Original Article

Zahedan Journal of Research in Medical Sciences

Journal homepage: www.zjrms.ir

The Validity of the Panoramic Radiography in Evaluating the Topographic Relationship between Mandibular Canal and Impacted Third Molars in Comparison with Cone Beam CT-scan

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Article information

Article history:
Received: 17 Oct 2010
Accepted: 16 Nov 2010
Available online: 17 Apr 2011
ZJRMS 2013; 15(1): 28-33

Keywords:
Cone beam
Third molar
Panoramic radiography
Inferior alveolar Nerve
Nerve injury

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Abstract

***Background*:** The purpose of this study is to compare the validity of panoramic radiography with CBCT (Cone Beam Computed Tomography) in the assessment of the relationship between the mandibular third molar and the mandibular canal.

***Materials and Methods*:** In this descriptive-analytical study, 80 mandibular third molars were extracted from 48 patients. On the panoramic radiography (PR) there was a close relationship between the root tooth and mandibular canal in all the teeth. The teeth were classified on the basis of six radiographic markers in panoramic radiographs (superimposition, root opacity/darkening of the roots, root deflection, diversion of the canal, interruption of the cortical border of the canal and narrowing of the canal). Then, the relationship between the markers and presence or absence of contact is CBCT was investigated.

***Results*:** The superimposition marker in the interrupted group and group with intact border was significantly higher than the group with no cortical border. The interruption of the cortical border of the canal and increased radiolucency marker were significantly higher in no-cortical border group than the other two groups. As to the other three markers (diversion of the canal, narrowing of the canal and root diversion) due to the low frequency in the 80 teeth, the findings were presented in a descriptive manner.

***Conclusion*:** Presence or absence of a radiological sign in panoramic radiography will not properly predict the existence of a close relationship with third molar and it is suggested that in case of tooth-canal overlapping either as a superimposition or as other aforesaid markers, the patient should be referred for CBCT assessment regarding the additional and useful information provided by CBCT.

Introduction

Inferior alveolar nerve damage and resultant temporary or permanent alteration of sensation is a common and serious complication caused by removal of mandibular third molar teeth [1, 2]. Several factors affect the inferior alveolar nerve (IAN) damage including: surgical techniques, type of anesthesia, patient age, third molar position, and the relationship between the third molar and mandibular canal. The most important of them is an exact evaluation of the proximity of the mandibular canal to the third molar and their relationship before extracting the third molar [2]. Panoramic radiography is the most common radiography used for this purpose [3, 4].

Specific radiographic signs such as darkening of the root, interruption of the cortical border of the canal, narrowing of the root and diversion of the canal are known as factors associated with IAN exposure [5-7]. Although such factors can be useful for the surgeon, exact and true observation of the relationship of tooth and mandibular canal is still imperfect because three-dimensional (3D) assessment of bony structures surrounding impacted mandibular third molars is not possible using conventional panoramic radiographs (OPGT) [8]. To overcome the limitations of two-dimensional (2D) imaging, tomography imaging and CT scan are used which are more useful than panoramic for evaluation of the 3D location of the mandibular canal in relation to the third molar [9-11]. However, CT scan has also some disadvantages including higher doses of radiation and economic costs and more difficult access to modality [3]. Recently, a new type of volumetric CT scan (VCT) is presented which uses the cone-beam technique instead of traditional fan-beam technique is introduced in oral and maxillofacial radiology. VCT offers the same geometric accuracy and reconstruction possibilities as spiral CT scan but at a much lower cost, low dose with less mechanical requirements [8].

CBCT provides a higher quality image of teeth and their surrounding structures than conventional CT scan and it seems to be a more accurate imaging modality for

determining the relationship of the third molar with the mandibular canal [12, 13]. Although the results of panoramic imaging have been compared with CT scans and conventional tomography in different studies [1, 9, 12-15], there are few studies in which panoramic findings are compared with CBCT [2, 16].

