Role of Panoramic Imaging and Cone Beam CT for Assessment of Inferior Alveolar Nerve Exposure and Subsequent Paresthesia Following Removal of Impacted Mandibular Third Molar

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Abstract

Objectives Pre-operative radiographic evaluation of impacted mandibular third molar and inferior alveolar canal (IAC) is important in preventing a possible nerve exposure and damage during surgical removal. The present study analysed the relation of the mandibular third molar with inferior alveolar canal using panoramic radiography (PAN) and cone beam CT (CBCT) and evaluated the radiographic features suggestive of IAN exposure and post-operative paresthesia.

Materials and Methods PAN and CBCT findings of 53 impacted mandibular third molars having a close relation with IAC undergoing extraction were analysed. Further, all cases were evaluated for any sensory loss in relation to IAN 1 week post-operatively.

Results The most common PAN feature was combination of darkening of roots (DR) and interruption of white line (IWL), seen in 35.86% (19) cases. The most common CBCT feature was thinning of lingual cortex in 81.14% (43) cases. The most common location of IAC in CBCT was inferior in 47.16% (25) cases, followed by buccal 26.41% (14). On comparison of PAN and CBCT findings, DR and IWL both exclusively 92.86% (13); 80% (12) cases and in combination 75% (15) were most commonly

associated with thinning of lingual cortex. IAN exposure was seen in 7.55% (4) cases, and 3.77% (2) cases reported with paresthesia. Absence of corticalisation and IWL was associated with all cases of nerve exposure, inter-radicular location of IAC seen in three out of the four cases. Cases with paresthesia had DR and deflection of roots (DEFR) with thinning of lingual cortex by roots.

Conclusion DR with DEFR or IWL in PAN as combination and inter-radicular location of IAC with thinning of lingual cortex by root tips in CBCT are highly predictive of nerve exposure and subsequent paresthesia.

Keywords Cone beam computed tomography · Panoramic radiography · Impacted mandibular third molars · IAN exposure · IAN paresthesia

Introduction

The biggest challenge in management of impacted mandibular third molar is to provide the patient with a complication-free recovery. Pre-operative careful radiological evaluation helps to predict and avoid the possible post-operative complications, especially paresthesia.

IAN injury depends on relationship between the third molar root and IAC and manual dexterity of surgeon [1, 2]. Intimate relationship leading to direct exposure of an intact IAN bundle carries 20% risk of subsequent paresthesia [3] and hence deserves considerable importance in assisting surgical planning and informed consent [2, 4].

PAN evaluations provide only a two-dimensional view of complex three-dimensional structure with limitations such as magnification, distortion, superimposition and misrepresentation of structures. CBCT has an edge in

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depicting this spatial relationship with significantly lower effective radiation dose [5].

This study was aimed to evaluate this relationship by comparing PAN and CBCT findings, with an objective to predict findings associated with nerve exposure and subsequent paresthesia.

Materials and Methods

Sixty cases visiting oral medicine and radiology department having a *close relationship* between impacted mandibular third molar and IAC in PAN were advised for CBCT evaluation. 88.33% (53) cases were included in the study, who underwent CBCT evaluation prior to surgical extraction. The approval of the Ethical Board of the Institutional Ethics Committee was obtained prior to conducting this study.

Informed consent was obtained from all the cases. Pregnant and lactating women, cases below 18 years of age and cases with sensory disturbance in the lip and chin region on the side of impacted mandibular third molar, were excluded. Further, those with pathologies associated with mandibular third molars such as cysts, tumours were excluded from the study.

The panoramic radiographs were obtained with Kodak 8000 C system operating at 75–80 kVp for 13.9 s at 12 mA. The relation between the mandibular third molar root apex and IAC was assessed on panoramic images using *Rood and Shehab criteria* [6]:

1. Darkening of roots (DR): an increased radiolucency due to impingement of canal on molar roots (Fig. 1);
2. Divergence of the mandibular canal (DMC): upward displacement of mandibular canal as it crosses mandibular third molar;
3. Narrowing of the IAC: reduction in diameter of canal as molar roots pass partially or completely around it;
4. Interruption of white line (IWL): deep grooving or thinning of molar roots;
5. Narrowing of the root (NR): deep grooving or perforation of molar root where canal crosses it;
6. Deflection of the root (DEFR): abrupt deviation of molar roots to buccal or lingual or both sides of mandibular canal or around it (Fig. 1);
7. Dark and bifid root apex (DBRA): a double shadow of periodontal membrane where canal crosses apex.

