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Original Research Article

Prediction of nerve damage by comparing periapical radiographic signs of impacted mandibular third molars in close proximity to inferior alveolar nerve with their true tomographic relationship – An observational study

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ABSTRACT

Background: The purpose of the study was to correlate the accuracy of Roods and Shehab signs in an intraoral periapical radiograph (IOPAR) with Cone-beam computed tomography (CBCT) findings to indicate Cone-beam computed tomography only in high-risk conditions.

Materials and Methods: 70 impacted mandibular third molar teeth in 58 patients above 18 years with intraoral periapical radiographs presenting with one or more root and canal signs of Rood and Shehab criteria were included in the study. Winter's classification was recorded, and the patients were exposed to a Cone-beam computed tomographic scan. True canal – tooth relationship was assessed in the sectional images. Pearson Chi-square test was used to correlate periapical radiograph and tomographic findings, and an unpaired t-test was applied for descriptive analysis.

Results: Rood and Shehab canal criteria in the periapical radiographs were significantly correlated to direct contact of an impacted lower third molar with the canal ($p< 0.05$) and loss of cortication of Mandibular canal ($p< 0.05$) on the cone-beam computed tomography.

Conclusion: Cone-beam computed tomography is recommended to assess the periapical radiographs with canal risk markers pre-operatively to help avoid iatrogenic complications.

1. Introduction

The mandibular third molar has a high incidence of failure to erupt into the oral cavity within the stipulated range of time. It is most likely to remain impacted when compared to the other teeth. This is because various anatomical and physiological causes come into force during its development and eruption.[1]

The impacted third molars unless surgically removed are retained throughout the life – time of a person and are thus prone to further complications like pericoronitis, cyst and tumor formation from the developmental remnants, neuralgic pain related to the inferior alveolar canal impingement, alteration in occlusion, masticatory dysfunction, and temporomandibular joint disorders in the long run.[2]

Removal of the impacted third molars is considered prophylactically or when associated with pathology. Deferring the procedure is related to comorbidities.[3,4] Moreover, the intimate anatomical relationship of the impacted mandibular third molar with the surrounding vital structures poses a risk of intra-operative and post-operative complications.[5] The most severe and unpleasant iatrogenic complication is the injury to the inferior alveolar nerve, causing neurosensory function disturbance over the

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areas supplied.[6] To avoid such an incident, a collaborative effort between the oral radiologist and surgeon would help obtain satisfactory treatment outcomes. Prior radiographic assessment will help circumvent neural injury during the procedure.[7]

A dilemma persists whether routine intra- oral periapical radiographs are sufficient or if CBCT should be performed to predict nerve - bundle injury during the disimpaction of the lower third molar. This has driven the need to compare and validate the IOPAR signs put forward by Rood and Shehab. They proposed seven radiographic signs representing the proximity of the impacted molar to the inferior alveolar canal on a two-dimensional radiograph. Out of the seven, four were root markers– darkening, narrowing, deflection of the root and bifid root apex, and three were canal markers– interruption of the white line, narrowing, and diversion of the canal. These signs serve as risk predictors of inferior alveolar injury.[8] The analysis could lead to concluding the most accurate predictor sign seen on the IOPAR and thus help limit advising CBCT to the most needful situations. It would also benefit rural and developing areas where there is no availability of CBCT.[9]

Based on the need for research, the present study was conducted with an aim to test and determine the most accurate Rood's sign that predicts the proximity of the impacted mandibular molar to the mandibular canal in an IOPAR and compare with the actual relationship as viewed on a three-dimensional modality, enabling the indication of the CBCT scan in high - risk cases only.

2. Materials and Methods

A prospective, observational study of cross-over type was designed and implemented. The study was conducted at a dental college and hospital in South India, and the design was approved by the institutional review board, ethical committee (VDC/IEC/2018/30) in November 2018. The study sample included 70 symptomatic or asymptomatic impacted mandibular third molar (IMM3) teeth in a population of 58 outpatients visiting the department of Oral Medicine and Radiology. The participants were selected using the convenience quota sampling method.

The inclusion criteria included participants with impacted mandibular third molars above the age of 18 whose intraoral periapical radiographs presented with one or more of Rood's criteria. Patients without positive IOPAR Roods criteria, those not willing for further assessment with CBCT scan, and lower third molars associated with cysts or tumors were excluded from the study. The purpose and procedure of the study were explained to each patient, and informed consent was taken.

