The Correlation Between Inferior Alveolar Nerve Canal and Mandibular Third Molar Assessed by Panoramic Radiography and Cone-Beam Computed Tomography

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Abstract

1) *Background:* When performing mandibular third molar (M3M) surgical removal, there was a possible risk of nerve injury. The main reason for the complications was the proximity between the inferior alveolar nerve (IAN) and the root of the M3M. Therefore, this research recognized the importance of the pre-operative procedure of assessing the relationship between the nerve and the M3M before the operation. 2) *Objective:* This study aimed to determine the relationship between angulation, class, and position of M3M and the nerve proximity, and study the position and distances between M3M and the inferior alveolar nerve canal (IANC). 3) *Materials and methods:* The panoramic and CBCT images of 41 patients with 61 M3M from the database of the College of Dental Medicine, Rangsit University were examined in this study. Panoramic images were assessed using Planmeca Romexis® dental imaging software to measure angulation, class, position, and nerve proximity. The samples with nerve proximity were then further evaluated by CBCT images to observe nerve position and measure nerve distance. The results were analyzed for relationship level using binary logistic regression analysis. 4) *Result:* The horizontal impaction was most likely to have nerve proximity. This result was not statistically significant (p >0.05). While nerve proximity was observed in vertical/distoangular impaction 0.1282 times lesser than mesioangulation and this result was statistically significant (p=0.018). Class II and Position B impaction were most likely to have nerve proximity. These results were not statistically significant (p>0.05). The lingual position of IANC was 100% nerve contact in nerve proximity cases. In the nerve proximity cases, the distance between the root and IANC ranged from 0 to 2.53 mm. 5) *Conclusions:* Vertical/distoangular impaction had the least chance of IAN proximity compared to other variables, while the horizontal impaction had the most chance of proximity. The nerve contact is most frequently observed in the lingual position.

Keywords: *Cone-beam computed tomography, Mandibular third molar, Inferior alveolar nerve*

1. Introduction

Nerve injury was the possible risk that may occur while performing surgical removal of M3M operation. The majority of complications involved transient sensory disturbance and permanent paraesthesia, hypoaesthesia, or even dysaesthesia (Loescher et al., 2003). The main reason for these complications was associated with the M3M's root contacting the nerve. A study of paresthesia's prevalence when the M3M's root contacted the IANC was 21 times greater than that of cases without contact (Kim & Lee, 2014).

Before surgical removal of the M3M, the planning had to be done by investigating the proximity between the IANC and the M3M to reduce the risk of IAN damage (Sedaghatfar et al., 2005). The incidence of IAN damage was a common complication (Rood & Shehab, 1990) that continued to be reported (Hillerup, 2007). To inspect the primary issue to specifically localize and perceive the tooth and IAN demographic information, the radiographic images such as periapical or panoramic radiographs were considerable tools (Mohanty et al., 2019). Although a panoramic radiograph was widely used, it could only represent two dimensions by showing radiographic signs of IANC wall interruption, such as the darkening of the roots. Hence, the panoramic radiograph might not be enough to tell the M3M and the IAN's accurate buccolingual relationship (Suomalainen et al., 2010). CBCT was, however, the recommended radiographic method that was used to image the M3M position in the three-dimensional image and provided more accurate details on the angulation of the tooth, position, and relationship of the nerve (Serrant et al., 2014).

Therefore, this research recognized the importance of the pre-operative procedure of assessing the M3M before removal to reduce the chances of nerve injuries by using panoramic and CBCT images.

2. Objectives

1) To study the relationship between angulation of M3M and nerve proximity
2) To study the relationship between the class and position of M3M and nerve proximity
3) To study the position of IANC and the distance between IANC to the M3M in nerve proximity cases

3. Materials and Methods

3.1 Population and sample size

The samples consisted of 41 panoramic and CBCT images and 61 teeth.

