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Comparison between cone beam computed tomography and panoramic radiography in the assessment of the relationship between the mandibular canal and impacted class C mandibular third molars

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ABSTRACT

Background: Preoperative radiographic evaluation of impacted third molars is essential to determine the proximity to the mandibular canal to minimize the risk of nerve injury. Our study aim was to evaluate the relationship between the mandibular canal and impacted mandibular third molars using cone beam computed tomography (CBCT) and to compare findings therein with panoramic radiographic signs.

Methods: CBCT images were taken from 29 patients having 43 Class C impacted mandibular third molars whose panoramic radiographs showed a close relationship between the mandibular canal and mandibular third molars. We evaluated their tomographs to determine the course of the canal, its proximity to the root, any narrowing of the canal, the presence of root grooving or hooks and the proximity of the root to the cortex. A Chi-square test was used for data analysis.

Results: The lingual course of the canal was the most frequently detected course in all panoramic findings. Contact of the tooth with the canal was observed in all cases in which panoramic signs of deviation of the canal and darkening of the roots were found. The frequency of observing the narrowing of the canal in CBCT as compared to seeing the presence or the absence of canal narrowing in panoramic radiographs was significantly different (P=0.01).

Conclusion: CBCT provides more precise diagnostic information to determine the relationship of impacted third molars to the canal. Deviation of the canal and darkening of the roots in panoramic view can be highly valuable to predict the risk of nerve injury.

Key Words: Cone beam computed tomography, mandibular canal, panoramic radiography, third molar

INTRODUCTION

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.[1-4] The overall risk of permanent impairment during mandibular third molar removal is low, but a considerable number of patients may be involved because many third molars are removed.

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.[4-7] 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.

Panoramic radiographs are most commonly used for assessing the relationship between these two structures

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preoperatively. Two-dimensional (2D) panoramic radiographs provide limited information about the buccolingual relationship between the mandibular canal and mandibular third molars, cortication of the mandibular canal and the detailed anatomy of the third molar.

Several clinical studies have determined the specific radiographic signs detected in panoramic radiographs, which may suggest the presence of a close relationship between the mandibular canal and mandibular third molars.[4-6,8] These radiographic signs include superimposition of the tooth roots on the canal, narrowing of the canal, deviation of the canal, interruption of the radiopaque borders of the canal, darkening of the roots, narrowing of the tooth roots as well as deviation of the tooth roots and the bifid apex. However, opinions vary regarding the frequencies of the above-mentioned signs for predicting exposure of the IAN or a clinical complication such as paresthesia as a result of mandibular third molar removal.

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,[9] increased financial cost and less accessibility, however, are the negative aspects of CT compared with conventional imaging.

3D images of Cone Beam CT (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[12] and offers high spatial resolution.[13] Thus, it seems that the relationship of the third molar to the mandibular canal is assessed more accurately with CBCT imaging modality.

According to the dispersion of the data regarding the comparison of panoramic signs with CBCT findings, the purpose of this study was to make a comprehensive analysis comparing panoramic signs with CBCT findings to study the relationship between impacted mandibular third molars and the IAN.

Since the risk of an IAN injury occurring during the removal of the impacted mandibular third molar is higher than in impacted Class C mandibular third molars (the level of cementoenamel junction of impacted third molar located under the level of alveolar crest), we evaluated both the panoramic and CBCT images of this group of impacted mandibular third molars.

MATERIALS AND METHODS

This cross-sectional study was carried out with the CBCT images of patients who had one or two impacted Class C mandibular third molars and referred us for taking CBCT images. In addition, their panoramic features suggested a close relationship between the mandibular canal and the roots of mandibular third molars, and thus the surgeon or dentists predicted the risk of nerve injury.

This study was performed between April 2009 and October 2010. Twenty-nine patients with 43 impacted mandibular third molars were included in this study. The patient group included 13 males and 16 females ranging in age between 18 and 51 years, with a mean age of 28.34 years.

We originally obtained the approval of the ethical board of the institutional ethics committee of the Guilan University of Medical Sciences Research Foundation in Rasht, Iran, before conducting this investigation (Ethics Approval Number 10229) to ensure our compliance with the recommendations of the Declaration of Helsinki and Tokyo for humans. Accordingly, our protocol complied with these guidelines. Moreover, we obtained written consent of the participating patients prior to initiating the study.

