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ORIGINAL ARTICLE

# Assessment of Panoramic Radiographic Variables as Predictors of Inferior Alveolar Nerve Injury During Third Molar Extraction

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**ABSTRACT**

**Objective:** To assess the role of radiological predictive markers on orthopantomogram for inferior alveolar nerve (IAN) injury related to the removal of mandibular third molar surgery and the occurrence of post-operative IAN paresthesia. **Material and Methods:** This prospective observational study was conducted on 60 patients (aged 17-35 years) indicated for extraction and showed one or more of the seven previously known panoramic radiographic risk signs of IAN injury. Variables such as age, sex, tooth angulation, and relationship with the inferior alveolar canal (IAC) were assessed to see their outcome on IAN injury. Data analysis is presented through tables and descriptive methods. **Results:** Among patients, 26 were male and 34 were female, with a mean age of 26.17 years. Out of seven radiological predictive markers, only six were found in this study, whereas one marker, viz. interruption of white line of the canal was not found. After surgical removal of the lower third molar, only two patients with radiographic signs showing the deflection of roots and darkening of roots continued with sensory deficit 5 weeks post-operatively. **Conclusion:** The risk of inferior alveolar nerve injury during lower third molar surgery is very low, even in patients with radiological predictive markers.

**Keywords:** Surgery, Oral; Molar, Third; Radiography, Dental.

## Introduction

Injury to the inferior alveolar nerve (IAN) is an infrequent but serious complication that might occur during the extraction of mandibular third molars [1,2]. The known risk of transient IAN injury after mandibular third molar surgery ranges from 0.6-5.3%, whereas the risk of permanent IAN damage is <1% [3]. However, the permanent injury to IAN can lead to considerable morbidity and patient dissatisfaction in addition to leading to legal disputes between patients and practitioners [4,5].

Exposure of the IAN upon extraction shows a close relationship between the nerve and roots of the third molar. The risk of post-operative paresthesia following IAN exposure is nearly 15-25%, with high anatomical variability among individuals [4]. The most predictable risk factor for IAN injury is the anatomical relationship between the mandibular third molar roots and the inferior alveolar canal (IAC). Hence, an accurate and detailed examination of this anatomical relationship using radiographic imaging techniques constitutes a critical pre-operative assessment tool to minimize the risk of IAN injury during surgery and prevent neurological complications [4].

The pre-operative radiographic techniques used to evaluate the relationship between the mandibular third molar and IAC are periapical radiographs, orthopantomogram (OPG), Cone Beam Computed Tomography (CBCT), DentaScan, and computed tomography (CT) [3]. Though the newer advanced imaging techniques exhibit better qualities, the high cost and reduced accessibility have made them unpopular [6]. Thus OPG has been recommended as the primary radiographic technique of choice in the pre-operative assessment of mandibular third molar teeth and their surrounding structures owing to its greater availability, lower cost, and low radiation exposure [1,7-11].

Several studies have been done on this topic globally, but our local record lacks any research in this context. Among all, four are seen on the root of a tooth (bifid root apex, darkening, deflection and narrowing of the root), whereas the other three are changes in the appearance of the IAC (diversion, narrowing and interruption in the white line of the canal). These radiographic signs have been regarded as the 'standard markers' for identifying the risk of IAN injury during lower third molar surgery [5,7,12].

There is a number of studies done on this topic globally, but our local record lacks any research in this context. Against this background, the current study aimed to positively contribute to available data and reach a definite conclusion by assessing the frequency of IAN injury, recognizing risk factors involved in IAN injury, and preventing IAN damage during lower third molar surgery, therefore, suggesting an appropriate plan.

## Material and Methods

Study Design and Sampling

This prospective observational study was conducted at Outpatient Department of Oral and Maxillofacial Surgery, Karachi Medical and Dental College and Abbasi Shaheed Hospital, Pakistan, from 1st March 2019 to 1st October 2019, after receiving ethical approval from the institute (AIDM/ERC/03/2019/02).

Inclusion criteria considered were i) individuals requiring mandibular third molar extractions; ii) aged between 17-40 years, and iii) OPG showing any of the seven radiological findings that are the predictor for IAN damage during third molar surgery. In addition, exclusion criteria were i) patients with a history of trauma/surgery to mandible; ii) presence of pathology affecting the jaws; iii) patients with uncontrolled systemic illnesses; and iv) pregnant women.

