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Reliability of panoramic radiography in predicting proximity of third molars to the mandibular canal: A comparison using cone-beam computed tomography

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ABSTRACT

Purpose: The purpose of this study was to analyze the reliability of 7 panoramic radiographic signs for predicting proximity of the root apices of mandibular third molars to the mandibular canal using cone-beam computed tomography and to correlate these findings with the Pell and Gregory and the Winter classification systems.
Materials and Methods: An observational, cross-sectional, descriptive study was conducted on 74 patients with bilateral impacted mandibular third molars. Four panoramic radiographic signs were observed in the tooth root (darkening, deflection, and narrowing of the root apices, and bifid apices), and another 3 in the mandibular canal (diversion, narrowing, and interruption of the mandibular canal). Cone-beam computed tomography images were analyzed to identify disruption and diversion of the mandibular canal and root deflection.
Results: Binary logistic regression showed that only 4 of the 7 panoramic radiographic signs were able to predict proximity of the root apices of the mandibular third molars to the mandibular canal: darkening of the root, deflection of the root, narrowing of the root, and interruption of the mandibular canal ($P<0.05$).
Conclusion: Darkening, deflection, and narrowing of the root, in tandem with the interruption of the mandibular canal on panoramic radiographs, indicate that cone-beam computed tomography should be performed when planning the extraction of impacted mandibular third molars. Proximity between mandibular third molars and the mandibular canal is correlated with the Winter classification. ***(Imaging Sci Dent 2021; 51: 9-16)***

KEY WORDS: Cone-beam Computed Tomography; Mandibular Nerve; Radiography, Panoramic; Third Molar

Introduction

Mandibular third molar extraction is one of the most common procedures performed in oral surgery, and is capable of causing transitory complications (e.g., pain, bleeding, and swelling) or permanent sequelae (e.g., paresthesia), which may have a profound effect on quality of life.[1-3]

Paresthesia of the inferior alveolar nerve involves spontaneous and unpleasant sensations (tingling, numbing, or burning) in the lower third of the face due to exposure of the inferior alveolar nerve.[4] Most of these injuries are transitory and show spontaneous regression. However, severe damage may cause permanent paresthesia. Therefore, a pre-surgical analysis of the mandibular anatomy through imaging is recommended.[5]

The Winter and the Pell and Gregory classification systems identify the dental crown position of the third molars without describing the relationship between the root apices and mandibular canal.[6,7] According to Rood and Shehab,[8] 7 signs of panoramic radiography are suggestive of proximity between the root apices and the mandibular canal: darkening of the root, deflection of the root, narrowing of the root, bifid root apex, diversion of the mandibular canal, narrowing of the canal, and interruption of the canal.

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However, it has been suggested that not all of these panoramic signs are reliable due to the distortion of linear measurements and overlapping of underlying structures.[9-11] Costa et al.[12] did not find a positive correlation between the presence of panoramic signs of the third molar and proximity to the inferior alveolar nerve.

In this context, there is a case to be made for the use of cone-beam computed tomography (CBCT), in which the images can be reformatted and viewed in multiplanar reconstructions.[13] Ghai and Choudhury[14] concluded that darkening with deflection of the root, interruption of the white line on panoramic radiography, and an interradicular location of the mandibular canal with thinning of the lingual cortex by the root tips on CBCT, were highly predictive of paresthesia.

No previous study has evaluated predictive panoramic signs of proximity between the dental apices and the mandibular canal using cone-beamed computed tomography and correlated these findings with the Pell and Gregory and the Winter classification systems; therefore, this study was conducted to address that gap in the literature.

Materials and Methods

This study was approved by the Human Research Ethics Committee of the Federal University of Juiz de Fora (No. 2424,513/2017) in accordance with the Helsinki Declaration of the World Medical Association.

This observational, cross-sectional, and descriptive study involved the evaluation of panoramic radiography and cone-beam computed tomography of 150 patients from a public university database. Imaging examinations containing bilateral impacted mandibular third molars were included, whereas those with pathological changes (cysts, tumors, fibro-osseous lesions) and incomplete root development were excluded. The final sample consisted of 74 patient examinations (148 teeth).