CBCT images for all patients were obtained with New Tom VG equipment (QR SRL Company, Verona, Italy) in HiRes zoom mode at 110 kV, 5.5 mA and 5.4 s. Two scout images, i.e. lateral and posterior–anterior views taken in accordance with the patient's position, were initially prepared, and after this a 360° scan was acquired. The total scan time was 18–20 s. The time required for the reconstruction of volumetric images after the patient's complete exposure was 4 min**.** Then, to reconstruct study images from the volumetric images, the plane was selected in such a way to ensure that it was parallel to the jaw. Axial images with a thickness of 1 mm and an interval of 1 mm were prepared.

The mandibular canal was color-marked by the "Show Mark" tool in the NNT viewer software of the CBCT machine in reconstructed panoramic images having a 1-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 [Figure 1a-e]. Overall, multiplanar reconstructed images were used to determine the topographic relationship between the impacted teeth and the mandibular canal more accurately.

Evaluation of images

An experienced Dentomaxillofacial Radiologist evaluated the corresponding panoramic and CBCT images to examine the topographic relationship between the impacted third molars and the mandibular canal. Panoramic radiographs were evaluated previously to analyzing CBCT images and in separate sessions every 1–2 weeks to avoid bias and memory effect of repeated viewing at closer intervals.

Figure 1a: Panoramic view of a left mandibular Class C impacted third molar having curved roots and odontoma adjacent to the coronal portion

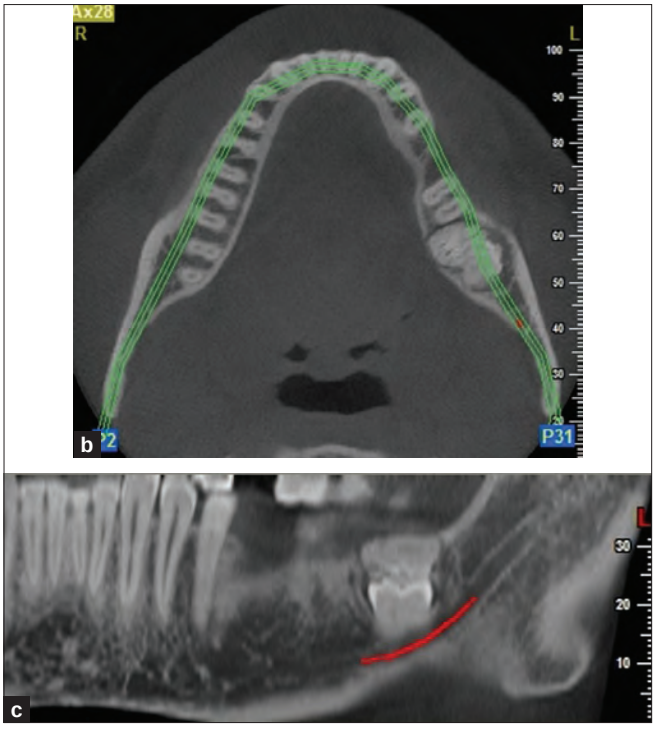

Figure 1b-c: Axial cut and reconstructed panoramic view showing colorization of the mandibular canal (colorization is only in panoramic view)

Panoramic radiographs were evaluated for determining the presence or absence of one of several of these radiographic signs mentioned earlier: superimposition of the roots on the mandibular canal, narrowing of the mandibular canal, deviation of the canal, interruption of the radiopaque border of the canal or darkening of the roots. CBCT images were assessed through the NNT viewer software program used with New Tom imaging devices. We evaluated these CBCT images to identify features described below based on terms defined by Öhman *et al*.[7]

1. The course of the mandibular canal as compared with the root of the impacted tooth: The course of the mandibular canal was classified as buccal, lingual, inferior or interradicular.
2. The proximity of the mandibular canal and the tooth roots: The proximity of the mandibular canal to the roots was rated as “contact” or “no contact”.
3. The narrowing of the mandibular canal: The observed narrowing of the mandibular canal was classified as “narrowing” or “no change”.
4. Grooving indicated the presence of concavity or invagination of the root surface wherein the canal was situated.
5. Hooks, either completely or partially encircling the mandibular canal, indicated the presence of a deviation of the root apex.
6. The proximity of the mandibular third molar and the cortex: The proximity of the tooth was scored as “simple contact”, “contact and thinning”, “contact and perforation” or “no contact”.