A minimum of 10 outcome events per predictor variable (EPV) was used in our study (Vittinghoff & McCulloch, 2007). The predictor variable in this study was the number of angulations based on Winter's classification which is 4 independent variables. In statistics, the degree of freedom indicates the number of independent values that can vary in an analysis without breaking any constraints. To determine the degree of freedom, we need to subtract one from an independent variable. So the degree of freedom of 3 was used in this study. Therefore, the event of nerve contact was equal to 3 times 10, which was 30.

Our study outcome was binary and 50% of the impacted M3M's root closed to the IANC in our pilot study. The sample size was 30 times 2 so 60 samples were needed in our study. As a sample size guideline, Peduzzi's study shows the minimum sample size in each model (Peduzzi et al.,1996).

3.2. Inclusion and Exclusion criteria

The inclusion and exclusion basis criteria would be referred to as the panoramic and CBCT.

Inclusion criteria

1) Presence of unilateral or bilateral M3M with complete root formation in both the panoramic and CBCT.
2) Presence of normal alignment mandibular second molar (M2M) on the same side as the M3M.

Exclusion criteria

1) Unclear images that affect the radiographic interpretation.
2) Presence of pathologic conditions in the third molar region and abnormality of the mandible, such as a periapical cyst, or a dentigerous cyst.
3) Presence of severe loss of tooth structure of M2M such as extensive caries.

3.3 Methods

The retrospective study was approved by the Ethics committee of Rangsit University. All radiographs were collected from the oral and maxillofacial radiology clinic, the college of dental medicine, Rangsit University from November 2008 until January 2022. Panoramic images were taken from Planmeca ProMax and X-MIND trium. CBCT images were performed using an i-CAT tomography scanner (Imaging Sciences International Inc., USA) by launching with the 120 kV. and 3-8 mA. The 17-19 i-CAT will be set with 0.25 mm. voxel size resolution and 23.2 cm. x 17 cm. FOV. The Romexis and CS3D imaging program was used in this study (Carestream Dental LLC., Atlanta, USA).

On a panoramic radiograph, the angle between the long axis of M3M and M2M were measured and then categorized into 4 categories: distoangular impaction (-79° to -10°), vertical impaction (-10° to 10°), mesioangular (11° to 79°) and horizontal impaction (80° to 100°) (Winter, 1926).

The class and position were categorized based on Pell and Gregory's classification (Pell & Gregory,1933). This classification was based on the sufficient space available between the anterior border of the mandibular ramus and the distal aspect of M2M. When the space was more than the mesiodistal width of M3M, M3M was classified into class I. When the space was lesser than the mesiodistal diameter of the M3M, M3M was classified into class II. When the M3M was totally embedded in the ramus of the mandible, M3M was classified into class III. The vertical relationship between M3M and M2M was

described as the position. Position A: the highest portion of the impacted M3M was at the same level or above the M2M's occlusal plane. Position B: the highest portion of the impacted M3M was between the occlusal plane and the M2M's cervical margin. Position C: the highest portion of the impacted M3M was below the cervical margin of the M2M.

The nerve proximity to the M3M was determined in panoramic films. When the seven signs of risk to injury of the IAN (Palma-Carrio et al., 2010) or the impinging root structure on the superior border of the IANC were detected, they were considered nerve proximity. The seven signs consisted of 1) Darkening of the root: loss of root density in a tooth impinged upon by the canal, 2) Interruption of the white line: the discontinuity of the superior radio-opaque line constituted the superior border of the IANC, 3) Diversion of the canal: a change in the canal's direction while crossing the M3M, 4) Deflection of the root: an abrupt deviation of roots near the canal, 5) Narrowing of the root: narrowing of the tooth roots where the canal crossed, 6) Narrowing of the canal: an abrupt decrease in the canal's width while it crossed the root apices, and 7) Dark and bifid root apex: a loss of root density in a tooth impinged upon by the canal with the root's bifid apex.