Panoramic radiography was obtained using an Orthopantomograph® OP300 machine (Instrumentarium Dental, Tuusula, Finland) with the patient with a semi-open mouth, positioned according to the light indications of the device, with peak kilovoltage (kVp) and current (mA) selected according to the patient's biotype. CBCT images were obtained using the ICAT® Next Generation device (Imaging Sciences International, Hatfield, PA, USA) with the patient in maximum habitual intercuspation, operating at 120 kVp for 26.9 s at 8 mA, with a field of view of 6 cm × 13 cm and a voxel size of 0.25 mm.

The images were analyzed by 3 oral radiologists, who were previously trained and calibrated in a pilot test with a smaller sample (n = 20) that was not part of the final sample of the study. The images were viewed on a 21.5-inch high-definition LCD monitor (1920 × 1080), (Dell S2240L, Dell Computers of Brazil Ltda., Eldorado do Sul, Rio Grande do Sul, Brazil) in a room with dimmed lighting and standardized conditions.

The exams were coded, randomized, and evaluated at different times, without patient identification. First, panoramic radiographs were evaluated in the Windows® photo viewer. The images were exported in TIFF format without compression. Fifteen days later, the CBCT images were evaluated using Xoran Cat® software version 3.0.34 (Xoran Technologies, Ann Arbor, MI, USA), using coronal, sagittal, and axial reconstructions, as well as panoramic and oblique sections when necessary. A limit of 20 daily assessments was standardized to avoid visual fatigue and impaired analysis. The zoom, brightness, and contrast tools could be used. Thirty days later, 20% of the samples were reassessed to calculate intra-rater agreement.

The panoramic radiographs were analyzed dichotomously with regard to the presence or absence of any of the 7 radiographic signs proposed by Rood and Shehab:[8] darkening (loss of density), deflection (abrupt diversion of direction), and narrowing (taper) of the root apices; bifid apices (double shadow of the periodontal membrane); and diversion, narrowing, and interruption of the mandibular canal (Fig. 1).

The CBCT images were analyzed qualitatively using 3 variables to assess proximity between the third molars and the mandibular canal: 1) intimate contact (interruption of the canal; 0: absence, 1: presence) (Fig. 2A); 2) root deflection (abrupt diversion in the direction of the root; 0: absent, 1: present) (Fig. 2B); and 3) mandibular canal diversion (0: absent, 1: present) (Fig. 2C). Also analyzed were interruption of the buccal or lingual mandibular cortex (0: both cortices preserved, 1: discontinuity of the buccal cortex, 2: discontinuity of the lingual cortex) (Fig. 2D) and the location of the mandibular canal in relation to the root apices of third molars (1: inferior [Fig. 3A], 2: buccal [Fig. 3B], 3: lingual [Fig. 3C], 4: interradicular [Fig. 3D]).

The positioning of the teeth was also analyzed according to the Pell and Gregory classification system, as follows: grade I: the radiographic space between the distal face of the second molar and the anterior edge of the mandibular ramus is greater than the mesiodistal diameter of the third molars; grade II: the radiographic space between the distal face of the inferior second molar and the anterior edge of the mandibular ramus is equal to the mesiodistal measurement of the third molars; grade III: the radiographic space distal to the second molar is insufficient to accommodate

