



Comparison of Analog Panoramic Radiography and Cone Beam Computed Tomography for Assessing Relationship between Impacted Mandibular Third Molar and Inferior Alveolar Nerve Canal

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ABSTRACT

The aim of this study is to compare OPG and CBCT for assessing relationship between impacted mandibular third molar and inferior alveolar nerve. 60 patients in the age range of 18–30 years with panoramic radiographs and impacted mandibular third molar (IMTM) were included in this study. A trained radiologist evaluated the panoramic radiographs and CBCTs, the relationship between IAN and IMTM was assessed using the Shehab & Rood classification and the nerve proximity to the third molar, both when in contact and separated, was determined using CBCT. The sensitivities and specificities of these findings were evaluated. Kappa values were used to assess the intra-observer reliability. Of 60 impacted third molars, 33 teeth showed contact between the tooth and the nerve. Except about narrowing of the canal, the difference between the two methods (panoramic and CBCT) in determining the relationship between the tooth and the nerve was not significant. The highest sensitivity of panoramic radiography was related to darkening of the root (48.6%), and the lowest sensitivity related to narrowing of the canal (5.7%) and diversion of the canal (5.7%). The highest specificity related to the deflection of the root (100%) and interruption of the white line (96%), and the lowest specificity related to deflection of the root (64%) and narrowing the canal (64%). More than 50% of cases indicate direct contact between the molar and the nerve. In diversion of the canal, interruption of the radiopaque border of canal, and darkening of the roots, the possibility of this contact is considerably high. The relationship between diversion of the canal and interruption of the radiopaque border of canal has a high predictive value for indicating the absence of this contact.

Key words: Diagnostic Accuracy, Cone Beam CT, Third Molar Surgery, Panoramic Radiography, Inferior Alveolar Nerve Injury, Third Molar Position

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The mandibular third molars are the most frequently impacted teeth in humans. The prevalence of third molar impaction ranges from 16.7% to 68.6%. It has been reported to be 9.54% in Iran [1]. Approximately one-third of the

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completely unerupted and partially erupted mandibular third molars are associated with pathological conditions and disorders. Prophylactic surgery and removal of the tooth are recommended [2].

The extraction of lower third molars is the most common intervention in oral surgery, but it is usually associated with significant postoperative complications that have a biological and social impact for the patient. The complications include dysesthesia, infection, fracture, pain, swelling, hemorrhage, trismus, and damage to adjacent teeth [3].

Impairment of sensation is caused because of damage to the inferior alveolar nerve (IAN). The IAN runs in a canal within the mandible usually near the apices of the third molar and, if the molar is impacted, a close relationship of the roots to the nerve is likely. Sometimes, during the surgical removal of a mandibular third molar, the inferior alveolar nerve is damaged leading to impairment of sensation in the lower lip [4].

The reported frequency of inferior alveolar canal injury associated with mandibular third molar removal ranges from 0.6% to 5.3%. The risk of permanent inferior alveolar canal injury is less than 1% [5]. Although the prevalence of this damage is low, it is one of the most unpleasant postoperative complications [4].

Precise anatomic definition of the mandibular canal with respect to the lower third molar is of utmost importance in preventing injury to the inferior alveolar nerve during surgical extraction of impacted lower molar [6].

An imaging exam is undoubtedly an essential tool for diagnosis and surgical management because it provides valuable information about the tooth position, the number/morphology of the roots and, especially, the relationship of the tooth to adjacent structures [7].

The panoramic radiograph is a useful screening tool for assessing the anatomical relationship between the third molars and the IAN [8]. Although panoramic radiography is one of the most effective and widely used dental radiographic tools for evaluating the risk of nerve damage, the absence of the cortical bone of the mandibular canal may not be clearly evident with this method, and it is impossible to determine

whether its course is buccal or lingual to the roots or between the roots [9, 10]. Therefore, many studies have suggested risk factors for the close relationship between the tooth and the mandibular canal or IAN injury based on the findings from panoramic images [7, 11, 12].

In 1999, Road and Shehab [7] revealed that seven radiological signs are indicative of a close relationship between the mandibular third molar tooth and the inferior alveolar canal. Four of these signs are seen on the root of the tooth, and the other three are changes in the appearance of the inferior alveolar canal.

Dental cone beam computed tomographic (CBCT) scanning images are widely used for planning impacted lower third molar surgery, dental implant surgery and for oral diagnosis [14]. Compared with panoramic images, CBCT images could be a great tool in predicting neurovascular bundle exposure during extraction of between impacted mandibular third molar [15-18]. CBCT was developed for dent maxillofacial imaging because it produces a lower radiation dose with high spatial resolution, is affordable and requires less space than conventional computed tomography [19-22]. Previous studies have reported that CBCT is more accurate than conventional methods such as panoramic radiography for determining the relationship between impacted third molars and the IAC [19, 23-25].