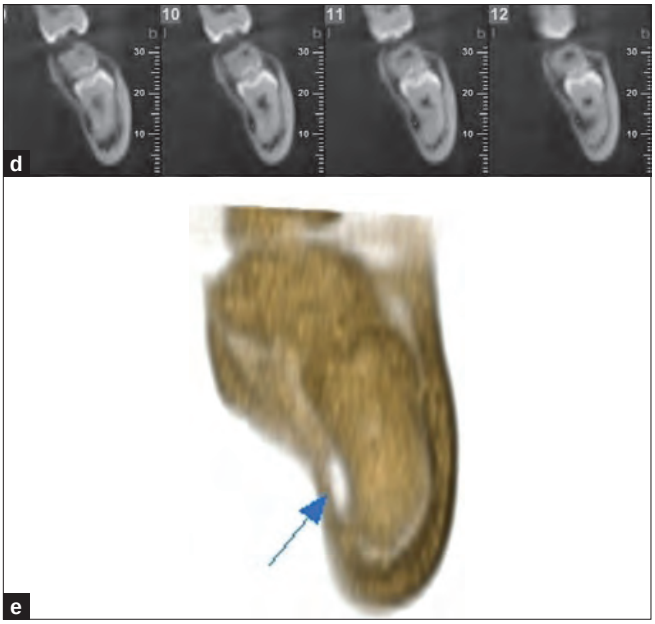

Figure 1d-e: Cross-sectional and 3-D images reveal a lingual position of the canal having close proximity to the root surface

Statistical analysis

Absolute and relative frequencies of each radiographic finding were reported. A Chi-square (χ^2) test was used to compare panoramic signs with CBCT findings. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) Version 16.0 for Windows (SPSS: Chicago, USA).

RESULTS

The study sample consisted of 43 impacted Class C mandibular third molars from 29 patients (13 males and 16 females) having an average age of 28.34 years, ranging from 18 to 51. Approximately 25 cases (58.1%) showed just one of the panoramic signs, while in 14 cases (32.6%), a combination of two and, in four cases (9.3%), a set of three panoramic signs were observed. Superimposition of the roots on the canal alone was the most frequently detected panoramic finding (14 cases, 32.6%). The combination of radiographic signs indicating superimposition of the roots on the canal and the interruption of the radiopaque border of the canal was the second most frequent panoramic sign (6 cases, 14%). Each of the combined panoramic findings of superimposition of the roots on the canal and narrowing of the canal, superimposition of the roots on the canal and deviation of the canal as well as narrowing of the canal and interruption of radiopaque border of the canal was just found in one case (2.3%). In general, superimposition of the roots on the canal was the most frequent panoramic sign (67.4%), while darkening of the roots was less frequently seen than other panoramic signs (11.6%). This radiographic finding was not observed independently and was associated with one or two other panoramic signs. The panoramic findings of the impacted third molars are shown in Table 1.

Hooks of impacted molar roots were only observed in two cases (4.6%). The panoramic and CBCT findings associated with this radiographic sign are shown in Table 2 separately, but were not included in further statistical analysis.

The data related to the comparison of the CBCT findings to different kinds of panoramic findings are shown in Table 3. A lingual course of the mandibular canal observed CBCT finding was the most frequent course detected in all panoramic signs. Contact of the tooth with the canal was observed in all cases in which panoramic signs confirmed deviation of the canal or darkening of the roots. Tooth contact with the cortex was observed in all the cases wherein the panoramic signs of narrowing of the canal or darkening of the roots were found. A significant difference was detected between the frequency of the narrowing of the canal in CBCT images as compared to observing the presence or absence of the narrowing of the canal in panoramic radiographs (P=0.01). Significant differences also existed between the frequency of various types of cortical proximity to the tooth root occurring and the frequency of thinning or perforation of the cortex seen in different types of tooth angulation (P=0.001; 0.005 respectively).

The data related to the comparison of panoramic signs with CBCT findings are shown in Tables 4 and 5. Superimposition of the roots on the canal was the most frequently detected panoramic finding in all the CBCT findings. Mesioangular positioning of the impacted third molar was the most frequent tooth angulation occurring in all CBCT findings except for cases in which we can see cortical proximity to the tooth.

Table 6 shows the mandibular canal course in relation to the third molar in CBCT findings. A lingual course of the canal was the most frequent course detected in all CBCT findings. The frequency of various courses of the canal occurring in the different types of cortical proximity of the tooth was significantly different (P=0.02).

DISCUSSION

Surgical removal of impacted third molars is one of the most common dentoalveolar surgeries. According to the considerable variety in the relationship of the mandibular canal to an impacted mandibular third molar, preoperative radiographic assessment is required to evaluate the relationship between these two anatomical structures.