Sixty participants, aged between 17-35 years, who showed a close relationship between the IAC and impacted mandibular third molars in their routine digital OPG were included in this study. Digital OPG

radiographs were reclaimed from the hospital records and were acquired with an orthopantomography (Soredex Cranex D Digital Dental X-ray unit), operating at 81 kVp/10 mA and an exposure time of 13.9 s. The participants were selected by purposive sampling. A self-designed proforma was used to record the demographics (age and sex) of the participants. The participants were stratified according to their age as 17-25 years, 26-30 years, and 31-35 years.

Radiographic Risk Predictive Markers

The selected radiographs were independently examined by an oral radiologist and an oral and maxillofacial surgeon, on a 21-inch LCD computer monitor workstation. All interpretations were done under standardized conditions, and any conflicts were decided by consensus. The following were evaluated on OPG:

1. Presence of one or more of the seven radiographic risk predictor signs as proposed by Rood and Shehab [7]:

i. Darkening of root: described as a loss of root density that is impinged upon by the canal;
ii. Deflection of roots: refers to an abrupt deviation of root when it reaches IAC;
iii. Narrowing of root: that occurs where IAC crosses;
iv. Dark and bifid roots: refers to a loss of root density in a tooth that is impinged upon by the canal with a bifid apex of the root.
v. Interruption of white lines: is discontinuity of the superior radio-opaque line that constitutes the superior border of the IAC.
vi. Diversion of canal: a change in direction as the canal crosses the third molar.
vii. Narrowing of canal: described as an abrupt decrease in width of the canal while it crosses the root apices.

2. Impacted tooth angulation was classified based on Winter's criteria [13] as a) mesio-angular; b) disto-angular; c) vertical; and d) horizontal.

The presence of any of the aforementioned radiographic signs on panoramic radiographs, either single or in combination, was considered close to IAC radiographically.

Procedure

Before extraction, all the patients were either asymptomatic or made asymptomatic by the use of standard analgesics and antibiotic protocol. All mandibular third molars were extracted by a single experienced oral surgeon using the inferior alveolar and long buccal nerve block (1.8 ml of 2% lignocaine with 1:200000 adrenaline added to it). All the selected and volunteered patients were informed of the possible complications of the procedure before getting a written informed consent. During the procedure, a full-thickness triangular mucoperiosteal flap was reflected and the buccal bone was removed with a diamond burr under continuous irrigation with sterile saline at room temperature. After adequate ostectomy, the tooth was removed and the socket was cleaned with 0.9% saline solution. The tooth was sectioned whenever necessary. The wound was closed by a 3'0 silk suture.

Post-operative Findings

Post-operatively, all the patients were followed up regularly (the next day, and after 1 week, 1 month and 3 months) to evaluate IAN injury. Neurosensory impairment along the course of the IAN was assessed by a 2-point discrimination test with a caliper, a light touch test with a small cotton swab, and a pinprick sensation with a probe. The unaffected side was taken as a control. Self-reported sensations of the lower lip or mental

region were also recorded. The finding was classified as one of the following: paresthesia, hypoesthesia, hyperesthesia, dysesthesia or anesthesia [14].

Data Analysis

Data was entered and analyzed using SPSS version 20.0 (IBM Corp., Armonk, NY). Mean and standard deviation was calculated for the age of the participants. Frequencies and percentages were calculated for sex, tooth angulation and radiological markers for IAN injury. Stratification with regards to age, sex, and tooth angulation was done to assess their relationship with the radiological predictive markers. Kruskal Wallis test was used to evaluate the correlation between signs and age groups. The level of statistical significance was set at $p \leq 0.05$.

## Results

A total of 26 (43.3%) males and 34 (56.6%) females were included, with an overall mean age of 26.17 years (±4.66). Based on Winters' classification, 17 (28.3%) were mesio-angular impactions, 16 (26.7%) disto-angular impactions, 15 (25.0%) vertical impactions, and 12 (20.0%) were horizontal impactions. The most common risk predictor sign seen on OPG was diversion of canal (n=24 / 40%) followed by a narrowing of canal (n=19 / 31.7%), narrowing of root (n=11 / 18.3%), dark and bifid apex of roots (n=4 / 6.7%), darkening of roots (n=1 / 1.7%) and deflection of roots (n=1 / 1.7%). In contrast, interruption of white line of canal was not seen in any of the cases.