Considering that panoramic radiograph is still used as a pre-surgical assessment method for third molars, assessment of the accuracy of this technique is essential. So the aim of this study is to compare OPG and CBCT for assessing relationship between impacted mandibular third molar and inferior alveolar nerve.

MATERIALS AND METHODS

The study population included patients who were referred to the School of Dentistry, Zahedan University for mandibular third molar surgery. The relationship between the inferior alveolar canal and lower third molar was observed in panoramic radiographs.

Patients in the age range of 25–45 years (mean age =35 years) with high-quality panoramic radiographs and impacted mandibular third molar (IMTM) were included in this study. The

relationship between IAN and impacted third molar was assessed using the Shehab & Rood classification.

The exclusion criteria were as follows: patients whose panoramic radiographs could not be accurately interpreted; those with mandibular pathologies, and those with contraindication to receive a higher dose of radiation (patients who had previous radiographs and should not receive more radiation).

52 consecutive patients who were referred to the School of Dentistry, Zahedan University were recruited into the study.

Patients thought to have a close relationship between the mandibular canal and impacted mandibular third molars (IMTM) diagnosed from panoramic radiographs were referred to the radiographic clinic after providing full informed consent to undergo additional CBCT imaging for confirming the presence or absence of a relationship between the tooth and the canal.

The types of relationship between the IMTM and the IAN in panoramic radiographs were categorized based on the Shehab & Rood classification [7]:

1. Darkening of the roots
2. Deflection of the roots
3. Narrowing of the roots
4. Bifid apex
5. Diversion of the canal
6. Narrowing of the canal
7. Interruption of the radiopaque border of the canal

Patients with a relationship between the IMTM and mandibular canal in the panoramic radiographs were selected to be evaluated by CBCT and to determine the nerve proximity to the third molar.

After evaluation of the CBCT 3D imaging, the presence or absence of contact between the impacted tooth and the mandibular canal was classified into two groups:

- 1) With direct contact, cortical bone between tooth and canal was observed and 2) without direct contact, cortical bone between tooth and canal was not observed.

The panoramic radiographs and CBCTs were evaluated by a trained radiologist in proper light

by using viewbox and computer. Ten panoramic radiographs and CBCT scans were selected to be evaluated by the radiologist in 2 weeks for assessment of the intra-observer reliability, and kappa values were calculated separately for the panoramic radiographs and CBCT.

The observed information in the panoramic radiographs and CBCT was recorded in a form for each patient.

Statistical analysis

The data were analyzed using SPSS computer software. The kappa values were used in the evaluation of the intra-observer reliability. The findings in the panoramic radiographs and CBCT were compared using the chi-square and Fisher's exact test. In this study, P value <0.05 was considered to be significant. The sensitivity, specificity, positive predictive value, and negative predictive value of the panoramic radiographs in diagnosing the direct contact of the IMTM and the IAN were computed using the following formulas:

$$\text{Sensitivity} = \frac{\text{number of true positive}}{\text{total number of true positive and false negative}}$$

$$\text{Specificity} = \frac{\text{number of true negative}}{\text{total number of true negative and false positive}}$$

$$\text{PPV} = \frac{\text{number of true positive}}{\text{total number of true positive and false positive}}$$

$$\text{NPV} = \frac{\text{number of true negative}}{\text{total number of true negative and false negative}}$$

RESULTS

The study sample consisted of 60 impacted third molars from 52 patients (15 women and 37 men) with the age range of 27–42 years. Table 1 summarizes the panoramic radiograph and CBCT findings according to the relationship between the roots of the third molars and the mandibular canal.

The kappa values for inter-examiner reliability within two weeks were 0.651 and 0.925 for panoramic radiographs and CBCT, respectively. These data showed an average agreement for the panoramic radiograph and favorable agreement for the CBCT findings within two steps of evaluation.

Panoramic radiograph findings for 60 IMTM indicated darkening of the root in 23 cases (38.3%), deflection of the root in 19 cases

(31.7%), narrowing of the canal in 11 cases (18.3%), interruption of white line in 5 cases (8.4%), and diversion of the canal in 2 cases (3.3%).

The CBCT findings indicated that among the 60 IMTMs, in 35 cases (58.3%) there was a contact between the third molar root and the IAC, and in 25 cases (41.7%) there was no contact between the third molar root and the IAC visible on the CBCT images.

