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ASSESSMENT OF ANATOMICAL PROXIMITY OF IMPACTED MANDIBULAR THIRD MOLARS TO THE MANDIBULAR CANAL USING PANORAMIC RADIOGRAPHIC MARKERS AND CONE BEAM COMPUTED TOMOGRAPHY

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ABSTRACT

A preoperative radiographic assessment of impacted third molars remains critical, as determining the relationship between the roots and the IAC is key to predicting risk and preventing postoperative sensory damage. The aim of this retrospective study was to evaluate panoramic radiographic markers and CBCT findings to predict the proximity of impacted third molars to the IAC.

Materials: We studied 260 impacted mandibular third molars from 214 patients who showed a close relationship between the IAC and lower third molars on panoramic radiographs. Patients who were referred to radiology clinics at Princess Nourah Bint Abdulrahman University for CBCT examination prior to extraction of lower third molars. The correlation between panoramic findings and CBCT was analyzed using a Chi-square test and Fisher's exact test.

Results: The most common risk markers seen on panoramic images were diversion of the mandibular canal, deflection of the roots, interruption of the mandibular canal, and narrowing of the roots. There was a statistically significant association between those panoramic markers and the communication of roots with the IAC on CBCT.

Conclusion: CBCT is recommended for evaluating the anatomical relationship between impacted third molars and the IAC when a panoramic radiograph shows a deflection of roots or a diversion or interruption of the mandibular canal.

KEYWORDS: Inferior alveolar canal, Cone Beam Computed Tomography, panoramic radiograph, Mandibular third molar.

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INTRODUCTION

Dentists face unique clinical challenges with third molars, which are prone to impaction, and studies have shown a 0.5% to 8% rate of incidence of neurosensory impairments after their extraction[1]. Therefore, pre-surgical evaluation is critical for avoiding extraction complications and nerve damage. As an essential diagnostic tool, radiographs provide valuable information about the tooth's position, root morphology, and relationship to adjacent structures that helps to minimize potential extraction complications. Being aware of the proximity between the root apices of impacted third molars and inferior alveolar nerve is critical in determining the safest surgical approach for extraction. The IAN, which supplies sensation to the lower teeth, cheeks, and chin, can be easily damaged during surgical extraction, possibly resulting in persistent neurosensory impairment [2,3].

Panoramic radiography is the imaging tool typically employed before extraction of mandibular third molars to evaluate anatomical risk factors [4,5]. Specific radiographic markers that may indicate a close relation between the IAC and lower third molars have been detected on panoramic radiographs [6–9]. These panoramic markers include root darkening, deflection, or narrowing; a bifid root apex; and a diversion, narrowing, or interruption of the mandibular canal [10]. However, these markers do not reliably predict a correlation between the impacted lower third molar and the IAC. Knowledge of such a correlation allows clinicians to make confident preoperative decisions regarding risk factors associated with surgical extraction procedures [11], and the correct management of a surgery depends on predicting its difficulty and complications. Winter's classification has been proposed as a method for meticulously categorizing the positions of impacted molar teeth and helps in assessing the best possible strategy for the removal of the impacted teeth. This allows the design of a treatment that minimizes the risk of complications.

Panoramic radiography has conventionally been utilized to assess mandibular third molar impactions; however, its ability to precisely evaluate the proximity of impacted third molars to IAC is limited [12,13], as this technique does not offer any information concerning the bucco-lingual dimension[4]. Assessment of the bucco-lingual dimension is important for cases where the IAC and third molar are anatomically close [14,15]. Since IAN injuries are significantly more likely to occur that at other tooth locations [4,16], Maxillofacial surgeons might approach the third molar from the buccal side and apply pressure on the lingual side [4]. In these cases, the buccolingual relationship should be precisely evaluated with CBCT.