In this study, the accuracy of six radiographic markers including the interruption of the cortical border of the canal, increased radiolucency, superimposition of tooth and canal, diversion of the canal, narrowing of the canal and root deflection (diversion) was evaluated and the contact between the third molar and the mandibular canal as well as the buccolingual position of the canal in relation to root was also detected. If panoramic findings can exactly determine the three-dimensional relationship between the third molar and mandibular canal, CBCT may not be necessary and the patient can be warned against high probability of nerve damage without CBCT. Or the surgeon may suggest CBCT based on his clinical judgment in cases where the predicative value of a particular marker is high in panoramic [1].

Materials and Methods

In this descriptive-analytical study, observation method was used for data collection. The samples were selected among the accessible and qualified samples. 48 patients (80 impacted mandibular third molar teeth) were selected from the patients who referred to two private office of oral and maxillofacial surgery in Tehran during a two-year period (2008 & 2009). The patients were 34 women and 14 men with average age of 26.2 and range of 15-56. Of 80 teeth, 37 teeth were right third molar and 43 were left third molar teeth. In all the teeth, there was a close relationship between the tooth root and mandibular canal in panoramic radiography.

In all the cases, the surgeon couldn't determine the close relation of canal ant tooth through panoramic radiography and referred the patients to a private office of oral and maxillofacial radiology for more examination with CBCT. Anatomic relationship between the third molars and the mandibular canal is classified on the basis of six radiographic markers which can be easily diagnosed in panoramic radiography. The markers are discussed in essays and it is reported that all are indicative of a close relationship between the third molar and the mandibular canal [4, 6].

The markers include: 1- tooth superimposition on the canal 2- interruption of the cortical border of the canal 3- diversion of the canal 4- narrowing of the canal 5- increased radiolucency (darkening of the root) 6- root deflection.

Superimposition occurs when the upper and lower opaque border of the mandibular canal is superimposed on tooth root. Darkening of the root includes a radiolucent band across the root in a region in which root and canal overlap. The radiopaque border of the canal is said to be interrupted just when it disappears before reaching the tooth structure. Both upper opaque border and lower opaque border may be involved. In this study, the researchers didn't separate these two modes. Diversion of the canal occurs when the canal changes it direction while passing the third molar root. The canal is said to be narrowed (thin) when the diameter of the canal decreases as passing the third molar root. Root deflection is the sudden diversion (deviation) of the root when it reaches the mandibular canal (Fig. 1-4).

CBCT images were evaluated in all the three dimensions and the relationship between the third molar and the mandibular canal were divided into 3 categories: contact and no-contact. In cases when there is contact, two other modes were also considered: 1- Cortical border of the canal is intact. 2- There is no cortical border in the canal. In cases of no contact, the distance between the tooth and root was measured: 1- greater than or equal to 1mm, 2- less than 1mm (Fig. 5, 6).

The position of the mandibular canal in relation to the third molar was determined in lingual, buccal, sub-root and inter-root CBCT images.

CBCT images were taken using (Planmeca Promax 3D Helsinki, Finland) machine with 84 KVP and 16mA for 12 seconds. The resolution of the machine was 0.16mm. Volume reconstruction was performed with (Planmeca Romeix viewer Helsinki Finland) software. Digital panoramic images were taken by Planmeca cc 2002 proline machine with 66 KVP and 7mA using Python Server Pages (PSP). The panoramic images were watched by three observers, two oral and maxillofacial radiologists and an oral and maxillofacial surgeon.

Three observers were trained before evaluating panoramic images and there was no time limitation for observing the images. Three observers separately evaluated the panoramic images in a dark room on Negatoscope. In cases where there was agreement between all the three observers or at least two observer, the agreed marker or markers were recorded as the final marker(s). In cases where the marker seen by each of the observers was different, two radiologists discussed about their findings and reached an agreement. Each observer watched 20 randomly selected sample a week later and intraobserver agreement was evaluated. For CBCT, 20 samples were investigated separately by two oral and maxillofacial radiologists. Due to the 100% agreement, other samples were evaluated only by one person. X^2 and ratio test were used in order to compare the agreement of each panoramic marker in three different modes of CBCT. Kappa statistics were used for panoramic radiographs to evaluate Interobserver and intraobserver agreement.

