mandibular canal

Figure 7: Cross sectional cone beam computed tomographic image showing lingual cortical plate perforation

Table 1: Position of impacted mandibular third molars determined in panoramic radiograph based on angulation

Tooth position in bone	Number of cases (n=40)	%
Vertical	16	40
Mesioangular	20	50
Distoangular	2	5
Horizontal	2	5
Total	40	100

Table 2: Findings associated with high risk injury to inferior alveolar nerve in panoramic radiograph

Radiographic finding	Number of cases (n=40)	%
DR	8	20
IWL	23	57.5
NMC	4	10
SMC	4	10
DMC	-	-
DMC + IWL	1	2.5
Total	40	100

Table 3: Bucco-lingual position of mandibular canal in relation to roots of impacted mandibular third molars determined in CBCT cross sectional images

Position of mandibular canal in CBCT	Number of cases (n=40)	%
Buccal	11	27.5
Lingual	9	22.5
At level of roots	20	50
Total	40	100

Table 4: Supero-inferior position of mandibular canal in relation to roots of impacted mandibular third molars determined in CBCT cross sectional images

Position of mandibular canal in CBCT	Number of cases (n=40)	%
Superior	2	5
Inferior	32	80
At level of roots	6	15
Total	40	100

Table 5: Evaluation of correlation of corticalisation of mandibular canal in CBCT cross sectional images associated with different panoramic radiograph signs

Panoramic findings(n=40)	Presence of corticalisation in CBCT	Absence of corticalisation in CBCT	P value
DR = 8 (20%)	6 (75%)	2 (25%)	<0.05
IWL = 23 (57.5%)	4 (17.3%)	19 (82.6%)	<0.05
NMC = 4 (10%)	0 (0%)	4 (100%)	>0.05
SMC = 4 (10%)	4 (100%)	0 (0%)	<0.05
DMC = 0 (0%)	0	0	-
DMC+IWL = 1 (2.5%)	0 (0%)	1 (100%)	>0.05

Table 6: Evaluation of correlation of cortical plate perforation in CBCT cross sectional images associated with different panoramic radiograph signs

Panoramic findings (n=40)	Cortical plate perforation in CBCT	P value
DR = 8 (20%)	7 (87.5%)	<0.05
IWL = 23 (57.5%)	5 (21.7%)	>0.05
NMC = 4 (10%)	1 (25%)	>0.05
SMC = 4 (10%)	1 (25%)	>0.05
DMC = 0 (0%)	0	-
DMC+IWL = 1 (2.5%)	0	>0.05

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