CBCT images were obtained using ORTHOPHOS XG 3D imaging system. The images were obtained by the same operator with the following exposure parameters kVp of 60–90, mA of 9–12 with a voxel size of 100 μ m. The field of view was set at 50 $\times$ 55 mm. A single 360 degree scan was used to obtain projection data (raw data) for image reconstruction.

A modified version of the criteria suggested by Ohman et al. (2006) [7] was used in the present study for evaluating the relationship between the root apex of mandibular third molar and IAC on CBCT images which is as follows:

1. Presence or absence of corticalisation of the IAC: absence of corticalisation is defined as loss of cortical lining between the tooth root and IAC;
2. Location of the IAC with regard to the roots of the third molar: in the present study the location of the

Fig. 1 Panoramic image shows darkening of roots (yellow arrow) and deflection of roots (blue arrow)

Fig. 2 CBCT image shows inter-radicular location of IAC (blue arrow) and thinning of lingual cortical plate (yellow arrow)

IAC was categorised into four types: lingual (L), buccal (B), inter-radicular (IR) (Fig. 2), inferior (I);

3. Narrowing of the IAC: present/absent;
4. Grooving of the IAC: present/absent;
5. Thinning of cortical plates (buccal, lingual): present/absent, because of root or because of canal.

All the radiographic features except NMC were evaluated on the coronal sections; NMC was evaluated on the sagittal section. The criterion used by Ohman et al. [7] that is contact/no contact of the roots with IAC was not assessed in the present study.

The CBCT and panoramic radiographic features were analysed by two observers. The first observer evaluated the features twice with an interval of 1 week. During the radiographic observations, the observers were blinded and a separate record number was assigned randomly to the cases.

The third molars were surgically removed under local anaesthesia by certified oral-maxillofacial surgeons according to standard atraumatic operating procedures as defined by the department protocol. The exposure of the IAN was noted by direct inspection of the extraction site (Fig. 3). Any grooving of the extracted tooth root was also noted.

Post-operative symptoms namely paresthesia and dysesthesia were evaluated for all cases after 1 week by *pin-prick method* of nerve testing [8]. Testing was performed over a 1-cm area on the labiomental fold on the side of the surgical extraction. The contralateral side of the labiomental fold was taken as control site. Any abnormality noted in the sensation was recorded. Inter-observer and intra-observer variability was assessed using Kappa statistics. It was found that there was an excellent

agreement in all observations; the Kappa values were also significant ($p < 0.05$).

Results

The distribution of the PAN and CBCT findings is summarised in Tables 1 and 2. The most common finding in PAN was a combination of DR and IWL, seen in 35.86% (19) cases followed by DR in 22.64% (12) and exclusive IWL in 18.86% (10). In CBCT images 81.14% (43) cases (maximum) presented with thinning and/or perforation of *lingual* cortical plate, 50.9% (27) with absence of corticalisation of IAC. IAC was inferiorly located in most of the cases 47.16% (25).

Among the CBCT findings, the location of IAC was correlated with the presence or AOC of IAC. In cases with AOC, 29.62% (8) presented with inferiorly located IAC followed by lingual location in 25.92% (7) and *inter-radicular location in 100% (7) cases*. Another significant finding was *thinning of lingual cortical plate*, most commonly associated with *inferiorly* and *inter-radicularly* located canals (Table 3).

In comparison of different PAN features with CBCT, the AOC was most commonly associated with *DR and IWL*, seen in 70% (14) cases (Table 4). 92.86% (13) cases with exclusive DR were associated with thinning of cortical plate (Table 5). It was found that in cases with DR and IWL, the *most common location* of canal was *inferior* in 40% (8) cases. When *DR* was seen exclusively, the most common location was *buccal* and with exclusive *IWL*, *inferior* (Table 6).

Nerve exposure accounted for 7.55% (4) cases, 3.77% (2) of them reported with *paresthesia* 1 week post-operatively. DR was found as a common PAN finding in 75% (3) of these cases, along with DEFR in both the paresthesia cases and along with IWL in both exclusive nerve exposure cases (Tables 7, 8).

The corresponding CBCT findings of the above four cases were noted. AOC was noted in all, inter-radicular location of IAC found in 75% (3) of these cases. The lingual cortical plate was found to be thinned by roots in both the paresthesia cases. Thinning of lingual cortex due to IAC was noted in both the exclusive nerve exposure cases. Other findings are mentioned in Table 8.

