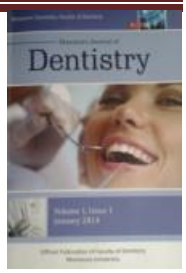
Assessment of the Relationship between the Mandibular Canal and Impacted Third Molars Using Cone Beam Computed Tomography



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Abstract:
Objectives: The aim of the present study is to evaluate the role of cone-beam computed tomography (CBCT) in the assessment of the relation between the mandibular canal and impacted third molars.
Methods: Forty three patients seeking surgical removal of this impacted mandibular third molars were selected from the Out-Patient Clinic of Oral and Maxillofacial Surgery Department, faculty of Dentistry, Mansoura University for this study. Who showed a close relationship between the mandibular canal and the third molars on panoramic radiographs. Panoramic radiographic signs images were evaluated for interruption of the white line, darkening of the roots, Interruption of white line + darkening of root, developing of root, Deflection of the root, diversion of the mandibular canal, and narrowing of the mandibular canal. All patients were referred for further evaluation using CBCT images to determine the course of each canal and its proximity to the roots. The statistical A Fisher's exact test was used to compare panoramic signs with CBCT findings.
Results: Cone-beam computed tomography examination showed that Interruption of white line were significantly associated with contact status (residuals > ±1.69). With the absence of corticalization between the impacted mandibular third molar and the mandibular canal on panoramic radiographs. All other panoramic radiographic signs showed no association with contact status (residuals < ±1.69).
Conclusions: The results of this study panoramic radiography is an effective method for pre-operative assessment of mandibular third molars Interruption of white line observed on panoramic radiographs, as isolated finding or in association with root darkening, are effective in determining the risk relationship between the tooth roots and the mandibular canal, requiring 3D evaluation of the case.

Keywords: *Impacted mandibular third molar, mandibular canal, cone-beam computed tomography panoramic radiography signs.*

Introduction

The mandibular third molar is the most commonly impacted tooth. It also presents the greatest surgical challenge and invites the greatest controversy when indications for removal are considered. When the surgeon is determining whether a specific third molar will become impacted and whether it should be removed, there must be a clear understanding of the development and movement of the third molar between the ages of 7 and 25 years [1].

The surgical removal of an impacted mandibular third molar may injure the inferior alveolar nerve (IAN). Neurological complications resulting from this kind of surgery may arise from an insufficient diagnosis of the surrounding anatomical structures or the applied surgical technique. The incidence of these neurological complications ranges from 0.2 to 1% for a permanent injury and from 3.3 to 13% for a temporary injury [2].

The incidence of damage to the IAN increases to 30% when a close relationship between the third molar and the mandibular canal is observed radiographically. Therefore, it is important to evaluate the position of the third molar and determine its relationship with the mandibular canal preoperatively to minimize the risk of nerve damage [3].

Imaging is undoubtedly an essential tool for diagnosis and surgical management, Although panoramic radiography is one of the most effective and widely used dental radiographic tools for evaluating the risk of IAN nerve damage, the absence of the cortical bone of the mandibular canal may not be clearly evident with this method, and it is impossible to determine whether its course is buccal or lingual to the roots or between the roots [4,5].

Therefore, many studies have suggested risk factors for the close relationship between the tooth and the mandibular canal or IAN injury based on the findings from panoramic images. Such as the darkening of the roots, the interruption of the white lines of the canal, the diversion of the canal, and the narrowing of the canal. These signs may be are associated with neurosensory disturbances or with a close relationship between the lower third molar and the mandibular canal [4,6].

If the radiological markers on a panoramic radiograph are suggestive of an intimate relationship between the impacted tooth and the mandibular canal, additional examination systems are recommended for further investigation to clarify the three-dimensional relationship between the two structures [7].

Computed tomography (CT) may be recommended to verify the close relationship between the third molar and the mandibular canal in a three-dimensional (3D) view. The higher radiation dose, increased financial cost and less accessibility, however, are the negative aspects of CT compared with conventional imaging [8].