CBCT is one of a three-dimensional imaging modality that permits a clear visualization of anatomical structures without superimpositions. The resulting images are high-resolution, and distortion-free in three dimensions. They can be manipulated in any plane for viewing and manipulation [17]. This facilitates interactive viewing and interpretation of images. Furthermore, the radiation dose of CBCT is considerably lower than that of conventional medical computed tomography. Although CBCT could expose the patient to a higher radiation dose than conventional radiographic techniques, the evaluation of the relationships of the IAC with surrounding anatomical structures has high diagnostic value [18,19]. Therefore, the purpose of the present study was to compare panoramic radiographic markers and the positioning of impacted third molars to CBCT findings to predict the proximity of the root apices to the IAC. We hypothesized that CBCT would be more accurate than standard two-dimensional imaging modalities in determining the exact relationship between the roots of lower third molars and the IAC, as a panoramic radiograph alone is not sufficient to identify this relationship prior to surgical extractions.

MATERIALS AND METHODS

The ethics committee of the College of Dentistry Research Centre, Princess Nourah Bint Abdulrahman University, Saudi Arabia, approved the study protocol (institutional review board number: 23-0380) and provided ethical guidelines.

Sample selection

This retrospective study involved 260 impacted mandibular third molars from 214 patients (80 men and 134 women), demonstrating a close association between the inferior alveolar canal (IAC) and the impacted mandibular third molars on panoramic radiographs. Patients who were referred to oral and maxillofacial radiology clinics at Princess Nourah Bint Abdulrahman University to assess the relationship between the impacted mandibular third molar and IAC using CBCT in preparation for extraction of the third molar. Individuals with incomplete root formation and those with signs of intraosseous pathological lesions associated with the third molars on radiographs were excluded from the present study.

Image acquisition and assessment

Two qualified and calibrated oral radiologists with more than 15 years of experience independently analyzed the panoramic and CBCT images for the relationship between the impacted lower third molars and IAC. Then, the images were analyzed to reach a consensus to ensure inter-observer reliability. Seven indicators from panoramic radiographs were evaluated: darkening of roots, root deflection, root narrowing, a bifid root apex, interruption of IAC, diversion of IAC, and narrowing of IAC. In addition, Winter's classification of the third molar position was evaluated.

The indicators were further evaluated with CBCT to examine the cortical borders of IAC, as well as to determine the reliability of the seven panoramic radiographic markers and molar positioning to predict the direct contact between impacted mandibular third molars and IAC. Direct contact was considered a case in which IAC cortical bone was lost between the canal and the roots of mandibular third molars. According to CBCT, the following criteria were assessed:

- Alignment of impacted mandibular third molars was classified as mesioangular, distoangular, horizontal, or vertical impaction (Winter's classification 1926) [20].
- The bucco-lingual relationship of the IAC and the impacted mandibular third molar was classified as buccal, lingual, in between, or inferior [21].
- The position of IAC relative to third molar was classified as communicated (no bone between the canal and lower third molar) or non-communicated (bone between the canal and lower third molar) [4].

All panoramic radiographs were acquired with a Planmeca ProMax 2D, and CBCT scans were performed using a Planmeca ProTouch 3D (Planmeca Co., Helsinki, Finland). The collected CBCT data were reconstructed using Planmeca Romexis 6.0 software. All images were interpreted on a Dell LCD monitor has a 24-inch screen and 1920 × 1080 high-definition screen resolution.

Statistical analysis

Categorical data were displayed as frequencies and percentages. A chi-square test and Fisher's exact test were used to assess associations between categorical variables. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, version 23.0 (Armonk, NY, IBM Corp.).

RESULTS

In total, 214 patients, 134 women (62.6%) and 80 men (37.4%), with 260 impacted third molars participated in the study. The mean and standard deviation patient ages were 31.4 ± 8.8 years, ranging from 20 to 54 years. Most participants (78.5%) had unilateral impacted third molars, while 21.5% had bilateral impaction.