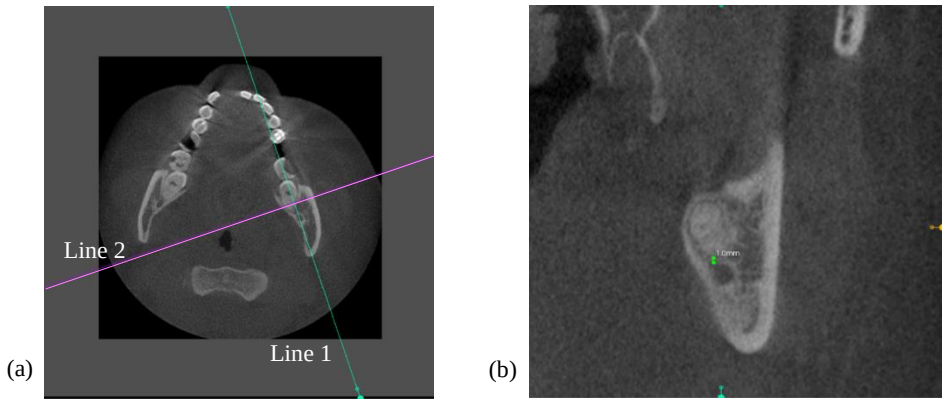

Figure 1 The CBCT images represent (a) axial view showed line 1 crossing the middle of the mandibular in the posteroanterior plane and line 2 crossing the middle of mandibular third molar in the buccolingual plane (b) cross-section slice plane showed the cortical of inferior alveolar nerve canal and the distance between nerve and mandibular third molar

3.4 Inter and intra-observer reliability

The samples with nerve proximity were then further evaluated by CBCT images. An axial view was used to indicate the position of the cross-section slice plane cut through the nerve canal. The cross-section slice plane cut was then used to study the nerve position and distance (Figure 1). The nerve position was categorized into 3 positions: lingual, inferior, and buccal. The nerve distance was measured when the root of M3M and IANC was the nearest, nerve distance of 0 mm would be considered as nerve contact.

The 10 samples were used to determine inter-observer and 10 samples intra-observer reliability. For inter-observer reliability, the same image was provided to the dental student and 19 years of experience in oral and maxillofacial surgery. This assessment was done separately. They were asked to classify angulation, class, and position of the M3M. The nerve proximity, position, and contact were evaluated. Also, the measurement of the distance between the M3M and IANC was performed. The angulation, class and position, nerve proximity, position, and contact were analyzed for inter-observer reliability by Cohen's Kappa statistic. The distance between the M3M and IANC was analyzed for inter-observer reliability by the intraclass correlation coefficient (ICC). For the intra-observer reliability evaluation, all the parameters were evaluated by the same observer on two occasions and one week apart.

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3.5 Data analysis

Data were analyzed by using binary logistic regression by utilizing the Statistical Package for the Social Sciences (SPSS-20.0) software package (IBM, Chicago, USA), which was applied to evaluate the correlation level between angulation, class, and position of the M3M, and nerve proximity. Results with $p < 0.05$ were considered statistically significant. Descriptive statistics described the position and distance between the IANC and the root surface of the M3M.

4. Result

The inter-observer reliability and intra-observer reliability were shown in Tables 1 and 2, respectively. All kappa values were greater than 0.8, which implied almost perfect agreement in all sectors. The ICC values were 0.9999 for inter-observer reliability and 0.9941 for intra-observer reliability. These values represented almost perfect agreement.