Cone beam computed tomography (CBCT) is an imaging modality that has recently become useful for dentomaxillofacial imaging. When compared with conventional CT scanners, CBCT units cost less and require less space, have a rapid scan time, limit the beam to the head and neck, reduce radiation doses and have interactive display modes that offer maxillofacial imaging and multiplanar reformation, making them more suitable for use in dental practices [9,10].

Therefore, this study was designed to assess the reliability of panoramic radiographs in detecting radiographic signs of inferior alveolar nerve proximity evidenced on CBCT images.

Patients and methods

Forty three patients seeking surgical removal of this impacted mandibular third molars were selected from the Out-Patient Clinic of Oral and Maxillofacial Surgery Department, faculty of Dentistry, Mansoura University for this study. Patients were referred for CBCT following a preliminary diagnosis by the referring practitioner from a Close relationship between the impacted mandibular third molar and the inferior alveolar canal as indicated in the preoperative panoramic radiographs. Patients with Panoramic radiographs showed one or more of the following radiographs: Interruption of the mandibular canal wall, darkening of the root, narrowing of canal, deflection of the root, diversion of canal, bifid root apex.

Therefore, the data for the study consisted of impacted lower third molars considered to be associated with a high risk of injury to the canal and consequently requiring further definitive examination using CBCT before surgery. Preoperative panoramic radiographs were taken with instrumentarium orthopantograph (OP 100) machine with a peak voltage of 68 KV and current of 7 mA and an exposure time of 18 sec. The radiographs were processed in a prom ax x-ray film processor. Patients with a pre-existing inferior alveolar nerve deficits with any pathologic lesion related to their mandibular third molars. The patient age ranging from 18 to 35 years mean age of included patients was 26.5 years.

All patients were referred for further evaluation using CBCT scans acquired with a cranex 3D (Soredex, Finland). The scanning parameters were 89 KVP, 24 seconds, 10mA, and voxel size 0.2mm, and a field of view height 6 cm x diameter 8 cm. The CBCT data were reconstructed using on demand 3D CBCT software. CBCT were performed for every patient and a three dimensional reconstruction screen was used to scroll through the axial, sagittal and coronal planes with a 0.2 mm slice thickness.

The mandibular canal was color marked by the "Nerve mapping" tool in the on demand 3D viewer software of the CBCT machine in reconstructed panoramic images having a 0-mm slice thickness and interval. Cross-sectional images with a thickness of 1 mm and an interval of 1 mm perpendicular to the mesiodistal and buccolingual axes of third molars were prepared. Overall, multiplanar reconstructed images were used to determine the topographic relationship between the impacted teeth and the mandibular canal more accurately.

Were evaluated to examine the topographic relationship between the impacted third molars and the mandibular canal. Panoramic radiography and CBCT images were evaluated independently by three Oral and Maxillofacial Surgeons with experience in CBCT diagnosis, on a computer monitor (21 inch LCD monitor with 1280x1024 resolution), under dim lighting conditions. To examine the images were evaluated with the use of the ''zoom'' tool and manipulation of brightness and contrast.

CBCT images were evaluated according to Ghaeminia et al [11]. In all three dimensions to establish if the cortical layer of the mandibular canal between the third molar and IAC Was still intact .The position of the mandibular canal with respect to the third molar was classified as lingual, buccal, interradicular or inferior.

For the CBCT images, the presence or absence of direct contact between the tooth root and the canal contents was three-dimensionally evaluated, which was used as the diagnostic criterion in predicting neurovascular bundle exposure. Direct contact was considered to be present when loss of canal cortical bone between the two structures was observed on axial, panoramic, and cross-sectional images.

Statistical analysis

To judge both the intra examiner agreements and inter examiner agreements, kappa (k) values were calculated. A ^{k} value <0.40 was considered poor agreement, 0.40-0.59 was fair agreement, 0.60-0.74 was good agreement and 0.75-1.00 was excellent agreement. Each radiographic finding was reported. A Fisher's exact test was used to compare panoramic signs with CBCT findings.