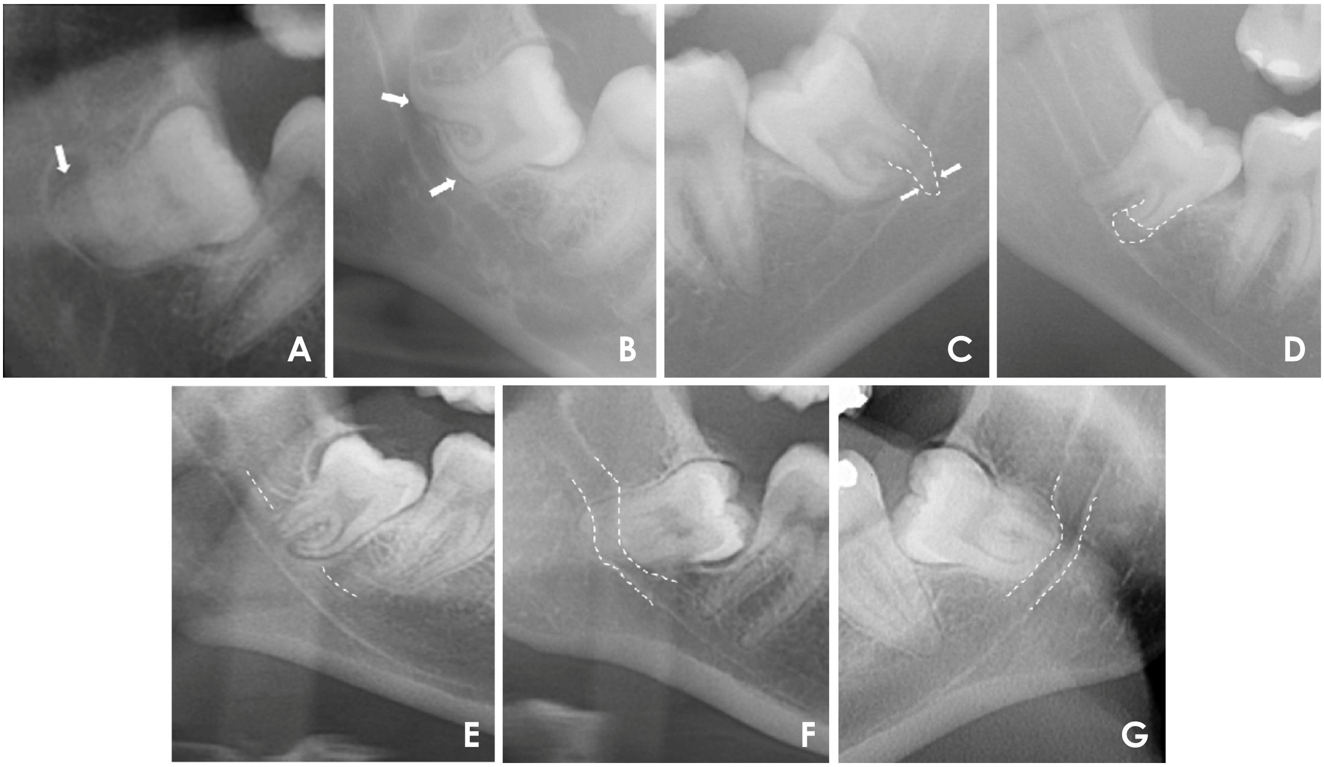

Fig. 1. Radiographic images of the relationship between the root apices of the mandibular third molar and mandibular canal. A. Darkening of the root apices. B. Deflection of the root apices in contact with the mandibular canal. C. Abrupt narrowing of the distal root. D. Bifid apices. E. Interruption of the mandibular canal. F. Abrupt diversion of the mandibular canal. G. Abrupt narrowing of the mandibular canal.