The majority of the patients belonged to the age group of 17 to 25 years (46.6%), followed by 26 to 30 years (31.7%) of the age group and only 13 (21.7%) were present in the age group of 31 to 35 years. A statistically insignificant (p=0.50) difference was noted between the panoramic radiographic signs and different age groups, as shown in Table 1.

**Table 1. Relationship between panoramic radiograph signs and age groups.**

| Panoramic Radiograph Sign | Age Groups (Years) | | | p-value |
|---|---|---|---|---|
| | 17-25 | 26-30 | 31-35 | |
| Diversion of Canal | 12 | 6 | 6 | 0.50 |
| Narrowing of Canal | 9 | 7 | 3 | |
| Narrowing of Root | 2 | 5 | 4 | |
| Dark and Bifid Apex of Roots | 3 | 1 | 0 | |
| Darkening of Root | 1 | 0 | 0 | |
| Deflection of Roots | 1 | 0 | 0 | |
| Interruption of White Line | 0 | 0 | 0 | |
| Total | 28 (46.6%) | 19 (31.7%) | 13 (21.7%) | |

Post-operatively, two (3.3%) patients had altered labial sensation that was confirmed with a neurosensory examination. One patient was injured with the diversion of canal and the other patient was injured with the darkening of roots, as shown in Table 2. Both cases of IAN injury were resolved within five weeks.

**Table 2. Frequency of IAN injury according to radiological markers.**

| Radiological Findings | IAN Exposure | |
|---|---|---|
| | Yes | No |
| Deflection of Roots | 1 | 0 |
| Darkening of Roots | 1 | 0 |
| Narrowing of Roots | 0 | 11 |
| Dark and Bifid Apex Roots | 0 | 04 |

| | | |
|---|---|---|
| Diversion of Canal | 0 | 24 |
| Narrowing of Canal | 0 | 19 |
| Interruption of White Line of Canal | 0 | 0 |
| Total | 2 (3.3%) | 58 (96.7%) |

## Discussion

A pre-operative assessment detailing the exact relationship between the IAC and roots of the third molar would assist in predicting risk and eventually avoiding sensory complications after surgery [3]. Panoramic radiographs are the most commonly employed pre-operative radiographs to evaluate the impacted mandibular third molars and estimate the risk of IAN damage. It is a less biased assessment tool as compared to periapical radiographs because the head position is fixed and operator bias is less likely to occur [15-19]. Several authors have evaluated the reliability of OPG against advanced radiographic techniques like CBCT and CT in predicting IAN exposure. Controversial results are reported where few researchers claim that the advanced imaging techniques have higher accuracy in the prediction of IAN exposure [20-22] whereas others report no statistical difference between the two imaging methods [4,21,23,24].

However, advanced radiography is recommended when radiographic signs appear in OPG that show a direct anatomical relationship between the third molar and canal [25]. Therefore, digital panoramic radiography is performed routinely at Karachi Medical and Dental College and Abbasi Shaheed Hospital, Pakistan, for all patients as an initial radiographic assessment.

The most frequently seen panoramic radiographic sign was the diversion of canal (40.0%), which is in accordance with the studies of Rood and Sehab [7], Valmaseda-Castellon et al. [15], and Renton et al. [16]. However, Elkhateeb and Awad [4] concluded that, as an isolated finding, diversion of the IAC is not related to a high risk of contact between the roots and canal, but when combined with other signs like darkening in roots or interruption of canal line, the risk of contact between the third molar and canal increases. Recently, Janovics et al. [26] further classified the "diversion of the canal" sign into "downward" (caudal) and "upward" (cranial) bending of the IAC. They found that upward diversion was significantly associated with IAN entrapment; however, the downward diversion was insignificant. Similarly, Pippi [27] and Chopra et al. [28] in their respective studies, suggested the upward deviation of the mandibular canal to be highly predictive of IAN injury.

Narrowing of the canal was the second most frequent (31.7%) radiographic sign; in contrast to the study by Monaco et al. [8], who reported narrowing of the canal to be the main sign, whereas Elkhateeb and Awad [4] reported this sign as the third most frequent panoramic radiographic marker. Narrowing of the roots was the third most frequent (18.3%) radiographic sign; in contrast with Pathak et al. [3], where this sign was found to be the most significant variable associated with post-operative paresthesia. The same authors explained that this sign is a most significant variable because in some individuals, the close relationship between a tooth and canal continues that resulting in trauma to the IAN during the removal of impacted third molar [3].