Results

Forty three patients with 50 impacted lower third molars were included in this study (7 patients had bilateral impacted third molars). Mean age of included patients was 26.5 with minimum 18y and maximum 35y. Both the intra examiner agreements and inter examiner agreements of radiographic signs of panoramic X-ray, sites of mandibular canal (MC) in CBCT and presence of contact in CBCT were excellent between observers (> .80) (Fig 1A, 2A).

Table 1. Summarizes the panoramic radiographic findings according to the relationships between the roots of the third molars and the mandibular canal. In general, interruption of the white line of the canal was the most frequent panoramic radiographic sign (23 cases), nine cases showed darkening of root while the presence of these two signs together was found in 13 cases. The least found signs were deflection of root, Narrowing of the mandibular canal, Diversion of the mandibular canal, developing of root with only one case for each signs.

The position of the 50 impacted teeth and their buccolingual relationship to the mandibular canal based on the imaging findings. A lingual course of the mandibular canal observed on CBCT images was the most frequent course (42 %), followed by a buccal course (30 %), and inferior course (22 %), while an interradicular course was less frequently seen than the other signs (6 %).

Contact status of mandibular canal to third molar roots in CBCT are 15 (30%) of the examined sites showed contact in CBCT while 35 (70%) of the examined sites showed no contact in CBCT. The relationship between the panoramic radiographic signs and the proximity of the roots to the canal are shown in table 2 There was a significant correlation between panorama radiographic signs and contact status (contact and no contact in CBCT) (Fischer exact test, p=.049) to detect where the exact significance exist, calculation of residuals were performed. Interruption of white line was significantly associated with contact status (residuals > ±1.69). All other panoramic radiographic signs showed no association with contact status (residuals < ±1.69).

The association between panorama radiographic signs and gender. There was significant correlation between panorama radiographic signs and gender (male and females) (Fischer exact test, p=.042) to detect where the

exact significance exist, calculation of residuals were performed. Only darkening of root was significantly associated with gender (residuals > ±1.69). All other panoramic radiographic signs showed no association with gender (residuals < ±1.69). The association between contact status (contact and no contact) and gender are presented in table 3. Although no contact observed more with males, however the correlation was not significant. There was no significant correlation between contact status (in CBCT) and gender (Fischer exact test, p=.76).

Discussion

Third molar removal is one of the most commonly performed dentoalveolar surgeries in young adults after 20 years of age. According to the considerable variety in the relationship of the mandibular canal to an impacted mandibular third molar, an accurate radiographic diagnosis is essential to evaluate the relationship between these two anatomical structures [12].

The objective of this study was to determine whether panoramic radiograph, which is the current evidence based standard of care for pre-surgical assessment of the relationship between the impacted mandibular third molar and the inferior alveolar nerve, or the more recently available cone beam computed tomography is a better.

A number of radiographic signs have been studied that indicate possible injury of the inferior alveolar nerve during extraction of the mandibular third molar [13,14].

In this study, 50 third molars that showed panoramic radiographic signs of interruption of the with line, darkening of the root, deflection of the root, developing of the root, narrowing of the mandibular canal and diversion of the mandibular canal Were included.

In this study of panoramic findings, interruption of white line on the canal had the highest frequency (46%), interruption of white line with darkening of the root (26%) and darkening of the root (18%). These findings are inaggrement with the observations of Monaco et al. [15] and Tantanapornkul et al. [16] In these studies, panoramic signs of the darkening of the roots and the interruption of the radiopaque border of the canal were the most frequent, while panoramic signs of the deviation of the canal and narrowing of the canal were the least frequent, respectively.

The incidence of root contact with the canal in CBCT was found in 30% of the third molars we studied. This frequency is lower than those reported by Ghaeminia et al. (85%) [11] and Öhman et al. (94%) [3] and is higher than that reported by Tantanapornkul et al. (28%) [16]. The differences observed in these studies may be due to the different case selection criteria used for CBCT examination.