Table1: Relationship between panoramic and CT findings

Panoramic Findings	N (%)	Cortication Between Tooth and IAC		*P value
		Yes	No	
Darkening of the roots	23 (38.3%)	17 (73.9%)	6 (26.1%)	0.055
Deflection of the roots	19 (31.7%)	10 (52.6%)	9 (47.4%)	0.583
Narrowing of the canal	11 (18.3%)	2 (18.2%)	9 (81.8%)	0.005
Interruption of the radiopaque border of the canal	5 (8.4%)	4 (80%)	1 (20%)	0.390
Diversion of the canal	2 (3.3%)	2 (100%)	0	0.506
Narrowing of the roots	0	0	0	
Bifid apex	0	0	0	
Total	60 (100%)	35 (58.3%)	25 (41.7%)	

Among the 23 cases of darkening of the root (panoramic radiography), in 17 cases (73.9%) the contact between the tooth and the nerve (CBCT) was observed. The difference between the two methods in determining the relationship between the tooth and the nerve was not significant (P = 0.055).

Among the 19 cases of deflection of the root (panoramic radiography), in 10 cases (52.6%) the contact between the tooth and the nerve (CBCT) was observed. The difference between the two methods in determining the relationship between the tooth and the nerve was not significant (P = 0.583).

Among the 11 cases of narrowing of the canal (panoramic radiography), in 2 cases (18.2%) the contact between the tooth and the nerve (CBCT) was observed. The difference between the two methods in determining the relationship between the tooth and the nerve was significant (P = 0.005).

Among the 5 cases of interruption of the white line (panoramic radiography), in 4 cases (80%) the contact between the tooth and the nerve (CBCT) was observed. The difference between the two methods in determining the relationship between the tooth and the nerve was not significant (P = 0.390).

The contact between the tooth and the nerve (CBCT) was observed in each of the 2 cases (100%) of interruption of the white line (panoramic radiography). The difference between the two methods in determining the relationship between the tooth and the nerve was not significant (P = 0.506).

Table 2 displays the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of panoramic radiography.

Table 2: The sensitivity, specificity, positive- and negative predictive values for each radiographic sign

Variable	Sensitivity	Specificity	PPV	NPV
Darkening of the roots	48.6%	76.0%	73.9%	51.4%
Deflection of the roots	28.6%	64%	52.6%	39.0%
Narrowing of the canal	5.7%	64%	18.2%	32.7%
Interruption of the radiopaque border of the canal	11.4%	96.0%	80.0%	43.6%
Diversion of the canal	5.7%	100%	100%	43.1%
Narrowing of the roots	-	-	-	-
Bifid apex	-	-	-	-

The highest sensitivity of panoramic radiography was related to darkening of the root (48.6%), and the lowest sensitivity related to narrowing of the canal (5.7%) and diversion of the canal (5.7%). The highest specificity related to the deflection of the root (100%) and interruption of the white line (96%), and the lowest specificity related to deflection of the root (64%) and narrowing the canal (64%), so deflection of the root is mentioned in both the highest and the lowest specificity. The highest PPV related to diversion of the canal (100%) and interruption of the white line (80%), and the highest NPV related to narrowing of the root (51.4%) and interruption of the white line (43.6%), so interruption of the white line is mentioned in both the highest PPV and the highest NPV.

DISCUSSION

An accurate radiographic diagnosis is essential to evaluate and predict the possible outcomes related to the extraction of an impacted third molar; so, parallel periapical radiography, panoramic radiography, and CT or CBCT are used. In oral and maxillofacial surgery, panoramic radiography is an examination initially requested to assess the impacted third molars and estimate the risk of IAN damage. However, this technique has a distortion. So, it does not always provide enough information to determine the actual risk level [25]. Because this method produces two-dimensional images, it cannot provide information in axial, coronal, and sagittal planes. However, CBCT is a 3D imaging technique and a more reliable imaging method in the assessment of mandibular third molars [13].

On this basis, CBCT was considered as the standard in this study, and panoramic radiographic findings were evaluated based on CBCT.

In the present study, the most common relationship between the molar and the IAN, among all observed findings, was darkening of the roots (38.3%) and deflection of the root (31.7%)

Similar to the present study findings, Paker *et al.*, (2014) reported that the most common relationship was darkening of the roots (39.9%), interruption of the radiopaque border (37.2%), narrowing of the canal (10.7%), and deflection of the canal (8.4%) [13].

In the study performed by Neves *et al.*, the most common panoramic radiograph findings were interruption of the white line (20.4%) and darkening of the roots (17.4%).

The evaluation of this study findings and that of other studies revealed that darkening of the roots is the most common finding.

However, in the study performed by Dalili *et al.*, (2011), darkening of the roots had the lowest frequency (11.6%) and in prevalence came after superimposition (67.4%), interruption of the white line (30.2%), and diversion of the canal (18.6%) [26].