Communicated roots were observed in 134 (51.5%) of the 260 impacted molars included in the study. Table 1 summarizes the association between tooth position and communicated roots. A statistically significant association was detected between tooth position and communicated roots (P=0.014, effect size =0.201). The highest prevalence of communication was found with mesioangular impactions, followed by distoangular, horizontal, then vertical impactions.

The most frequent risk indicators observed on panoramic radiographs were diversion of mandibular canal, deflection of roots, interruption of mandibular canal, and narrowing of roots. There was a statistically significant association between those panoramic markers and communicated roots on CBCT. Moreover, according to CBCT, there was an increased likelihood of diversion of mandibular canal, deflection of roots, and interruption of mandibular canal in patients whose roots of the third molar communicated directly with the IAC (3.515, 3.246-, and 1.973-fold increases, respectively). In contrast, patients with communicated roots were 0.351 times less prone to show narrowing of the roots than those with non-communicated roots.

Table 2 summarizes the results of the association between panoramic markers and communicated roots. Darkening of the roots was one of the most frequent panoramic markers, with either communicated or non-communicated roots, on CBCT, with no statistically significant between darkening of the roots and communication of the roots (P = 0.313, effect size = 0.778).

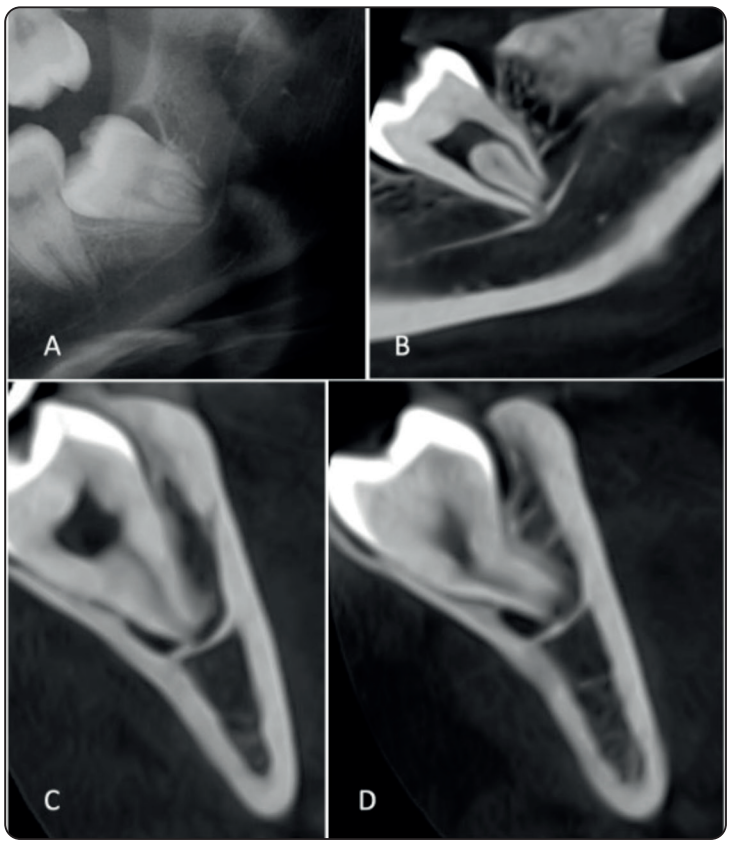

Fig. (1) (A) Cropped panoramic radiograph reveals an interruption in IAC at impacted # 38. (B) Sagittal CBCT view shows an interruption of the IAC at the roots of the same tooth. (C, D) Cross-sectional CBCT views showing both roots of the same tooth are in direct communication with the IAC; Mesial root (C) and Distal root (D).