Interruption of white line were significantly associated with contact status (residuals > ±1.69). All other panoramic radiographic signs showed no association with contact status (residuals < ±1.69).This was in agreement with Nakagawa et al. [17] stated that when the superior white line of the canal was invisible on panoramic radiographs, the possibility of contact between the mandibular canal and the dental root was enhanced. In this study cases showing darkening of roots in panoramic images were clearly seen in CBCT without contact of mandibular canals. This was in agreement with. Kapila et al. [18] who found no intimate relationship between root darkening and mandibular canals. This result is also in accordance with Mahasantipiya et al. [19] investigators who sated that root darkening indicate thinning of the cortex rather that grooving of the root by the canal. But these results are contrary to previous studies as Tantanapornkul et al. [16] who evaluated 80 third molars that showed a panoramic radiographic finding of darkening of the root, and reported that canal perforation as show in CBCT was significantly correlated with this panoramic radiographic finding. This may be due to small sample size in patient groups in this study.

Szalma et al. [20]. and Neves [21], stated IAN exposure was only significantly associated with certain panoramic radiographic signs, especially interruption of the white line and darkening of the roots. Monaco et al. [22], recommended that three-dimensional examinations should be performed when interruption of the white line, darkening of the roots, and narrowing of the mandibular canal are observed on a panoramic radiograph.

While Gomes et al. [23] described that no significant associations were observed between the presence of seven panoramic radiographic findings and IAN paresthesia after third molar extractions. Because he did not observe any statistically significant relationship with any radiographic sign; for these authors, the panoramic radiograph does not provide any definitive data to predict nerve damage during surgery of lower impacted third molar.

The position of the third molar in relation to the mandibular canal was reported to be a significant risk factor for the occurrence of IAN exposure [24]. In the present study, the mandibular canal was most often positioned lingually to the third molar (42 %) than buccally. This is in accordance with the results of several studies [25,3], while other reports stated a higher number of mandibular canals were positioned buccally to the third molar [24,25]. Ghaeminia et al. [11] concluded that the IAN was more commonly exposed during third molar removal when the mandibular canal was positioned lingually or interradicularly to the third molar root rather than buccally. Maegawa et al. [24] reported the same findings using medical CT, although their results were not significant. It was also found in this study that in cases in which the mandibular canal was interrupted on panoramic radiographs, lingually positioned canals were more frequent, increasing risk of IAN exposure this was in agreement with results of Sekerci et al. [26] This could be why surgeons most often approach from the buccal aspect of the third molar and generate pressure in a lingual direction [11].

An interradicular course is difficult to determine with conventional methods. However, Maegawa et al. [24] who used CT, found an interradicular course in only 4 % of their cases. Another study that used stereographic views (scanograms) found an interradicular course in 3 % of the cases [27]. In this study an interradicular course in 6 % of cases were found.

In high risk situations, the bucco-lingual information from CBCT provides the surgeon with the opportunity to leave in an asymptomatic impacted molar, alter their surgical approach, or perform a coronectomy [28]. The 3D relationship provided by CBCT also paints a better picture for the patient in terms of the risks involved with surgery

and allows for improved informed consent, which further protects the surgeon in terms of liability [24].

In conclusion, panoramic radiography is an effective method for pre-operative assessment of mandibular third molars. Interruption of white line observed on panoramic radiographs, as isolated finding or in association with root darkening, are effective in determining the risk relationship between the tooth roots and the mandibular canal, requiring 3D evaluation of the case.

Conclusion

Based on the results of this study, it can be concluded that:

- Panoramic radiography is an effective method for pre-operative assessment of mandibular third molars. Interruption of white line observed on panoramic radiographs, as isolated finding or in association with root darkening, are effective in determining the risk relationship between the tooth roots and the mandibular canal, requiring 3D evaluation of the case.
- Cone Beam Computed Tomography provides useful information regarding the 3-dimensional relationship between the mandibular third molar and the mandibular canal. Thus it can be used for risk assessment and planning of the surgical procedure.

Table 1: Frequency distribution and percentage (%) of panorama radiographic risk signs.