Table 1 Inter-observer reliability

	Kappa	**P value**
Panoramic		
Angulation	0.8333	0.0002*
Class	0.8553	0.0000*
Position	1.0000	0.0000*
Nerve proximity	1.0000	0.0005*
CBCT		
Nerve position	0.8077	0.0002*
Nerve contact	1.0000	0.0008*

*Shows statistical significance ($p < 0.05$)

Table 2 Intra-observer reliability

	Kappa	**P value**
Panoramic		
Angulation	0.8305	0.0000*
Class	0.8246	0.0000*
Position	0.9237	0.0000*
Nerve proximity	0.8571	0.0001*
CBCT		
Nerve position	0.8326	0.0000*
Nerve contact	1.0000	0.0000*

*Shows statistical significance ($p < 0.05$)

Among a total of 61 impacted teeth, 45 (73.8%) were considered as nerve proximity. The relationship between angulation, class, and position of M3M and nerve proximity is shown in Table 3. Out of the 31 samples in mesioangulation, 26 (83.9%) showed nerve proximity. Nerve proximity was observed in all samples of class III and position C.

Table 3 The relationship between angulation, class, and position of M3M and nerve proximity

	Nerve proximity		Total
	Yes n (%)	No n (%)	
Angulation			
Mesioangulation	26 (83.9%)	5 (16.1%)	31 (100%)
Vertical/distoangulation	6 (40.0%)	9 (60.0%)	15 (100%)
Horizontal angulation	13 (86.7%)	2 (13.3%)	15 (100%)
Class			
I	6 (46.2%)	7 (53.8%)	13 (100%)
II	35 (79.5%)	9 (20.5%)	44 (100%)
III	4 (100%)	0 (0%)	4 (100%)
Position			
A	8 (50.0%)	8 (50.0%)	16 (100%)
B	21 (72.4%)	8 (27.6%)	29 (100%)
C	16 (100%)	0 (0%)	16 (100%)

Table 4 showed the association of nerve proximity in different angulations by using bivariable logistic regression, the mesioangulation was used as a reference value. Vertical/distoangulation had a protective chance of nerve contact event (adjusted OR = 0.128, 95% CI = 0.031-0.524, reference mesioangulation). The result was statistically significant.

Class II had the highest odds of nerve proximity (adjusted OR = 4.53, 95% CI = 1.219-16.87, reference Class I). The result was statistically significant. Position B had the highest odds of nerve proximity (adjust OR = 2.65, 95% CI = 0.734-9.386, reference position A) but the result was not statistically significant. The odds ratio of class III and position C were not available.

Table 4 Logistic regression bivariate nerve proximity

	Odd ratio	P-value	95% conf. interval
Angulation			
Mesioangulation (Reference)	1ǂ		
Vertical/Distoangulation	0.1282	0.004*	0.0315 - 0.5242
Horizontal angulation	1.25	0.805	0.2130 - 7.3373
Class			
I (Reference)	1ǂ		
II	4.537	0.024*	1.2200 - 16.8761
III	N/A	N/A	N/A
Position			
A (Reference)	1ǂ		
B	2.625	0.138	0.7341 - 9.3861
C	N/A	N/A	N/A

*Shows statistical significance ($p < 0.05$)
ǂ Reference category
N/A: not available

Table 5 illustrated the multivariable logistic regression of the different variables result from the analysis, compared with other independent variables class and position, Vertical/distoangulation had the lowest odds of nerve proximity (adjust OR = 0.121, 95% CI 0.02 - 0.701)

Table 5 Logistic regression multivariable nerve proximity

	Odd ratios	P-value	95% conf. interval
Angulation			
Mesioangulation (reference)	1ǂ		
Vertical/distoangulation	0.1211	0.018*	0.0209 - 0.7013
Horizontal angulation	0.4014	0.396	0.0487 - 3.3039
Class			
I (reference)	1ǂ		
II	3.2573	0.201	0.5332 - 19.8972
III	N/A	N/A	N/A
Position			
A (reference)	1ǂ		
B	2.7653	0.222	0.5397 - 14.1690
C	N/A	N/A	N/A

*Shows statistical significance ($p < 0.05$)
ǂ Reference category
N/A: not available