Results

Intraobserver agreement was 95%. Interobserver agreement was 80%. In cases of disagreement for reaching 100% agreement, the two radiologists discussed with each other and reached an agreement. 80 teeth were classified on the basis of panoramic radiography analysis as follows: interruption of the cortical border of the canal

in 34 teeth, superimposition in 33, increased radiolucency in 10, root deflection in 4, narrowing of the canal in 4 teeth and deviation of the canal was found in 1 tooth. In 6 teeth, two makers were observed. Based on CBCT analysis of the contact between the mandibular canal and tooth, 29 cases of interrupted cortical border (6 cases of intact border, 23 cases with no border), 23 cases of superimposition (11 cases of intact border, 12 cases with no border), 9 cases of increased radiolucency (1 case of intact border, 8 cases with no border) was observed and in all the cases root deflection, narrowing of the canal, and deviation of the canal was observed with no border. In all the cases with a distance between tooth and canal, the distance was more than 1mm. In 41% of the cases the canal was under the root, in 27.5% was lingual and 30% was buccal. Only in one tooth of 80 teeth, the canal passed between the roots.

Cross-tabulations done for CBCT findings and panoramic markers are indicated in tables (1, 2): the results indicated that superimposition marker was significantly higher in the two groups with distance and intact border than the group with no border (p=0.001) but between the first two groups, there was no significant difference (p=0.358). The marker of interruption of the cortical border of the canal in the group with no border was more than the other two groups (p=0.046) but between the other two groups the statistical difference was not significant (p=0.001). In the other three markers, due to the low frequency in 80 teeth, the findings were presented descriptively.