Panoramic radiography is the most widely used technique for this purpose. Because of the limitations of conventional radiographic techniques, the need for more advanced techniques that could show anatomical

Table 1: Panoramic findings concerning 43 impacted mandibular third molars

Panoramic findings	Number	%
Superimposition	29	67.4
Narrowing	10	23.3
Deviation	8	18.6
Interruption	13	30.2
Root darkening	5	11.6

Note: For each of our 29 cases, one of more findings may be present in each impacted tooth

Table 2: Panoramic and CBCT findings of two cases with hook of the tooth roots

		CBCT findings				
Panoramic findings		**Angulation**	**Canal course**	**Canal contact**	**Narrowing**	**Cortical proximity**
Case 1	Superimposition deviation	Mesioangular	Lingual	Contact	–	Contact thinning
Case 2	Superimposition root darkening	Vertical	Interradicular	Contact	–	Simple contact

Table 3: Comparison of CBCT findings to different kinds of panoramic findings

CBCT findings		**Panoramic signs**													
		Superimposition			**Narrowing**			**Deviation**			**Interruption**			**Darkening**		
		Yes (%) *n*=29	**No (%) *n*=14**	***P***	**Yes (%) *n*=10**	**No (%) *n*=23**	***P***	**Yes (%) *n*=8**	**No (%) *n*=35**	***P***	**Yes (%) *n*=13**	**No (%) *n*=30**	***P***	**Yes (%) *n*=5**	**No (%) *n*=38**	***P***
Canal course	B	17.2	21.4	0.34	20	18.2	0.5	25	17.1	0.85	15.4	20	0.92	0	21.1	0.15
	L	65.5	50		50	63.6		62.5	60		61.5	60		80	57.9	
	I	10.3	28.6		30	12.1		12.5	17.1		15.4	16.7		0	18.4	
	IR	6.9	0		0	6.1		0	5.7		7.7	3.3		20	2.6	
Canal contact		75.9	78.6	0.84	90	72.7	0.25	100	71.4	0.08	76.9	76.7	0.98	100	73.8	0.19
Narrowing		41.4	57.1	0.33	80	36.4	0.01	62.5	42.9	0.31	53.8	43.3	0.52	40	47.4	075
Grooving		27.6	21.4	0.66	30	24.2	0.71	0	31.4	0.06	30.8	23.3	0.6	40	23.7	0.43
Cortex proximity	SC	37.9	57.1	0.6	60	39.4	0.42	37.5	45.7	0.64	61.5	36.7	0.46	80	39.5	0.24
	CT	41.4	21.4		20	39.4		25	37.1		23.1	40		0	39.5	
	CTP	13.8	14.3		20	12.1		25	11.4		7.7	16.7		20	13.1	
	NC	6.9	7.1		0	9.1		12.5	5.7		7.7	6.7		20	7.9	

B: Buccal, L: Lingual, I: Inferior, IR: Interradicular, SC: Simple contact, CT: Contact thinning, CTP: Contact-thinning-perforation, NC: No contact, CBCT: Cone beam computed tomography

Table 4: Frequency of CBCT findings of course, contact and narrowing of canal associated with different panoramic signs

Panoramic findings		**Canal course**					**Canal contact**			**Narrowing**		
		B (%) *n*=8	**L (%) *n*=26**	**I (%) *n*=7**	**IR (%) *n*=33**	***P***	**Yes (%) *n*=33**	**No (%) *n*=23**	***P***	**Yes (%) *n*=20**	**No (%) *n*=23**	***P***
Superimposition		62.5	73.1	42.9	100	0.34	66.7	70	0.84	60	73.9	0.33
Narrowing		25	19.2	42.9	0	0.5	27.3	10	0.25	40	8.7	0.01
Deviation		25	19.2	14.3	0	0.85	24.2	0	0.08	25	13	0.31
Interruption		25	30.8	28.6	50	0.92	30.3	30	0.98	35	26	0.52
Darkening		0	15.4	0	50	0.15	15.2	0	0.19	10	13	0.75
Angulation	M	62.5	46.2	85.7	0	0.18	48.5	70	0.44	60	47.8	0.39
	D	0	7.7	0	50		9.1	0		0	13	
	V	12.5	26.9	14.3	50		27.3	10		25	21.7	
	H	25	19.2	0	0		15.2	20		15	17.4	