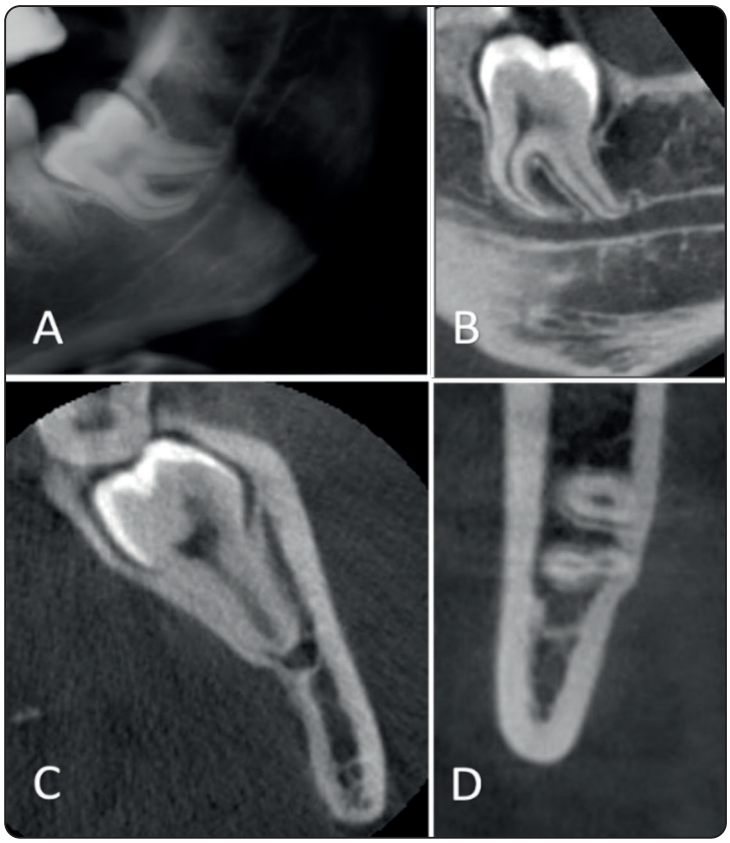

Fig. (2) (A) Cropped panoramic view showing deflected root apices of impacted # 38. (B) Sagittal CBCT view showing the deflected root apices of the same tooth with high resolution. (C) Axial and (D) Cross-sectional CBCT views showing direct communication of distal root apex (C) and mesial root at the level of its apical third (D) with the IAC.

TABLE (1) Descriptive statistics and Chi-square test results for the association between tooth position and communicated roots.

Tooth position	Communication (n = 134)		No communication (n = 126)		P-value	Effect size (v)
	n	%	n	%		
Horizontal	13	9.7	16	12.7	0.014*	0.201
Vertical	6	4.5	19	15.1		
Mesioangular	100	74.6	83	65.9		
Distoangular	15	11.2	8	6.3		

: Significant at P ≤ 0.05

Table 3 shows the association between the IAC position in relation to the apices of lower third molars and panoramic markers. The most common positioning of the IAC relative to the roots of lower third molars on CBCT was apical (72.4%), followed by lingual (29.1%) then buccal (17.2%); the least common position was in between the roots (10.4%). There were statistically significant associations between the IAC being in an apical position relative to the tooth and both interruption of mandibular canal and the presence of a bifid root apex. Patients whose IAC was in an apical position relative to the impacted third molar were 2.282 times more likely to experience an interruption of the mandibular canal. When the IAC was in a buccal position relative to the tooth, there were statistically significant associations with the presence of a bifid root apex, deflection of the roots, diversion of the mandibular

canal, and narrowing of the roots. Patients with the IAC in a buccal position relative to the impacted third molar were 29.067 times more likely to have a bifid root apex.

Moreover, when the IAC was located in between the roots of mandibular third molars, there were statistically significant associations with deflection of the roots and narrowing of the IAC. Patients whose IAC was amidst the roots of the impacted third molar were 3.6 times more likely to exhibit deflection of the root. In patients whose IAC was located lingually relative to the tooth, there were no statistically significant associations between lingual position and any panoramic markers.

TABLE (2) Descriptive statistics and Chi-square test results for the association between panoramic signs and communicated roots.