Other less common panoramic signs observed in this study were the dark and bifid apex of roots (6.7%), darkening of roots (1.7%) and deflection of roots (1.7%). This finding is inconsistent with the results of Rud [29], Owatade et al. [30], Kim et al. [31] and Ghai and Choudhury [32] where they found the darkening of root to be the most reliable indication of a true relationship between the tooth and IAC whereas Pathak et al. [3] and Elkhateeb and Awad [4] found that darkening of root was a second most reliable predictive marker for nerve injury. The explanation provided is that hooked roots are difficult to remove and require more bone cutting for extraction, which may eventually cause trauma to IAN [3].

In this study, interruption of the white line was not seen in any of the radiographs, which is in accordance with the study by Nakamori et al. [33]. However, Pathak et al. [3], Elkhateeb and Awad [4], Rood and Sehab [7], Ghaeminia et al. [21], Szalma et al. [24] and Rud [29] found that this radiographic sign to be significantly related to IAN injury.

In the current study, more than one of the radiological predictive markers was not present. This is in contrast to the findings of Elkhateeb and Awad [4], Szalma et al. [24], Nagaraj and Chitre [34], Huang et al. [35], Pandey et al. [36], Fauzi et al. [37] and Issrani et al. [38] who opined that presence of multiple radiographic signs increases the likelihood of nerve injury and needs to be studied further. This could be attributed to the small number of patients involved in this study.

In this study, most of the participants (46.7%) were in the age group of 17-25 years with a mean age of 26.17 years, comparable to Deshpande et al. [6], Singh et al. [39] and Nyugen et al. [40] documented that the risk of IAN injury increases with age as observed in this study. This can be explained based on increased operative difficulty due to age-related changes like increased bone density, decreased bone elasticity, decreased vascularization impairing the nerve regeneration process, and a higher incidence of hypercementosis, ultimately leading to more bone removal [41].

Females constituted most (56.7%) of the study sample, in accordance with Szalma et al. [24] and Jerjes et al. [41]. In contrast, a study done by Deshpande et al. [6] observed a female preponderance. This could be attributed to the variations in sample sizes involved.

In the current study, impacted molars were commonly found on right side (65.0%); in agreement with Deshpande et al. [6] but in contrast to Tay and Go [42], which could also be attributed to the variations in sample sizes involved.

The present study found that mesio-angular was the most common angulation (28.3%) followed by disto-angular (26.7%), vertical (25.0%), and horizontal (20.0%). This was in agreement with Deshpande et al. [6], Sedaghatfar et al. [10], Nyugen et al. [40] and Gomes et al. [43]. This could be attributed to the fact that the normal development and path of eruption of mandibular third molars is anterosuperior [6]. In contrast, Tantanapornkul et al. [20] revealed that horizontal angulation was the most frequent followed by angular and vertical.

In the current study, 58 patients with positive radiographic appearances did not suffer nerve injury. The presence of these predictors does not indicate nerve injury will definitely occur. Two patients experienced labial sensation impairment following lower third molar surgery with positive radiological markers. In one patient IAN injury was related to the diversion of the IAN canal, whereas another patient had an IAN injury due to the presence of darkening of the roots on OPG. Tay and Go [42] reported a 20% risk of paresthesia in patients with an exposed IAN bundle seen intra-operatively. Hull et al. [44] documented that pre-surgery finding of an impacted mandibular third molar in close proximity to the IAC is associated with a patient's prolonged health-related quality of life recovery but not a significant delay in clinical recovery.

## Conclusion

The radiological predictive markers are valuable in suggesting the risk for IAN injury pre-operatively. The study established that 'diversion of the canal' was the most reliable radiographic risk sign that should caution the dental practitioner regarding the close proximity of the tooth to the canal. This study also established that the panoramic radiograph, despite its evident limitations, is a cost-effective primary diagnostic tool that provides

sufficient information in determining the proximity of the impacted mandibular third molars to the canal. Additional studies incorporating larger samples are recommended to justify the findings of the present study.

## Authors' Contributions


| | | |
|---|---|---|
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All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.


## Financial Support

None.

## Conflict of Interest

The authors declare no conflicts of interest.

## Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

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