Discussion

In the past, there have been many studies evaluating the panoramic features and/or CBCT features in relation to impacted mandibular third molar and IAC, but very few studies have actually compared all the features in PAN

Fig. 3 Clinical picture depicting IAN exposure during surgical removal of 48 (yellow arrow)

Table 1 Distribution of study subjects based on panoramic features

Panoramic feature	No of samples	%
DR (darkening of roots)	12	22.64
DBRA (dark and bifid root apex)	2	3.77
IWL (interruption of white line)	10	18.86
DMC (diversion of mandibular canal)	1	1.88
IWL and NMC (interruption and narrowing of mandibular canal)	3	5.66
DR and IWL (darkening of roots and interruption of white line)	19	35.86
DR and IWL and DBRA (darkening of roots and interruption of white line and dark and bifid root apex)	1	1.88
IWL and DMC (interruption of white line and diversion of mandibular canal)	1	1.88
DR and DEFR and NMC (darkening of roots deflection of roots and narrowing of mandibular canal)	1	1.88
DEFR and IWL and NMC (deflection of roots and interruption of white line and narrowing of mandibular canal)	1	1.88
DEFR and NMC (deflection of roots and narrowing of mandibular canal)	1	1.88
DR and DEFR (darkening of roots and deflection of roots)	1	1.88
Total	53	100

Table 2 Distribution of study subjects based on CBCT features

CBCT features	No of samples	%
Presence of corticalisation	26	49.06
Absence of corticalisation	27	50.94
Narrowing of canal present	1	1.89
Grooving of roots present	1	1.89
Thinning of lingual cortical plates	43	81.13

Table 3 Comparison of position of inferior alveolar canal with complete cortical plate and thinning of cortical plate in CBCT

Position of canal	Complete Cortical plate		Thinned Cortical plate		Total
	N	%	N	%	
L	3	42.8	4	57.14	7
I	5	20	20	80	25
IR	0	0	7	100	7
B	2	14.28	12	85.71	14

L lingual, I inferior, B buccal, IR inter-radicular

Table 4 Comparison of panoramic (PAN) features with presence or absence of corticalisation of inferior alveolar canal (IAC) in CBCT

PAN features	Presence of corticalisation		Absence of corticalisation	
	N	%	N	%
DR	8	57.14	6	42.86
IWL	10	66.66	5	33.33
DR and IWL	6	30	14	70
Others	2	50	2	50

DR darkening of roots, IWL interruption of white line

with CBCT in addition to considering the incidence of post-operative paresthesia.

IAN exposure and paresthesia has been reported commonly in cases undergoing removal of impacted mandibular third molars. The *incidence of nerve exposure* has been reported to be in the range of 5.7–43% [9, 10], *temporary paresthesia* reported from 0.26 to 20.3% [2, 9–11] and permanent paresthesia being less than 1% [2, 9, 12, 13]. In this study, the incidence of IAN exposure (7.55%) and paresthesia (3.77%) was found to be in the lower end of the range reported in the literature. This difference in the present study is probably due to a lesser number of older individuals as compared to studies in the literature. It has been suggested that surgical removal of teeth is more cumbersome in older individuals secondary to sclerosis of bone [14]. The degree of nerve exposure or damage also depends on the skill and experience of the operating surgeon [8, 14].

PAN is commonly used to evaluate type of impaction, the root morphology and angulation. However, the spatial relationship between the IAC and the impacted third molar cannot be assessed. In a study by Rood and Shehab, it has been suggested that DR and IWL can predict IAN exposure and paresthesia [6]. In the present study, similar results were found, DR being the most common 22.64% (12) while IWL being the second most common 18.86% (10) PAN feature. This is in accordance with previous studies [6, 12].

DR may be caused either by grooving of the root by the IAC or thinning of the cortical plates or superimposition of buccally placed IAC [4, 5, 10]. In the present study, DR was significantly associated with thinning of the cortical plates, three with buccally located IAC and only one case

Table 5 Comparison of panoramic features with complete cortex and thinning of cortical plate in CBCT

	Complete cortex		Thinning of cortex		Total
	<i>N</i>	%	<i>N</i>	%	
<i>PAN</i>					
Darkening					
Interruption	5	25	15	75	20
No interruption	1	7.14	13	92.86	14
No darkening					
Interruption	3	20	12	80	15
No interruption	1	25	3	75	4

was associated with grooving. Hence, it may be concluded that the cause of DR in the present study was due to thinning of cortical plates. This is in accordance with the literature [4, 15, 16]. Also the risk of nerve injury increases with presence of more than one radiographic sign in PAN which is in agreement to the present study [7, 17].