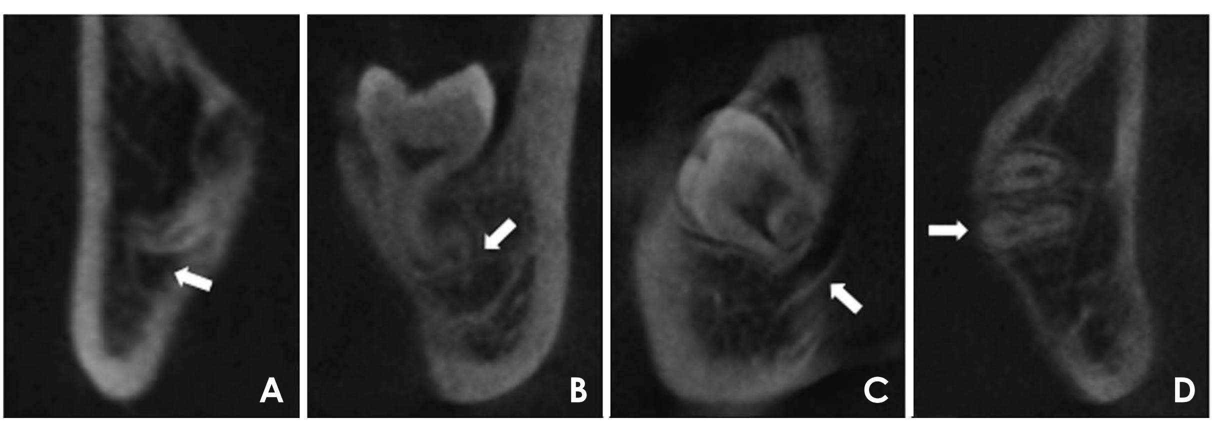

Fig. 2. Cone-beam computed tomography coronal (A and D) and sagittal (B and C) sections show the relationship between the mandibular third molar and mandibular canal. A. intimate contact with interruption of the mandibular canal. B. Deflection of the root, emphasizing the path of the mandibular canal. C. Diversion of the mandibular canal. D. Interruption of the mandibular lingual cortex.

the mandibular third molars; depth A: the occlusal face of the third molar is on the same level as the occlusal plane of the second molar; depth B: the occlusal face of the third molars is between the occlusal and cervical surfaces of the second molar depth; and depth C: the occlusal face of the third molars is below the cervical face of the second molar crown.[7] The mandibular third molars were further assessed using the Winter classification system based on the angulation of their long axis with the long axis of the second molar, as vertical, mesioangular, distoangular, horizontal, inverted, and transverse (buccal or lingual).[8]

The data were analyzed using descriptive statistics for both panoramic radiography and CBCT. Intra-rater agreement was assessed using the kappa (dichotomous variables)

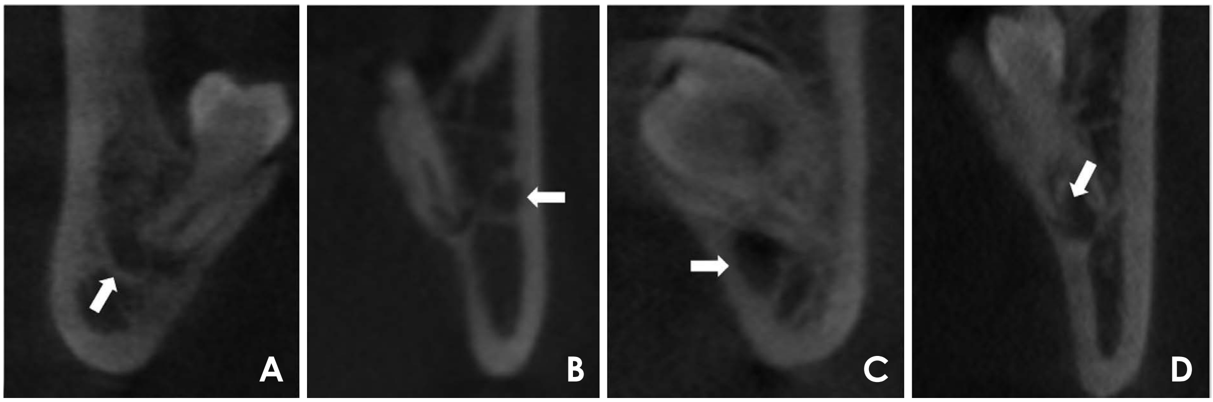

Fig. 3. Cone-beam computed tomography coronal sections show the position of the mandibular canal in relation to the third molar. A. Inferior. B. Buccal. C. Lingual. D. Interradicular.