The patients with symptomatic and asymptomatic impacted mandibular third molars were examined, and clinical visibility of the impacted tooth was assessed. They were then subjected to a diagnostic IOPAR. Radiation protective measures were taken, where the patient was secured with a lead apron and a thyroid collar and seated on a dental chair. The patient's head was placed so that the lower arch's occlusal plane was parallel and the midsagittal line perpendicular to the floor. The Long Cone technique (Paralleling) was followed using a posterior Dentsply Rinn XCP and a Carestream Ekta speed–size two radiographic film. The film was placed in the lingual sulcus, and the mandibular third molar was centered. The patient was then asked to bite on the bite- block. Once the holder was in place, the locator ring was moved close to the skin, and the X-ray cone was aligned with the ring. The exposure was made setting exposure parameters at 70kVp, 10mA, 0.3 s. The film was then processed manually in a well-set darkroom and viewed under an appropriate light source.

The IOPAR was checked for the presence of any of the seven signs of Roods and Shehab Criteria, namely the root signs - darkening of the root, deflection of the root, narrowing of the root, bifid root apex, and canal signs - diversion of the canal, narrowing of canal and interruption of the white line. The type of impaction according to Winter's classification was recorded. Patients requiring a three-dimensional evaluation as suggested by an oral maxillofacial surgeon were exposed to a CBCT scan.

A Cranex 3D Soredex CBCT (Tuusula, Finland) unit with a flat panel detector was used. As recommended by the manufacturer, the parameters were set at 10mA, 90kVp for duration of 2.3s. Tomographic scan of the impacted mandibular third molar region with a field of view (FOV) either 61 x 41 mm or 61 x 78 mm and standard resolution of 200μm or 300μm voxel size was obtained. Three-dimensional (3D) images were reconstructed using 3D visualization using Scanora^{TM} imaging software 5.2 version. The raw data were converted into a set of images in three orthogonal planes and a three-dimensional view using On-Demand 3D^{TM} software (California, USA).

The axial, coronal, sagittal, 3D sections were analyzed in Direct Volume Rendering (DVR) and 3D modes while adjusting magnification, contrast, and slice thickness. The IAC was traced with the nerve tracking tool. The true canal–tooth relationship was assessed and categorized as contact and non – contact, and the presence or absence of IAC cortical integrity was recorded. This was done in the cross-sectional view and coronal view. All the data collected were tabulated into a spreadsheet. Statistical analysis was performed using IBM SPSS software 22.0. The comparison between the IOPAR and CBCT findings was assessed using Pearson's chi-square test. A p-value of 0.05 was considered statistically significant for all analyses.

3. Results

Outpatients with symptomatic or asymptomatic impacted molars were screened, and a diagnostic IOPAR was taken and examined. Based on the presence of Roods and Shehab

criteria, 58 patients with 70 IMM3s subsequently underwent CBCT examination using a flat panel detector CBCT scanner (Cranex 3D Soredex). Informed consent was taken from each patient. The study population enrolled was above the age of 18 years and included 46 females and 21 males. (Table 1)

3.1. IOPAR findings

IOPARs of 70 IMM3s (34 molars on the right side and 36 molars on the left side) were analyzed, and tooth angulation (Winter's classification, 1926) was recorded. 46 IMM3 were of mesioangular impaction, the most prevalent type, and the least were vertically impacted lower third molars (5 IMM3). According to Roods Criteria on the periapical radiographs, the common risk factors were interruption of the white line of the canal in 35 lower third molars, darkening of the root apex in 28, and narrowing of the root apex in 10 teeth. The most frequent IOPAR root sign was darkening of the root in 28 cases, whereas interruption of the white line was common among the canal signs in 35 cases. 37 of the total periapical radiographs had root and canal criteria, 23 presented with only root criteria, and 10 cases depicted only canal criteria. (Table 1)

3.2. CBCT findings

3.2.1. Contact with IMM3 and Cortical integrity of IAC

50 impacted lower third molars were in contact with the underlying IAC, and there was a loss of cortication of the superior border of the IAC in 49 cases. (Table 1)

3.3. Predictive factors and true tomographic relation

IOPAR root predictor signs of Roods criteria were correlated with a contact of root to the canal, loss of canal cortical integrity, and position of IAC. There was no significance between the parameters. Among IOPAR root signs, 73.9% of cases with darkening of root, 64% cases with narrowing of the root, and all the cases with bifid root apex and deflection of root were in contact with the canal. 71.7% of cases with darkening of root, 60% cases with narrowing of the root, and all the cases with bifid root apex and deflection of root presented with loss of cortication. The canal was most frequently positioned inferior to the IMM3 in the periapical radiographs with root markers - darkening of root (45.7%) and narrowing of the root (48%), bifid root apex (57.1%). However, all cases with deflection of the root had a buccally placed IAC.