All samples of nerve proximity were evaluated using CBCT for nerve contact, nerve position, and distance from root apices to IANC (Table 6). Nerve contacts were observed in 40 from 45 samples. Three nerve position categories were established: buccal, lingual, and inferior and each category had an equal number of 15 samples. The distance between the root and IANC ranged from 0-2.53 mm. The lingual position was found to have the most nerve contact of 100% with a mean distance of 0 mm. The incidence of nerve contacts in the inferior position was 93.99% with a mean distance of 0.168 mm (SD = 0.653). The buccal position had the least events of nerve contact of 73.30% with a mean distance of 0.298 mm. (SD = 0.645).

Table 6 Nerve contact, nerve position, and distance from root apices to IANC in CBCT

	Not contact	Contact	Total	Distance		
	n (%)	n (%)	n (%)	Range (mm.)	Mean	SD
Position of IANC						
Buccal	4 (26.7%)	11 (73.3%)	15 (100%)	0.57-2.37	1.117	0.851
Inferior	1 (6.7%)	14 (93.3%)	15 (100%)	N/A	N/A	N/A
Lingual	0 (0%)	15 (100%)	15 (100%)	0	0	0
Total	5	40	45			

SD: Standard deviation
N/A: Not available

5. Discussion

During surgical removal of the impacted tooth, there was a possible risk of IAN injury. Therefore, in preoperative evaluation, the assessment of IANC position from radiographic images was requested for determining the proper surgical removal plan. The nerve proximity which possibly caused postoperative complications can be screened from panoramic radiographs (Sarikov & Juodzbalys, 2014). A panoramic radiograph was the first-line radiographic investigation for determining general information of M3M, however, it distorted and was limited to a two-dimensional view of the dental x-ray. On the other hand, CBCT played an important role in providing an accurate and three-dimensional image of M3M, nerve position, and nerve contact.

In this study's population, mesioangulation impaction was found to be the most common angulation at 50.82%, followed by 24.59% of vertical/distoangulation and 24.59% of horizontal angulation. Elkhateeb's study as well found that mesioangulation impactions were 77% of the total of 210 M3M (Elkhateeb & Awad, 2018).

Relationships of each independent variable and nerve proximity were statistically analyzed by bivariable logistic regression. However, small sample sizes of distoangular impaction in this study were insufficient to calculate. Alfadil L. and Almajed E. (2020) also found that distoangular impaction was found only in 3.1% of the total population (Alfadil & Almajed, 2020). Magnitudes of all angles in distoangular samples were quite close to vertical angulation and were difficult to distinguish in clinical investigation. Therefore, they were merged into one independent variable. The results showed statistical significance of vertical/distoangulation (OR = 0.121, 95% CI 0.020 - 0.701). Vertical and distoangular impaction were less likely to have nerve injury compared with mesioangulation. While the difference between horizontal angulation and mesioangulation was not statistically significant.

In accordance with class and nerve proximity, Class II showed the highest odds ratio in this sector. In the position category, position B had the highest odds of nerve proximity but not significantly (OR = 2.625, CI 0.73 - 9.38). Our study also found that all of Class III and position C had nerve proximity. As a result, the nerve not being close was zero. When calculating the odds ratio, the results were "Not available." To improve the study, more sample sizes should be collected.

This study found that IAN position and nerve were related, the IAN in the lingual position had the highest contact percentage of 100% (15 out of 15), followed by the inferior position, 93.3% (14 out of 15), and buccal position, 73.3% (11 out of 15) respectively. This was corresponding to Bikash Chaudhary's study which also found that the lingual position had the most nerve contact of 97.3% (Chaudhary et al., 2020).

6. Conclusion

From our population, the vertical/distoangular impaction had the least chance of IAN proximity compared to other angulation, while the horizontal impaction had the most chance of nerve proximity. Class II and position B had the highest possibility of nerve proximity. The nerve contact is most frequently observed in the lingual position.

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