In the present study, interruption of the white line (8.4%) and diversion of the canal (3.3%) showed the least prevalence.

According to the study performed by Peker *et al.*, (2014), narrowing of the canal (10.7%) and diversion of the canal (8.4%) were the least frequent findings [13].

In the study by Monaco *et al.*, (2004), diversion of the canal (9.6%) was the least frequent [27].

The difference between the frequencies of types of relationship between the impacted molar and IAN can be attributed to the variety of the studied population.

The findings of the present study indicated that among the 60 cases studied, in 85.3% of the cases there was contact between the roots and the IAN. Similarly, Jung *et al.*, (2012) reported (85.3%) of contact between the roots and the IAN for the cases that showed the superimposition of mandibular canal and the third molar [28].

Also, in the study by Yamada *et al.*, in 57.5% of the cases, the presence of contact between the molar and the nerve was confirmed by CBCT [29].

Kositbowonchai *et al.*, (2010) showed that among the 32 cases which showed a relationship between the roots of the mandibular third molar and the IAC, in 6.68% of the cases there was contact between the tooth and the IAC based on the evaluation of CBCT [30].

According to the study by Ghaemini *et al.*, (2011), the number of cases related to the contact of the tooth and the IAN which were observed in CBCT were considerably less than those which were observed in panoramic radiographs [31].

Also, Dalili *et al.*, (2011) reported significant differences in the relationship between IMTM and the mandibular canal as seen in the CBCT and panoramic radiography finding [26].

In the present study, among the five relationships seen in panoramic radiographs, the cases with diversion of the canal, interruption of white line, and darkening of the roots revealed the highest percentage of contact between the roots and the nerve in CBCT; 100%, 80%, and 73.9% cases, respectively, showed the presence of contact in CBCT.

In agreement with the present study findings, Dalili *et al.*, (2011) observed that in all the cases related to diversion of the canal and darkening of the roots, there was contact between the tooth and the canal [26].

According to Neves *et al.*, (2012), there was a significant correlation between the darkening of the roots, interruption of the white line, and the contact between the tooth and the canal [25].

Also, Ghaemini *et al.*, (2009) observed that three panoramic radiographic findings, interruption of the white line, darkening of the root, and diversion of the canal, were most likely to reveal a contact between the third molars and the dental canal [19].

Peker *et al.*, (2014) found that darkening of the roots and interruption of the white line on DPR images were significantly associated with the presence of contact between the IMTM and the IAC on CBCT images, but there was no significant correlation between the other signs and the contact between IMTM and IAC on panoramic radiograph images [13].

Szalma *et al.*, (2010) found that Interruption of the white line, diversion of the canal, and darkening of the root was significantly associated with IAN paresthesia [32].

In contrast to the present study findings and some other studies that presented the interruption of the white line as a radiographic sign with a high probability of contact between IMTM and IAC, Nakamori *et al.*, (2008) didn't report this relationship [33].

Based on our observations, to determine the contact between IMTM and IAC, darkening of the root had the highest sensitivity (84.9%) and diversion of the canal the lowest (5.7%). Shahidi *et al.*, (2013) also observed that the diversion of the canal had the lowest sensitivity to predict the contact between IMTM and IAC [34].

In the present study, diversion of the canal (100%) and interruption of the white line had the highest PPV.

Monaco *et al.*, (2004) also found that diversion of the canal had the highest PPV [27].

Shahidi *et al.*, (2013) acclaimed that darkening of the roots had the highest PPV [34].

According to our observations, darkening of the roots (4.15%) and interruption of the white line (6.34%) had the highest PPV while in the study performed by Shahidi *et al.*, (2013) diversion of the canal had the highest NPV [34].

In the present study, the relationship between the tooth and the nerve was not assessed during the surgery of IMTM, and the findings provided are exclusively based on the evaluation of two radiographic techniques. The findings revealed that CBCT is to be considered the standard. However, the comparison between CBCT and the clinical observations during third molar surgery indicated that the accuracy of this technique is higher than that of panoramic radiography, but it's not 100% [35].

CONCLUSION

According to the results of this study, it's concluded that:

- 1- In more than half of the cases in which panoramic radiographs reveal a relationship between the IMTM and IAN, there is a direct contact between the molar and the nerve.
- 2- In cases in which panoramic radiographs indicate a relationship between IMTM and IAN based on the type of diversion of the canal, interruption of the radiopaque border of canal, and darkening of the roots, the possibility of direct contact between the IMTM and IAN is considerably high.
- 3- The relationship between diversion of the canal and interruption of the radiopaque border of canal has a high predictive value for indicating the absence of contact between IMTM and IAN.

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