Among IOPAR canal predictors, 78.9% of cases with interruption of white line, 85.7% cases with canal diversion, and all the cases with narrow canal were in contact with the canal and presented with loss of cortication. There was a statistical significant association between the IOPAR canal signs and CBCT canal relation – contact ($p = 0.03$) and cortication ($p = 0.042$). (Table 2). The canal was most frequently positioned inferior to the IMM3 in the periapical radiographs with canal markers - interruption of the white line (55.3%) and narrowing of the canal (42.9%). However, lingually placed IAC was more frequent in cases with diversion of the canal (71.4%). The relation between the position of the canal and the canal predictor signs was statistically significant ($p = 0.049$). 80.4% of the mesioangular impacted lower third molars were in contact with the IAC, which was the most common.

4. Discussion

The intraoral periapical radiograph is the most commonly used radiographic diagnostic tool, is cost-effective, requires low amounts of radiation exposure, and is not technique sensitive.[10] Hassan BA[11] supported this in his survey. He stated that IOPARs are a primary option as an initial diagnostic radiograph since they have good resolution and sharpness and are better discriminating with minimal magnification than the panoramic radiograph. Hence for this study, IOPAR was the preferred two – dimensional radiographic method to assess the proximity of an impacted third molar to the mandibular canal and predict nerve damage.

Dodson,[12] in his study described that the Rood and Shehab criteria could be utilized as a predictive tool for nerve injury using an IOPAR. Also, a study conducted by Nagaraj M and Chitre AP[2] described the significant correlation of IOPAR Rood's warning signs such as darkening of the root, interruption of the white line, and deflection of IAC with intraoperative exposure of the inferior alveolar nerve leading to the post-operative sensory deficit.They concluded that IOPAR is effective in being utilized as a conventional method to predict IAC damage.

In the present study, the most frequent individual root predictor sign seen on the IOPAR was the darkening of the root (40%). The frequent individual canal predictor sign and most prevalent among the entire sample was the interruption of the white line (50%) which was consistent with a panoramic study performed by Elkhateeb SM et al.,[9] where a higher percentage of interruption of the IAC white line (60%) both in isolation and combination was observed among the risk predictors followed by the darkening of the root and narrow canal. Deshpande P and Guledgud MV[13] also recorded 32.4% of subjects with interruption of the white line, which was the most commonly observed radiographic risk predictor marker. The present data set was in contrast to several studies by Mular A et al.,[10] and Sinha P et al.,[14] who concluded that darkening of the root is the most common sign followed by interruption of the white line. This difference could be due to improper paralleling of the film or a smaller sample size when compared to the current study.

Nevertheless, an IOPAR cannot predict or display the true relation of the IMM3 with the underlying neural

Table 1: Study variables (58 patients; 70 impacted mandibular third molars)

Gender	
Female	49
Male	21
Impaction type (Winters classification)	
Mesioangular impaction	46
Distoangular impaction	13
Horizontal impaction	06
Vertical impaction	05
IOPAR Roods and Shehab Predictor Signs	
Root Signs	
Darkening of the root	28
Narrowing of the root	10
Deflection of the root	01
Bifid root apex	01
Canal Signs	
Interruption of white line	35
Narrowing of the canal	04
Diversion of the canal	04
Distribution of IOPAR Criteria	
IOPAR with root and canal signs	37
IOPAR with only root signs	23
IOPAR with only canal signs	10
True tomographic relation – CBCT	
Contact Status of IAC with IMM3	
Contact	50
No contact	20
Cortication status of IAC with IMM3	
Loss of cortication	50
Intact cortication	20

Table 2: Relation between IOPAR canal signs and true tomographic relation CBCT

IOPAR Canal Predictor Signs	**Contact**	**No Contact**	**Total (N)**	**p- value**
White line interuption	30	08	38	
Canal narrowing	07	0	07	.030
Canal diversion	06	01	07	
IOPAR canal predictor signs	Loss of IAC cortication	No loss of IAC cortication	Total (N)	p- Value
Interuption of white line	29	09	38	
Narrowing of canal	07	0	07	0.042
Diversion of canal	06	1	07	

bundle in multiple planes like CBCT. This was supported by Sinha P et al,[14] where who conducted a study and concluded that IOPAR has poor reliability compared to CBCT. Khojastepour L et al.,[15] performed a study where they conveyed that CBCT has a high diagnostic value and pre-operative CBCT confirmation is essential in IMM3 removal.