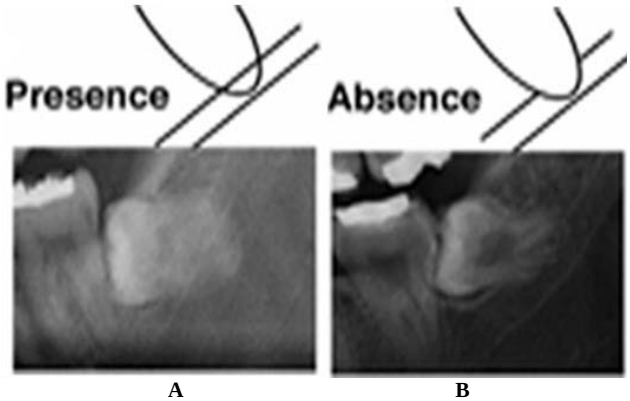

Figure 1. A: Superimposition, B: Dissociation of the cortical border of canal

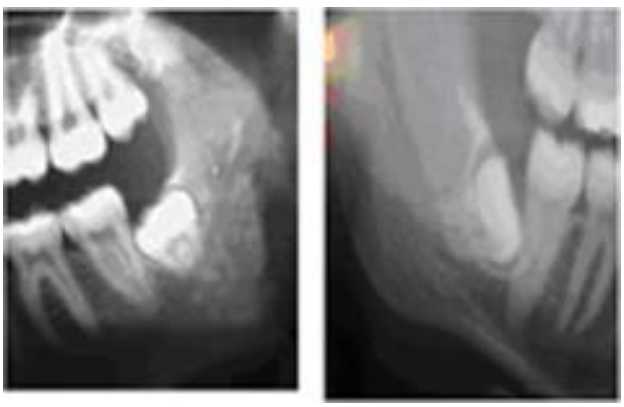

Figure 2. Opacity of the root

Figure 3. A: Thinning of canal, B: Inclination of canal

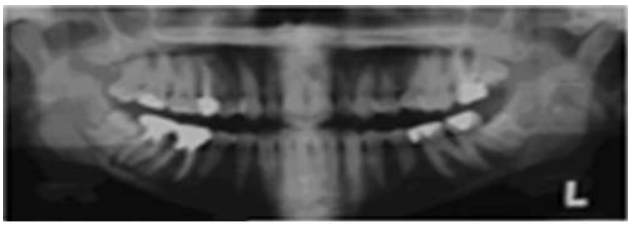

Figure 4. Curvature of the root

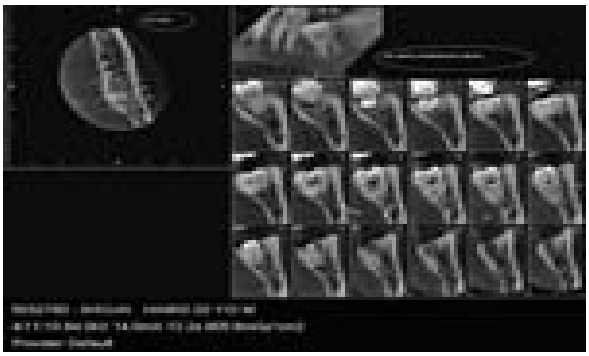

Figure 5. No contact of the tooth and root (> 1 mm)

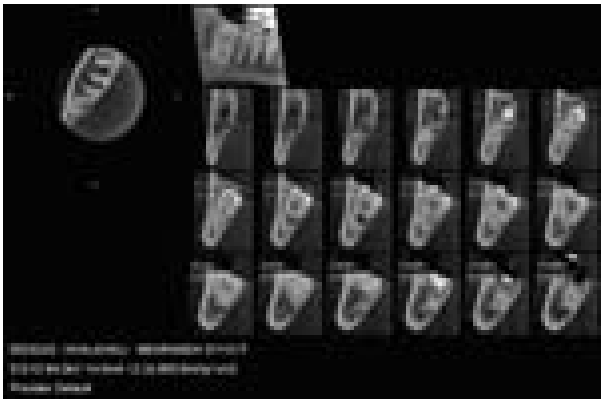

Figure 6. Contact of the tooth and root (loss of the cortical border of the canal)

Discussion

The present study showed that in many cases especially when there is no tooth-canal overlapping, only panoramic or intraoral radiography is used. Since three-dimensional imaging is a useful instrument in minor oral surgery, clinicians are not usually inclined to suggest CT scan or CBCT due to the additional exposure imposed on the patient [2].

Table 1. Frequency and relative abundance of panoramic radiographical markers by the kind of the relation between the tooth and canal in CBCT

CBCT		PANORAMIC						Total
		Root deflection N(%)	Superimposition N(%)	Canal diversion N(%)	Interruption N(%)	Canal narrowing N(%)	Root darkening N(%)	N(%)
More than 1 mm Distance	Coun% within CBCT t	0(0)	10(62.5)	0(0)	5(31.3)	0(0)	1(6.3)	16(100)
Intact cortical border	Count% within CBCT	0(0)	11(64.7)	0(0)	5(29.4)	0(0)	1(5.9)	17(100)
No cortical border	Count% within CBCT	3(6.4)	12(25.5)	1(2.1)	21(44.7)	2(4.3)	8(17.0)	47(100)
Total	Coun t % within CBCT	3(3.8)	33(41.3)	1(1.3)	31(38.8)	2(2.5)	10(12.5)	80(100)

Table 2. Frequency and relative abundance of the position of canal than third molar by the kind of the relation between the tooth and canal in CBCT

CBCT		CANAL Position				Total
		Buccal N(%)	Lingual N(%)	Inferior N(%)	Inter radicular N(%)	N(%)
More than 1 mm distance	Count% within CANAL	6(25. 0)	1(4. 5)	9(27. 3)	0(0)	16(20. 0)
Intact cortical border	Count% within CANAL	10(41. 7)	0(0)	7(21. 2)	0(0)	17(21. 3)
No cortical border	Count% within CANAL	8(33. 3)	21(95. 5)	17(51. 5)	1(100)	47(58. 8)
Total	Count% within CANAL	24(100)	22(100)	33(100)	1(100)	80(100)

Although the dose is significantly lower in CBCT. On the other hand, it is indicated that when there is a close relationship between tooth and canal, the incidence of Inferior Alveolar Nerve injury will increase significantly. Therefore, many efforts have been made to use different radiological signs especially in panoramic radiography in order to determine whether there is a relationship between these markers and nerve injury during surgery [21]. Thus, in this study it is attempted to provide surgeons with instructions so that by watching panoramic images they can decide more easily about prescribing three-dimensional radiographies.