The results of the present study suggest that *DR and IWL either individually or in combination* are more predictive of thinning of cortical plates rather than absence of corticalisation of IAC alone. The probability of tooth contact with IAC increases in the presence of DR [4, 16, 18]. AOC of IAC and thinning of cortical plates of IAC suggest a direct contact between the IAC and third molar. This proximity of the root with the IAC increases the chances of nerve exposure [4]. Thinning of cortical plates in the present study was mostly observed on the lingual side which can occur either due to the proximity of roots of third molar or proximity of IAC or both. In the present study, cortical thinning was caused by the root proximity 60.38% (32) which is in line to a previous study [4].

CBCT has gained popularity for imaging osseous structures in the maxillofacial region in a short span of time and has distinct advantages over CT such as higher spatial resolution, especially in the longitudinal direction, lower dosage and cost. CBCT units are also technically easy to operate, and the reconstruction software employed is more

Table 7 Distribution of subjects with sensory disturbances with inferior alveolar nerve exposure

Sensory disturbance	No. of samples	% of samples
Paresthesia	2	3.77
No sensory disturbance	2	3.77
Total	4	7.55

user friendly than CT units. Furthermore, CBCT units can be accommodated in dental office settings in contrast to the hospital requirements of a CT machine.

Another major advantage of CBCT is that it provides three-dimensional images with the possibility of basic enhancements, addition of annotations and cursor-driven measurement algorithms which provides interactive capability for real-time-dimensional assessment [19]. The CBCT findings such as the location of IAC assist the surgeon to discern the safe regions and the danger zones [15] to gauge the direction of luxation. In this study, IAC was located *inferiorly* in most of the cases followed by buccal and inter-radicular.

The majority of cases with inter-radicular location of IAC suffered nerve exposure and paresthesia. It was also observed that lingual cortical plate thinning was more frequent in buccally located canals than in lingually located canals [15] due to the completion of IAC well before the completion of the root apex of third molars which get deflected in a lingual direction owing to the lack of space [20] resulting in thinning. In the present study, only one out of the four cases of nerve exposure reported with buccally located canal. One more description which seeks attention in PAN findings is DEFR in the presence of DR. In the present study, DEFR was present in cases with IAN exposure and paresthesia. DEFR suggests abrupt deviation of molar roots to buccal or lingual or both sides of mandibular canal or around it (inter-radicular), which was seen as a common finding in cases with nerve exposure and consequent paresthesia in this study. Similar finding was reported in a previous study [21]. These findings suggest that post-operative paresthesia can be predicted in cases

Table 6 Comparison of panoramic features with position of inferior alveolar canal

	L		B		IR		I		Total (N)
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	
<i>PAN</i>									
Darkening									
Interruption	3	15	6	30	3	15	8	40	20
No interruption	0	–	6	42.85	3	21.42	5	35.71	14
No darkening									
Interruption	4	26.66	1	6.66	1	6.66	9	60	15
No interruption	0	–	1	25	0	–	3	75	4

Table 8 CBCT features of subjects with nerve exposure

Case	PAN feature	Presence/absence of corticalisation of mandibular canal	Position of canal	Grooving of roots	Thinning due to roots	Thinning due to canal
Case 1 paresthesia	DR and DEFR and NMC	A	IR	P	TL	A
Case 2 paresthesia	DR and DEFR	A	B	A	TL	A
Case 3 nerve exposure	DR and IWL	A	IR	A	A	TL
Case 4 nerve exposure	IWL and DMC	A	IR	A	A	TL

IR inter-radicular, B buccal, A absent, P present, TL thinning of lingual cortical plate

with DR and DEFR in PAN. The results of the present study revealed that not one single PAN finding rather presence of *more than one findings* needs consideration of further assessment of IAC. CBCT should be advised when PAN reveals DR, DEFR or IWL.

It can be concluded that cases with above findings should be subjected to CBCT for evaluating the three-dimensional relationship between the IAC location and proximity of root tips as CBCT is more useful than PAN in predicting paresthesia. We also conclude that IAN exposure is more frequent when the location of canal is inter-radicular and a very careful surgical approach is recommended for this subgroup.

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