B: Buccal, L: Lingual, I: Inferior, IR: Interradicular, M: Mesioangular, D: Distoangular, V: Vertical, H: Horizontal, CBCT: Cone beam computed tomography

Table 5: Frequency of some of CBCT findings associated with different panoramic signs

Panoramic findings		**Grooving**			**Cortical contact**			**Cortical proximity**					**Cortical thinning/perforation**		
		Yes (%) *n*=11	**No (%) *n*=32**	***P***	**Yes (%) *n*=40**	**No (%) *n*=3**	***P***	**SC (%) *n*=19**	**CT (%) *n*=15**	**CTP *n*=6**	**NC *n*=3**	***P***	**Yes (%) *n*=21**	**No (%) *n*=22**	***P***
Superimposition		72.7	65.6	0.66	67.5	66.7	0.97	57.9	80	66.7	66.7	0.6	76.2	59.1	0.23
Narrowing		27.3	21.9	0.71	25	0	0.32	31.6	13.3	33.3	0	0.42	19	27.3	0.52
Deviation		0	25	0.06	17.5	33.3	0.49	15.8	13.3	33.3	33.3	0.64	19	18.2	0.94
Interruption		36.4	28.1	0.06	30	33.3	0.9	42.1	20	16.7	33.3	0.46	19	40.9	0.11
Darkening		18.2	9.4	0.43	12.5	0	0.51	21.1	0	16.7	0	0.24	4.8	18.2	0.17
Angulation	M	63.6	50	0.79	55	33.3	0.75	31.6	93.3	33.3	33.3	0.001	76.2	31.8	0.005
	D	9.1	6.2		7.5	0		15.8	0	0	0		0	13.6	
	V	18.2	25		22.5	33.3		42.1	6.7	0	33.3		4.8	40.9	
	H	9.1	18.8		15	33.3		10.5	0	66.7	33.3		19	13.6	

CT: Contact thinning, CTP: Contact-thinning-perforation, NC: No contact, M: Mesioangular, D: Distoangular, V: Vertical, H: Horizontal, CBCT: Cone beam computed tomography

Table 6: Course of mandibular canal in relation to the third molar in CBCT images

CBCT findings		Buccal		Lingual		Inferior		Interradicular		*P*
		n	%	*n*	%	*n*	%	*n*	%	
Canal contact		4	12.1	22	66.7	5	15.2	2	6.1	0.18
Narrowing		4	20	12	60	4	20	0	0	0.55
Grooving		1	9.1	7	63.6	2	18.2	1	9.1	0.7
Cortical contact		6	15	26	65	6	15	2	5	0.08
	SC	1	5.3	14	73.7	2	0.5	2	10.5	
Cortical proximity	CT	5	33.3	6	40	4	26.7	0	0	0.02
	CP	0	0	6	100	0	0	0	0	
	NC	2	66.7	0	0	1	33.3	0	0	
Thinning/perforation		5	23.8	12	57.1	4	19	0	0	0.42

SC: Simple Contact; CT: Contact-Thinning; CTP: Contact-Thinning-Perforation; NC: No Contact.

relationships three dimensionally increased. Due to the introduction of CBCT, 3D images are becoming more easily available for use in dentistry.

In our study of panoramic findings, superimposition of the roots on the canal had the highest frequency (67.4%) while darkening of the roots had the lowest (11.6%). These findings are in contrast to the observations of Monaco *et al*.[14] and Tantanapornkul *et al*.[15] 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. Our study sample consisted only of impacted Class C mandibular third molars, and this limitation can result in such observed differences.

The mandibular canal was most often positioned lingually to the third molar (60.5%) than buccally. This is in accordance with the results of several studies,[7,15-17] while other reports stated a higher number of mandibular canals were positioned buccally to the third molar.[14,18-20]

The incidence of root contact with the canal was found in 76.6% of the third molars we studied. This frequency is lower than those reported by Ghaeminia *et al*. (85%)[17] and Öhman *et al*. (94%)[7] and is higher than that reported by Tantanapornkul *et al*. (36%).[15] The differences observed in these studies may be due to the different case selection criteria used for CBCT examination.

Tooth contact with the cortex was observed in 93% of the impacted molars evaluated. This contact with the lingual cortex was found in 83.7% of the third molars and concurs with the result of the Öhman *et al*.'s study (86%).[7]

A lingual course of the mandibular canal was the most frequent course in all of the panoramic findings. Ghaeminia *et al*.[17] showed a significant relationship between the lingual positioning of the canal to the third molar and an IAN injury. In the present study, the panoramic sign of darkening of the roots had the highest frequency (80%) of a lingual course that can suggest a higher risk of nerve injury in cases wherein this panoramic sign exists.