Panoramic signs	Communication (n = 134)		No communication (n = 126)		P-value	Effect size (OR)
	n	%	n	%		
Darkening of the root	65	48.5	69	54.8	0.313	0.778
Deflection of the root	49	36.6	19	15.1	<0.001*	3.246
Narrowing of the root	20	14.9	42	33.3	<0.001*	0.351
Bifid root apex	10	7.5	9	7.1	0.921	1.048
Diversion of the mandibular canal	17	12.7	5	4	0.012*	3.516
Narrowing of the canal	2	1.5	3	2.4	0.602	0.621
Interruption of the canal	81	60.4	55	43.7	0.007*	1.973

: Significant at P ≤ 0.05, OR: Odds Ratio

TABLE (3) Descriptive statistics and the results of a Chi-square test and Fisher's Exact test for the association between tooth position and panoramic signs.

Panoramic signs	Buccal (n = 23)		Lingual (n = 39)		Apical (n = 97)		Between roots (n = 14)	
	n	%	n	%	n	%	n	%
Darkening of the root	13	56.5	24	61.5	46	47.4	5	35.7
P-value, OR	0.398, 1.475		0.053, 2.107		0.684, 0.854		0.311, 0.556	
Deflection of the root	4	17.4	14	35.9	37	38.1	9	64.3
P-value, OR	0.036*, 0.309		0.918, 0.960		0.539, 1.285		0.023*, 3.6	
Narrowing of the root	0	0	6	15.4	16	16.5	2	14.3
P-value, OR	0.024*, 0.798		0.924, 1.052		0.409, 1.63		1, 0.944	
Bifid root apex	8	34.8	2	5.1	0	0	2	14.3
P-value, OR	<0.001*, 29.067		0.723, 0.588		<0.001*, 0.218		0.280, 2.333	
Diversion of the mandibular canal	0	0	4	10.3	13	13.4	0	0
P-value, OR	0.043*, 0.803		0.777, 0.721		0.780, 1.277		0.214, 0.880	
Narrowing of the canal	0	0	2	5.1	0	0	2	14.3
P-value, OR	1, 0.826		0.083, 0.280		0.075, 0.265		0.010*, 0.091	
Interruption of the canal	10	43.5	24	61.5	64	66	11	78.6
P-value, OR	0.067, 0.433		0.869, 1.067		0.034*, 2.282		0.143, 2.619	

: Significant at P ≤ 0.05, OR: Odds Ratio

DISCUSSION

Among the most impacted teeth in the mandible is the third molar. It is critical to make a radiographic diagnosis earlier to extracting an impacted third molar to determine the depth of impaction, root morphology, and relationship to the mandibular canal. This diagnosis will help to predict the likelihood of postoperative extraction complications. A study was conducted by Feifel et al. [14] found that nerve injuries are more likely to occur (35.6%) when teeth are in direct contact with the IAC. Panoramic radiographs can be requested to evaluate impacted mandibular third molars to make this diagnosis and establish a proper treatment plan. However, panoramic radiography has an image distortion of 20% compared with the patient's true anatomy [22].

There have been several studies estimating risk factors detected using panoramic radiography [23–26]. Nonetheless, as it is a two-dimensional evaluation, it is not accurate in diagnosing the relationship between the third molar and the IAC. Therefore, it is important to employ other radiographic modalities, such as CBCT, to obtain more accurate images of the patient's anatomy. CBCT is a more accurate method of imaging, as it is a three-dimensional scan that provides detailed images of the teeth and adjacent structures. CBCT has been shown to be a reliable tool for confirming potential panoramic risk factors [27].

Ghaeminia et al. [4] reported that the accuracies of CBCT and panoramic radiography were 55% and 45%, respectively. The sensitivity and specificity of panoramic radiography (100% and 3%, respectively) were not statistically significantly different from those of CBCT (96% and 23%, respectively), indicating that the two modalities did not differ in predicting IAN exposure prior to extraction of the third molar. In contrast, Tantanapornkul et al.[28] found that CBCT is more accurate (80%) than panoramic radiography (64%).