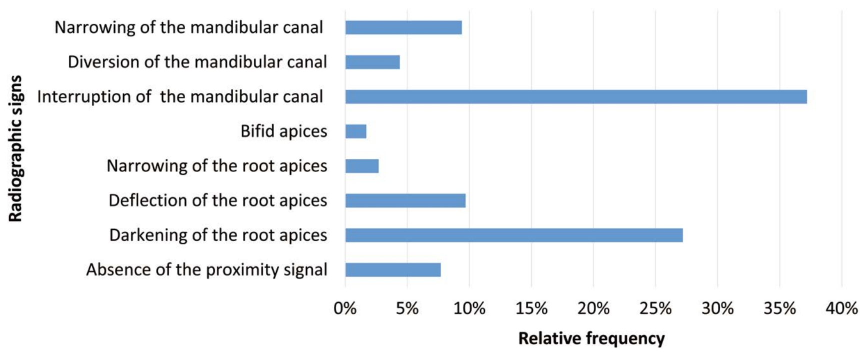

Fig. 4. Distribution of radiographic signs identified on panoramic radiographs.

and weighted kappa (qualitative variables with more than 2 scores) tests. A binary logistic regression model, showing odds ratios (ORs), was constructed to verify whether panoramic signs could predict maximum contact of the mandibular third molars with the mandibular canal, and Spearman rank correlation analysis was conducted to assess the correlation of the number of panoramic radiography signs with maximum contact. Associations between CBCT variables and proximity to the mandibular canal were assessed using the chi-square test. The data were then analyzed using SPSS version 23.0 (IBM Corp., Armonk, NY, USA), with a significance level of 95%.

Results

The intra-rater kappa values for the panoramic radiography and CBCT images ranged from 0.91 to 0.97 and from 0.93 to 0.96, respectively.

Interruption of the mandibular canal (37.2%) and darkening of the root (27.2%) were the most frequently observed signs on panoramic radiographs (Fig. 4). Most of the analyzed teeth showed 2 panoramic signs suggestive of proximity between mandibular third molars and the mandibular canal. Also noteworthy was the association between interruption of the mandibular canal and darkening of the root in 20% of these teeth. Ten teeth showed a combination of 5 panoramic signs (Fig. 5). In the Spearman correlation analysis, a higher number of signs for a single tooth increased the chances of close contact between a mandibular third molar and the mandibular canal ($P=0.451$ and $P<0.001$).

No significant difference was found when comparing the position of the third molars on the right and left sides. The positioning of the teeth according to the Pell and Gregory classification was not associated with proximity between mandibular third molars and the mandibular canal ($P>0.05$). However, this proximity was associated with the Winter classification (Table 1).

Table 2 shows that root deflection, interruption, and diversion of the mandibular canal were strongly associated with panoramic radiography signs when analyzed using CBCT ($P<0.05$, Table 2). Finally, binary logistic regression analysis (Table 3) showed that darkening, deflection, and nar-

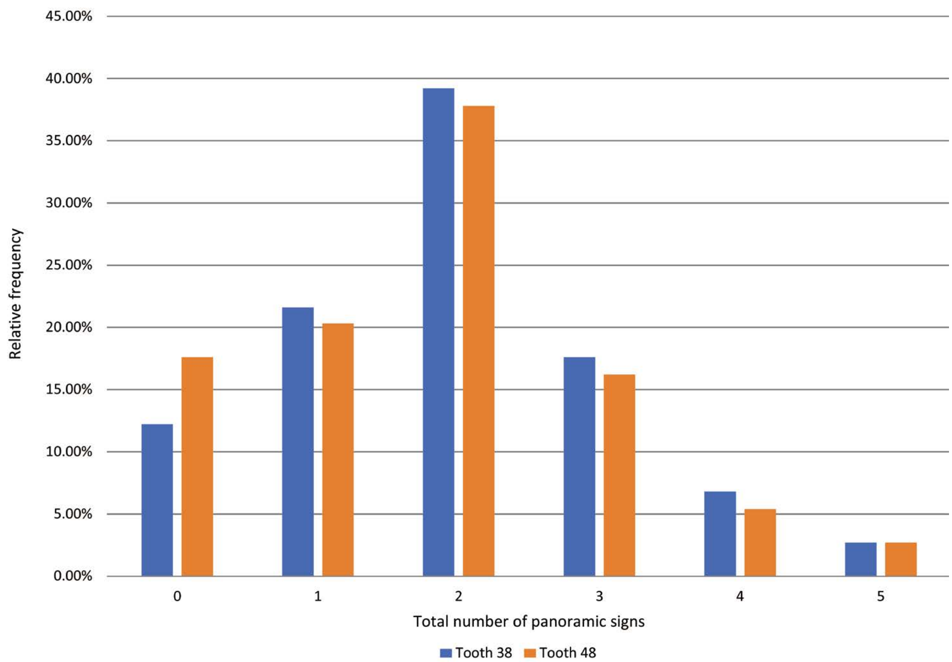

Fig. 5. Distribution of the number of panoramic signs found on the same tooth.