The advent of digital three-dimensional CBCT has allowed a better pre-operative assessment of the tooth - canal relationship. However, not most of the geographic population is fortunate enough to access this technology, especially in developing and underdeveloped countries. Not only is there less availability, but CBCT also involves high radiation exposure. Keeping this in perspective, the primary focus of this study was to validate periapical Roods signs that signify a possibility of nerve damage and thus narrow down the need for CBCT to benefit underprivileged areas with only IOPAR facility and also to advise CBCT in high-risk cases. In the present study, CBCT was utilized to evaluate only cases where IOPAR depicted the proximity of the third molar root apices to the mandibular canal with a high probability of neurovascular damage. 71.4% of the

total sample were in contact with IAC when viewed on the dental CBCT, and 70% of cases presented with loss of corticalization of the superior wall of the mandibular canal. The radiological signs in the IOPAR most commonly associated with contact with the IAC were the darkening of root and interruption of the white line.

Canal risk markers were insignificant correlation which helps conclude that the canal criteria visible on the IOPAR are predictive of intra- operative nerve exposure and the loss of cortication in relation to the mandibular canal represents a compression of the nerve by the impacted lower wisdom tooth, the consequence of which is an elevated risk of partial or complete paraesthesia in the area supplied by the mandibular nerve and its branches. Though the number of samples was notably on the lesser side, 100 percent of the cases with narrowing of canal and 85.7% of those with diverted canals were insignificant association with canal contact and absence of IAC cortication on the CBCT. This was in conflict with the study according to Sinha and Pai [14] where diversion and narrowing of the canal were said to show no loss of corticalization on the CBCT.

The current study results enabled us to narrow down the predictor factors to those significantly correlated to a high risk of intra-operative nerve injury. In scenarios of high-risk predictor signs, it is advisable to opt for a three-dimensional radiographic modality. According to the statistics obtained and based on the most frequent Rood and Shehab canal criteria, we have come to an opinion that the interruption of the radiopaque wall of the inferior alveolar canal on the IOPAR could be the most reasonable cause further to advise a higher diagnostic modality such as Cone – Beam Computed Tomography before the surgical removal of an impacted lower wisdom tooth. Elkhateeb et al.,[9] reported that interruption of the white line was statistically in correlation with direct contact of the IMM3 to the inferior alveolar canal on the CBCT. This was consistent with the present study's findings, which calls attention to regard interruption of IAC white line and other canal predictor markers as signs of escalated risk. The IOPAR Roods canal criteria can be used as confirmatory markers of IAN damage in remote areas and developing countries where the availability of CBCT is sparse.

The type of impaction (Winter's classification) observed on the IOPAR was the other parameter correlated to the tomographic variables, namely presence or absence of contact of the IMM3 root to the IAC and the cortical integrity. Mesioangular impacted mandibular molars were mainly in contact with the IAC and were nearly significant (p=0.059); hence can be considered a risk factor for possible nerve damage. Distoangular impacted teeth can be considered as the most negligible threat to further neural complications. This study was in accordance with studies conducted by Wofford DT et al.,[16] and Miloro M et. al,[17] where they found out that mesioangular impacted molars have a closer association with the canal, indicating escalated risk of nerve injury. The reason being mandibular third molars have a mesial path of eruption. During this process, the tooth crosses the IAC. It thus has a higher possibility to come in contact with the IAC in a scenario where the eruption potential of the lower third molar arrests.[18]

5. Conclusion

The present study has given a good insight to the dental surgeons who need to decide whether cone-beam computed tomography is required in addition to pre-operative intraoral periapical radiograph. Dentists working in geographic regions with less availability of advanced radiographic modalities can also benefit from the criteria visible on the periapical radiograph. The present study arrived upon radiographs with various combinations of Roods criteria. Including combinations could help evolve a modification of Roods and Shehab criteria with the support of further studies. The present study showed that IOPAR canal predictor signs could be considered reliable predictors for inferior alveolar nerve injury during removal of the impacted mandibular third molar.

6. Source of Funding

None.

7. Conflict of Interest

The authors declare no conflict of interest.

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