In the present retrospective study, only patients who demonstrated a close relationship between the impacted third molar and the IAC and were referred for CBCT examination were included. CBCT was used to assess the validity of panoramic radiographic markers of communication between the third molar and the IAC, the buccolingual IAC position, and the mandibular third molar position.

In the present study, the most frequently reported panoramic radiographic marker was interruption of the IAC (in 60.4% of communicated roots and 43.7% of non-communicated roots). These results agree with the findings of previously published studies [24–29] but contrast with others that did not observe a high diagnostic value for interruption of the IAC [26]. Among patients with interruption of the IAC, CBCT revealed that 81 impactions of a total of 134 were in direct communication with the IAC (60.4%), and 55 impactions of a total of 126 were not in communication with the IAC. However, there was a statistically significant association between the interruption of the IAC and communicated roots. This agrees with the results that were concluded by Peker et al. [30], who reported that CBCT images with communication showed darkened roots and an interrupted IAC on panoramic radiography.

Darkening of the roots was the second most frequent panoramic marker, for both communicated roots (48.5%) and non-communicated roots (54.8%), on CBCT, and there was non- statistically significant association between darkening of the roots and root communication. In contrast, Ghaeminia et al.[4] and Jhamb et al.[31] reported that interruption of the IAC, darkening of roots, and diversion of the mandibular canal were significantly associated with IAN exposure.

Szalma et al.[24] reported three risk markers, interruption of the IAC, diversion of IAC, and darkening of the roots, on panoramic radiographs that were commonly correlated with IAN exposure. In the present study, the most frequent risk markers

observed on panoramic radiographs were diversion of the mandibular canal, deflection of the roots, and interruption of the mandibular canal. Patients in our study with direct communication between the roots of the mandibular third molars and the IAC on CBCT were 3.515, 3.246, and 1.973 times more likely to show diversion of the mandibular canal, deflection of the roots, and interruption of the mandibular canal, respectively. In contrast, darkening of roots was not a risk factor of contact between the molar roots and the IAC.

The present study investigated the buccolingual position of the IAC in relation to mandibular third molars. The IAC was mostly in the apical position (51.5%), followed by the lingual position (29.1%) then the buccal position (17.2%), while the least common position of the IAC was in between the roots (10.4%). In addition, when the IAC was in an apical position relative to the impacted third molar, there were statistically significant associations with both interruption of the mandibular canal and the presence of a bifid root apex. Moreover, a buccal position of the IAC relative to the tooth was statistically significantly associated with the presence of a bifid root apex, deflection of the roots, narrowing of the roots, and diversion of the mandibular canal. When the IAC was located in between the roots, there were statistically significant associations between molar position and both deflection of the roots and narrowing of the IAC. These results are in accordance with a study conducted with Saudi patients that found that the IAC was most frequently positioned lingually, rather than buccally, relative to the impacted mandibular third molar [32].

Previous studies have classified the alignment of the impacted third molar as vertical, horizontal, or angular[9,15]. Our results revealed that the most frequent type of alignment was mesioangular (74.6%), followed by distoangular (11.2%), horizontal (9.7%), then vertical (4.5%). The results of this study are in accordance with those of Msagati et al.[33], who reported mesioangular alignment in 76% of their cases, and those of Syed et al.[34], who reported mesioangular impaction in 50.75% of their studied Saudi population. In contrast, Tantanapornkul et al. [28] documented that horizontal alignment was the most common (52%), followed by angular (32%) and vertical (16%).

CONCLUSIONS

Panoramic radiography is the most commonly used imaging technology for evaluating impacted third molars. However, we recommend the use of CBCT to assess the anatomical relationship between tooth roots and the mandibular canal. This is particularly important if a diversion of the IAC, deflection of the roots, or interruption of the IAC is observed on a panoramic radiograph as an isolated or associated finding. Communication between impacted third molars and the IAC was highly prevalent when the teeth were in mesioangular alignment.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author.

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