Various studies[6,21-23] have suggested that anatomical proximity of third molar roots to the neuro-vascular bundle increases the risk of an IAN injury. In our study, tooth contact with the canal was observed in all of the cases wherein panoramic signs of deviation of the canal or darkening of the roots were found. This finding concurs with those of the studies by Monaco *et al*.[14] and Öhman *et al*.[7]

Tooth contact with the mandibular canal was observed in 94% of the cases that showed the presence of more than one of the panoramic signs studied. This frequency is comparable with that reported by Öhman *et al*.[7] According to our findings, it seems that the probability of tooth contact with the mandibular canal increases in the presence of deviation of the canal or darkening of the roots and also in the cases in which more than one of the studied panoramic findings exist.

Several investigators[21,23,24] present the premise that narrowing of the canal, when it passes through lower third molar roots, may be an excellent indicator of high-risk cases for neurological damage. Thus, narrowing of the canal seems synonymous of an intimate contact of the mandibular canal with the third molar. In the present study, the frequency of the narrowing of the canal seen in CBCT images as compared to that of the presence or the absence of the narrowing of the canal detected in panoramic radiographs is significantly different (P=0.01); so, this panoramic sign is the best

predictor of decreased canal diameter in CBCT images. This finding is in contrast with that of Mahasantypiya *et al*.[25] who reported that a panoramic finding of a deviation of the canal is the best predictor of probable narrowing of the canal.

Several studies[14,16,26,27] reported that darkening of the third molar roots where the mandibular canal was superimposed was strongly suggestive of an intimate relationship between the root and the nerve, or of nerve injury following third molar extraction. Various authors[5,7] believe that this radiographic sign reflects grooving of the root carved by the canal. On the other hand, other investigators[25,28] have stated that this finding indicates thinning or perforation of the cortex. In the present study, the frequency of grooving of the tooth root in the cases wherein the panoramic sign of the darkening of the roots was observed was higher than in combination with other panoramic findings. Conversely, the frequency of thinning or perforation of the cortex in cases in which this sign, i.e. root darkening, was present was lower than that detected in combination with other panoramic signs (superimposition of canal 55.2%, narrowing of the canal 40%, deviation of the canal 50% and interruption of the canal 30.8%). No significant relationship between grooving of the tooth roots and thinning or perforation of the cortex and the presence of darkening of the roots was apparent**.**

Tooth contact with the cortex was observed in all cases in which panoramic signs of the narrowing of the canal or the darkening of roots were found. Surgeon awareness of the thinning or perforation of the lingual cortex may decrease the risk of lingual nerve injury or displacement of bone or tooth fragments to the adjacent structures. This frequency was observed in 48.8% of our study sample and is in accordance with those reported by Tantanapornkul *et al*. (47.4%)[28] and Mahasantipiya *et al*. (45.5%).[25]

Tooth contact with the canal in distoangular (100%) and vertical (90%) groups occurred more frequently in our study than in other groups and concurs with the observations by Monaco *et al*.[14] Therefore, in these two positions, the probability of an intimate relationship existing between the impacted third molar and the mandibular canal is higher.

A lingual course of the mandibular canal was the most frequent course detected in cases in which tooth contact with the canal (66.7%), canal narrowing (60%) and grooving of the tooth root (63.6%) were detected in CBCT images. Our findings concur with those reported by Ghaeminia *et al*.[17] Mahasantipiya *et al*.[28] and Öhman *et al*.,[7] respectively.

Our study sample consisted of impacted Class C mandibular third molars, while in previous and similar studies, the depth of impaction was not considered. A small sample size in several patient groups is one of the limitations of the present study. We focused on CBCT findings as the gold standard. Availability of surgical findings would have allowed the authors to evaluate the diagnostic accuracy of CBCT and panoramic images more precisely. Further investigations with a greater sample size and the consideration of the nerve exposure during surgical removal of impacted third molars and probable neurological complications are required to validate the clinical usefulness of CBCT in preoperative evaluation of impacted mandibular third molars.

CONCLUSIONS

The data acquired by CBCT can be useful in assessing the risk of the surgery and increasing patient awareness about potential anatomical complications and making decisions to undergo surgery. Deviation of the canal and darkening of the roots in panoramic view can be helpful to guess the risk of nerve injury.

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