Several studies have reported that the most common topographic relationship between mandibular canal and third molar has been buccal position of the canal [20, 11, 10]. In two studies, the lingual position of the canal was the most common position [13, 16]. In our study, the most common position was the under-root position which is in accordance with studies by Monaco et al., Tantanapornkul et al. and Tammisallo et al [17, 3, 1]. The high discrepancy in the position of the canal in different studies is probably the result of inclusion criteria [21]. In our study, the loss of cortical border of the canal was mostly seen in cases where the position of the canal in relation to the third molar was lingual (21 out of 22 cases where the canal was in a lingual dental position) and in the only case where the canal passed between the roots, there was no cortical border.

This finding is consistent with other studies showing that inferior alveolar nerve exposure occurs mostly in cases where the direction of the lingual canal is between the roots [10, 13]. It may be because the surgeon begins the surgery from the right buccal side even in cases that the nerve is located in the lingual. This generally will result in an inadequate force in the lingual side as well as damage to the nerve [13]. In 6 out of 80 teeth, two radiography markers were observed. In two cases the interruption of the cortical border of the canal was accompanied with narrowing of the canal. In two other cases, the interruption of the cortical border of the canal was along with root deflection and in the last two cases the interruption of the cortical border of the canal was seen with darkening of the root and narrowing of the canal with darkening of the root. In all the six cases in CBCT images there was contact between the canal and tooth (in 5 cases there was no cortical border and in one case it was intact). The finding is similar to that of Monaco et al. so that in their study in 11 cases two marker or more was seen and in all the 11 cases the CT indicated a contact between tooth and canal [1]. Therefore, it seems true to assume that more than one marker in a panoramic will increase the possibility of contact between the tooth and canal. In such case CBCT will help the surgeon to confirm his diagnosis [1].

In our study, a significant relationship was found in CBCT between the two markers, darkening of the root and the interruption of the cortical border of the canal with loss of the cortical border of the canal which is consistent with the findings of the study of Monaco et al. who indicated that darkening of the root, interruption of the cortical border of the canal and narrowing of the canal are significantly related with the contact between the canal and tooth in CT scan and suggested axial CT scan in such cases [1].

In the study of Tantanapornkul et al. interruption of the radiopaque border of the canal and in the study of Ohman et al. increased radiolucency have also been introduced as factors relating to nerve exposure during surgery [3, 13]. In the study of Kaeppler et al. CT scan is suggested that in cases that upper and lower opaque border of the canal is not observed in panoramic [10]. In the study of Ohman et al. in 100% of cases where increased radiolucency was observed in panoramic images, in CBCT the contact between canal and tooth was seen. In our study, 9 out of 10 teeth which indicated increased radiolucency (90%), indicated contact in CBCT which 2% more than what was stated by Monaco et al [1].

Although they used only axial sections of CT scan for evaluating the contact between tooth and canal, we used also coronal sections in our study so we can easily judge about the contact between tooth and canal in this section [16]. In the study of Maegawa et al. in 14 teeth with increased radiolucency, 13 teeth (1.92%) showed contact between tooth and canal in conventional tomography images [9]. In our study, superimposition marker in the distant group and the group with intact border was