Type of radiographic sign	Frequency	Percent (%)
Interruption of white line	23	46.0
Darkening of root	9	18.0
Interruption of white line + Darkening of root	13	26.0
Developing of root	2	4.0
Deflection of the root	1	2.0
Narrowing of the mandibular canal	1	2.0
Diversion of the mandibular canal	1	2.0
Total	50	100.0

Table 2: Frequency distribution and percentage (%) of contact status (contact and no contact in CBCT) for each panorama radiographic sign.

Type of radiographic sign	Contact	No contact	Fischer Exact test
Interruption of white line	11 (47.8%)	12 (52.2%)	.049*
Residuals	4.1	-4.1	
Darkening of root	0 (0%)	9 (100%)	
Residuals	-2.7	2.7	
Interruption of white line + Darkening of root	4 (30.8%)	9 (69.2%)	
Residuals	.1	-.1	
Developing of root	0 (0%)	2(100%)	
Residuals	-.6	.6	
Deflection of the root	0 (0%)	1 (100%)	
Residuals	-.3	.3	
Narrowing of the mandibular canal	0 (0%)	1(100%)	
Residuals	-.3	.3	
Diversion of the mandibular canal	0 (0%)	1 (100%)	
Residuals	-.3	.3	
Total	15	35	50

* Significant difference at 5% level of significance

Table 3: Frequency distribution and percentage (%) of gender (males and females) contact status (in CBCT).

	Male	female	Fischer exact test
Contact	7 (46.7%)	8 (53.3%)	.76 (NS)
No contact	19 (54.3%)	16 (45.7%)	
Total	26	24	

NS; non-significant at 5% level of significance.