Table 1. Distribution of teeth according to the Pell and Gregory and the Winter classification systems and their association with the mandibular canal when assessed using cone-beam computed tomography

	Left third molar	Right third molar	Intimate contact with mandibular canal	*P* value
Pell and Gregory				
Class I	12 (16.2%)	16 (21.6%)	23/28 (82.1%)	
Class II	60 (81.1%)	55 (74.3%)	94/115 (81.7%)	0.57
Class III	2 (2.7%)	3 (4.1%)	5/5 (100.0%)	
A	34 (45.9%)	38 (51.4%)	60/72 (83.3%)	
B	36 (48.6%)	32 (43.2%)	55/68 (80.9%)	0.86
C	4 (5.4%)	4 (5.4%)	7/8 (87.5%)	
Winter				
Vertical	24 (32.4%)	24 (32.4%)	42/48 (87.5%)	
Mesioangular	30 (40.5%)	31 (41.9%)	48/61 (78.7%)	
Distoangular	7 (9.5%)	10 (13.5%)	17/17 (100.0%)	
Horizontal	12 (16.2%)	7 (9.5%)	12/19 (63.2%)	<0.05
Inverted	0	0	–	
Buccal transverse	0	0	–	
Lingual transverse	1 (1.4%)	2 (2.7%)	3/3 (100%)	

P value: chi-square test

rowing of the root and interruption of the mandibular canal predicted proximity between the third molar and mandibular canal ($P<0.05$).

Discussion

Shahidi et al.[11] highlighted that, although CBCT provides a better assessment of anatomical structures and greater intraoperative safety, panoramic radiography is still the most widely used modality to analyze proximity between the third molars and the mandibular canal. The present study showed that, among the 148 impacted mandibular third molars, 11 teeth did not present panoramic signs suggestive of proximity to the mandibular canal.

Table 2. Distribution of tomographic variables and their association with proximity between mandibular third molars and the mandibular canal

	Left third molar	Right third molar	*P* value
Interruption of the mandibular canal	60 (81.1%)	62 (83.8%)	<0.05
Location of mandibular canal to third molar			0.40
Vestibular	19 (25.7%)	21 (28.4%)	
Among the root apices	2 (2.7%)	1 (1.4%)	
Lingual	12 (16.2%)	6 (8.1%)	
Inferior	41 (55.4%)	46 (62.2%)	
Interruption of the mandible			0.52
Buccal	3 (4.1%)	2 (2.7%)	
Lingual	16 (21.6%)	21 (28.4%)	
Deflection of the root	37 (50%)	40 (54.1%)	<0.05
Diversion of the mandibular canal	25 (33.8%)	23 (31.1%)	<0.05

P value: chi-square test

Table 3. Binary logistic regression to predict intimate contact of mandibular third molars with the mandibular canal from radiographic proximity signs on panoramic radiographs

Radiographic signs	β	SE	Wald test	Odds ratio test	95% confidence interval of the odds ratio		*P* value
					Minimum	Maximum	
Darkening of the root apices	3.18	.60	28.04	24.16	7.43	78.54	<.00
Deflection of the root apices	4.15	1.11	13.93	64.00	7.21	568.12	<.00
Narrowing of the root apices	2.77	1.16	5.70	16.00	1.64	155.76	.01
Bifid apices	22.03	17974.84	.00	3692513926.51	0.00	−	.99
Interruption of the mandibular canal	3.38	.58	33.63	29.42	9.38	92.28	<.00
Diversion of the mandibular canal	22.03	11147.52	.00	3692513926.51	0.00	−	.99
Narrowing of the mandibular canal	22.03	7595.75	.00	3692513926.51	0.00	−	.99
Constant	−.82	.45	3.32	0.43			.06

Having prior knowledge of these signs could prevent surgical complications such as temporary or permanent paresthesia. Cheung et al.[1] showed that postoperative recovery deficits were most prominently noted at 3 months. By the end of the follow-up period, 67% of the patients had recovered completely. Although the present study was not clinical in nature, the authors nonetheless suggest that all patients facing extraction of an impacted third molar sign an informed consent form and recommend that surgery be performed by an experienced oral surgeon.