significantly more than the group with no border but there was not a significant difference between the first two groups. In the study of Monaco et al. it is reported that superimposition is not a good marker for predicting the contact between the canal and tooth (positive indicative value 38%) and in such cases that superimposition could be observed in panoramic radiography, there is no need to three-dimensional imaging such as CT and periapical radiography will suffice in cases which this marker can be observed in panoramic [1]. Actually, it is not specified that whether the intactness of the cortex is considered as contact or not and as it was mentioned only axial sections of CT scan are used and confidence interval (CI) is reported to be between 10 to 66%. In the study of Nakagawa et al. it is reported that in cases of tooth and canal overlapping in panoramic, it is very likely that the tooth and canal be in contact, even if upper opaque border of the canal is clearly seen in panoramic (superimposition) [2]. When upper opaque border of the canal cannot be observed in panoramic; the likelihood (probability) of contact between the canal and root will increase. In the study of 31 cases of superimposition, 20 teeth (5.64%) showed contact which is very similar to our study (23 out of 33 teeth) which this amount was unexpectedly high. The result depends on the cortication of the upper opaque border of the canal; when there is contact in CBCT but the cortical border of the canal is intact, panoramic border shows a clear opaque. Thus, if in such cases there is contact in CBCT, in panoramic the opaque border of the canal is intact (superimposition) because the root has severed (cut) only a small part of the canal wall.

In this study in which the intactness of the cortex in CBCT is also considered as contact, it is concluded that it is hard to predict whether the root has contact with tooth when there is superimposition in panoramic i.e. the upper opaque border of the canal is intact [2]. Due to the small number of studies about this marker, no judgment can be made and further studies are required. In our study and many other studies, different radiographic signs are introduced as factors related to damage to the alveolar nerve and the close relationship between the mandibular third molar and the mandibular canal. But even if a relationship exists, presence or absence of a radiologic sign on panoramic radiography neither completely predicts the existence of a close relationship with the third molar nor completely denies the existence of such a relationship [21]. In fact, these markers are indicators but they are not absolute, so that one or several marker(s) may be observed in panoramic but there is no relationship between tooth and canal or on the other hand, no marker may be observed in the panoramic but there is a close relationship between the canal and tooth [20]. Even if there was a way to predict the relationship between canal and tooth correctly through determining the presence or absence of different markers in panoramic radiography, still the exact location of the mandibular canal its path (direction) could not be evaluated due to the two-dimensional nature of panoramic radiography and since knowing the direction of the canal can affect the surgeon access a lot, it is better to determine this issue through three-dimensional radiographic examinations [21]. Three dimensional imaging such as CBCT can also provide the surgeon with other information such as narrowing or puncturing of the lingual cortex by root [16, 19], which can result in decreasing the risk of injury to the lingual nerve, fracture of the lingual cortex, or displacement of tooth or bone into the soft tissues at the floor of the mouth [16]. Therefore, the exact information surgeon gains through CBCT images will make the process of surgery easier and safer and also will provide the patient with enough information and a better understanding of the process of surgery and its relevant risk [15].

Finally, panoramic or intraoral radiography is suggested to be used in many cases especially when there is not overlapping between tooth and canal, but in case there is overlapping between tooth and canal either as a superimposition (upper and lower opaque border of the canal are clear in panoramic) or if the aforesaid markers could be observed so that the relation of nerve and canal cannot be determined by conventional radiographies, the patient should be referred to oral and maxillofacial radiology office for CBCT due to the additional and useful information it provides.

Acknowledgements

Besides appreciating the Research Deputy of Shahid Beheshti University of Medical Sciences who undertook to pay the research costs, it should be mentioned that this paper is extracted from the research project with No. 555.

Authors' Contributions

All authors had equal role in design, work, statistical analysis and manuscript writing.

Conflict of Interest

No conflict.

Funding/Support

Zahedan University of Medical Sciences.

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Please cite this article as Ebrahimifard T, Poorzamani M, Tavakoli M, Varshowsaz M. The validity of the panoramic radiography in evaluating the topographic relationship between mandibular canal and impacted third molars in comparison with cone beam CT-scan. Zahedan J Res Med Sci (ZJRMS) 2013; 15(1): 28-33.