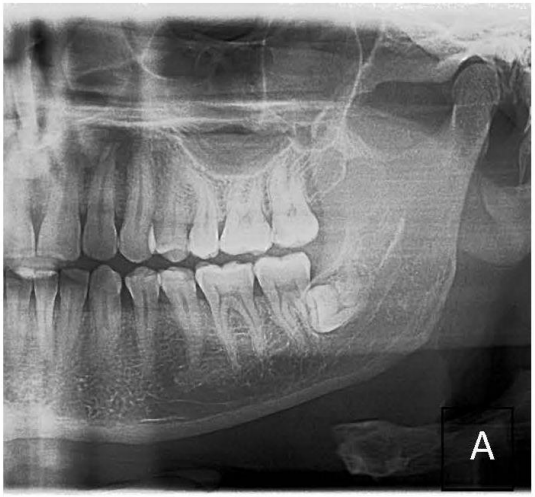
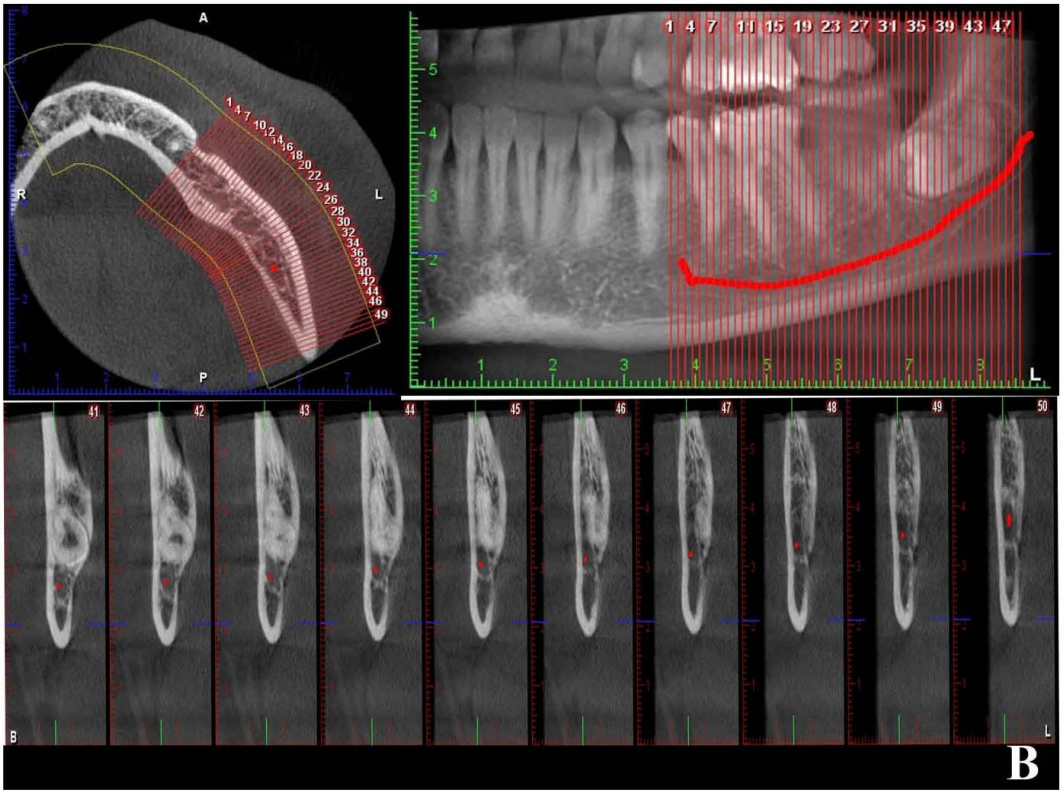
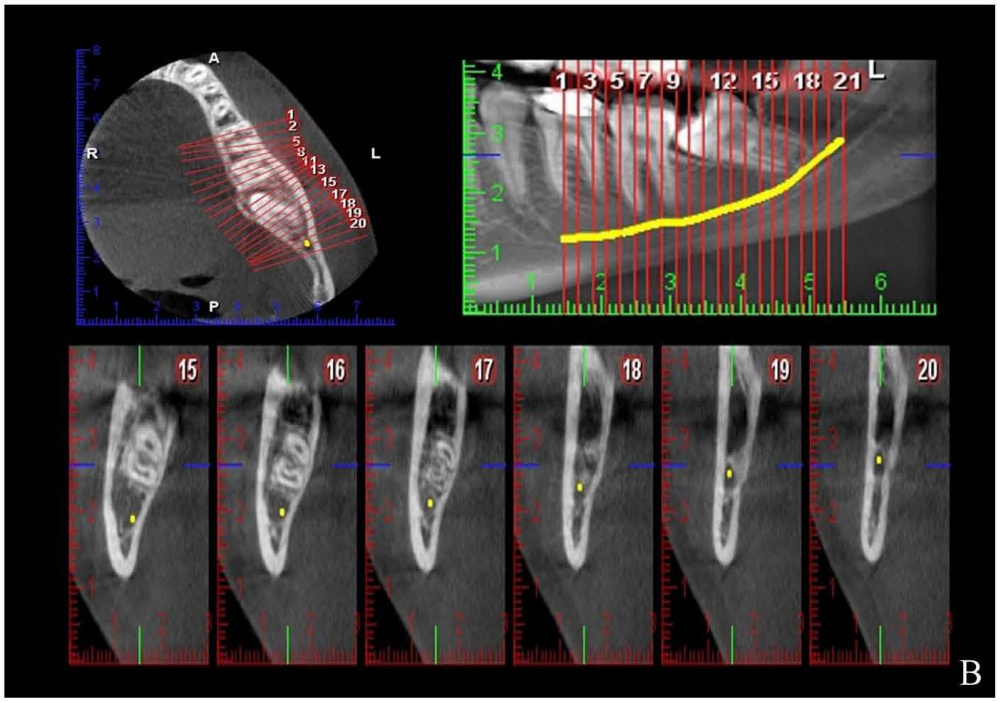


Fig.1.A. cropped panoramic radiograph Shows the interruption of the supperior Wall of the mandibular canal by roots of impacted lower Third molar.



B. Cone beam CT cross-sectional images showing inferior position of canal without wisdom root contact

Fig. 2. **A.** cropped panoramic radiograph Shows the interruption of the supperior Wall of the mandibular canal by rootsof impacted lower third molar.



B. Cone beam CT cross-sectional images showing inferior position of canal without wisdom root contact.

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