Concerns about preserving the inferior alveolar nerve led Rood and Shehab[8] to identify 7 signs suggestive of proximity between the root apices and the mandibular canal. Gomes et al.[15] concluded that panoramic radiography is not capable of predicting neurosensory complications because only 3.5% of patients developed paresthesia despite these signs having been identified in 61% of the cases.

Conversely, Huang et al.[2] reported that 3 panoramic signs (interruption of the mandibular canal, deflection, and narrowing of the root apices) were significantly associated with sensory impairment. In the present study, the incidence of paresthesia was not evaluated; nonetheless, these 3 signs predicted intimate contact.

Peker et al.[16] investigated correlations between panoramic signs suggestive of contact between the roots of mandibular third molars and the mandibular canal on CBCT in 191 patients and concluded that interruption of the mandibular canal and darkening of the root apices were predictive of intimate contact. The same authors further concluded that panoramic radiographs could not accurately identify the number of root apices of the mandibular third molar. Similar results were also found in the present study, where darkening, deflection, and narrowing of the root and interruption of the mandibular canal predicted proximity of the root apices to the mandibular canal. In addition, there was a strong association between interruption of the mandibular canal and darkening of the roots in 20% of cases.

The statistical results for these 4 panoramic signs were significant. Deflection of the root presented an odds ratio (OR) of 64, meaning it was 64 times more likely to be associated with intimate contact. Interruption of the mandibular canal presented an OR of 29.42, while darkening of the root presented an OR of 24.16, and an OR of 16 was found for narrowing of the root, reinforcing the findings of previous studies.[17,18] The other evaluated signs showed a prevalence of less than 10%, being, in decreasing order, deflection of the root, diversion of mandibular canal, and bifid apices. Kim et al.[19] demonstrated that narrowing of the root was the most significant radiographic sign as a risk factor for injury to the inferior alveolar nerve, with an OR of 22.98.

Some authors[1,9,18] have suggested that third molar angulation does not represent a risk factor for inferior alveolar nerve injury. Other authors have defended using the Winter classification as a strategy to prevent surgical complications that might result from impacted third molar extraction.[20,21] The present study found statistically significant results ($P=0.032$) for the Winter classification. Blondeau and Daniel[9] reported that most cases of paresthesia involved mesioangular teeth. The present study found a high prevalence of mesioangular teeth (78.7%). However, the lingual transversal and distoangular positions showed the best results (100%) for proximity between the third molar and the mandibular canal.

In our study, the Pell and Gregory classification was not associated with close contact between the third molar and the mandibular canal ($P>0.05$), aligning with the findings of Carmichael and McGowan.[22] Notwithstanding, teeth with more significant bone inclusions (III and C) showed the highest percentages of intimate contact.

All 3 variables analyzed on CBCT (interruption and diversion of the mandibular canal and root deflection) were strongly associated with panoramic signs ($P<0.05$). Wang et al.[23] affirmed that intimate contact between the third molar and the mandibular canal on CBCT was significantly associated with injuries to the inferior alveolar nerve. Therefore, it is suggested that a study should explore the correlations of darkening, deflection, and narrowing of the root and interruption of the mandibular canal, as visualized on CBCT, with postoperative clinical findings.

In conclusion, darkening, deflection, and narrowing of the root, in tandem with interruption of the mandibular canal on panoramic radiographs, indicate that CBCT should be performed when planning the extraction of an impacted mandibular third molar. The proximity between mandibular third molars and the mandibular canal was correlated with the Winter classification.

Conflicts of Interest: None

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