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Research Article

Association of Inferior Alveolar Nerve Canal Position (CBCT-Based) and Impaction Angulation with Neurosensory Deficit Risk in Mandibular Third Molar Surgery

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Abstract:
Background: The removal of impacted mandibular third molars (M3M) is a frequent oral surgical procedure, and postoperative neurosensory deficits from inferior alveolar nerve injury are one of the most important complications. CBCT can be used to accurately identify anatomical risk factors to predict nerve-related complications and help with surgical planning. **Objective:** To assess the association of inferior alveolar nerve canal position on CBCT and the angulation of the third molar and the potential for neurosensory deficits after removal of the third molar. **Methods:** This was an analytical cross-sectional study carried out on 34 patients with impacted mandibular third molars who were to be extracted surgically. The position of the IAC and the impaction angulation were evaluated in the preoperative CBCT scans. Neurosensory disturbances after surgery were assessed by clinical examination. The data was analyzed in SPSS. A p-value of 0.05 was taken as statistically significant. **Results:** Postoperative neurosensory deficit was observed in 5 (14.7%) patients. The lingual and interradicular canal positions were significantly associated with sensory deficits ($p=0.041$). Horizontal and distoangular angulations showed a higher risk of neurosensory complications than other angulations ($p=0.018$). Patients with deficits had significantly reduced canal-root distance ($p<0.001$), greater root-canal contact length ($p=0.001$), and increased depth of impaction ($p=0.02$). **Conclusion:** CBCT assessment of the position and impaction characteristics of the inferior alveolar canal offers valuable information for prediction of neurosensory deficit risk after third molar extraction.

Keywords: Cone-Beam Computed Tomography; Mandibular Third Molar; Inferior.

INTRODUCTION

The extraction of the third molars is one of the most common oral and maxillofacial surgery procedures in the world.[1] The prevalence of impacted third molars varies by region and ethnicity, and is believed to be between 2030% of the population.[2] Recurrent pericoronitis, caries, periodontal disease, cystic lesions, orthodontic considerations, and prophylactic management of future pathology are all common indications for surgical removal.[3] Third molar surgery is generally a safe procedure, but there are several complications to consider, such as pain, swelling, infection, trismus, alveolar osteitis, and neurosensory disturbances.[4] Injury to the inferior alveolar nerve (IAN) is one of the greatest threats among these, not only to the patient's quality of life but also to the medico-legal aspects.[5]

The inferior alveolar nerve traverses the mandibular canal and supplies the lower teeth, lower lip, and chin.[6] The inferior alveolar canal is in proximity to the roots of the impacted tooth during extraction of the third molar, and this may result in nerve damage.[7] The reported incidence of transient inferior alveolar nerve injury is 0.4% to 8.4%, while permanent sensory disturbances occur in 0.1% to 1% of cases.[8] Several factors are involved in the risk; such factors include the age of the patient, the difficulty of the surgery, the surgeon's experience, depth of impaction, root morphology, and the spatial relationship between the roots of the impacted tooth and the mandibular canal.[7]

An accurate evaluation of the location of the inferior alveolar canal and impacted mandibular third molars is crucial to reduce surgical complications.[9] Surgical planning conventionally has been performed using panoramic X-rays, but this method is limited by the 2-D nature of the image, which does not adequately visualize buccolingual relationships and canal positions.[10] Three-dimensional assessment of canal location in relation to the tooth roots is possible with Cone Beam

Computed Tomography (CBCT), so it has become the preferred imaging modality for high-risk cases.[11]

Although CBCT use has grown in the evaluation of third molars, there is limited and inconclusive evidence to support the combined effects of the position of the IAC and the angulation of tooth impaction on postoperative neurosensory deficits. Most studies have investigated radiographic proximity and impaction characteristics separately, and a few studies have looked at the association of these two with clinically relevant sensory outcomes. Understanding high-risk anatomical arrangements has the potential to improve patient safety and outcomes during surgeries, as well as reduce the risk of nerve-related complications, increase the precision of surgical planning, and improve preoperative counseling. The purpose of this study is to fill this knowledge gap by examining the relationship between the position of the inferior alveolar canal, impaction angulation, and risk of neurosensory deficits after mandibular third molar extraction. In the present study, the investigators sought to ascertain the relationship between the position of the inferior alveolar nerve canal on CBCT and the angulation of the third molars with the risk of neurosensory deficit after surgical extraction of the third molar.

Materials and Methods

It was an analytical cross-sectional study carried out in the Department of Oral and Maxillofacial Surgery of Bahria University's health sciences campus, Karachi. The study was carried out over a period of six months, from 1st April, 2025 to 30th September, 2025. The study aimed to investigate the relationship between the position of the inferior alveolar nerve canal on CBCT and the angulation of the third molar and the occurrence of post-operative neurosensory deficit after extraction of the mandibular third molar.

The sample size was determined using OpenEpi Software for a single population proportion. A previously reported prevalence of postoperative neurosensory deficit following impacted mandibular third molar extraction was 5.9%, with an 8% margin of error and a 95% confidence interval.[12] The sample size was determined to be 34.
The sampling technique was a non-probability consecutive sampling technique, and patients who met the inclusion criteria were recruited during the study period. The study included patients aged 18 years and older who received surgical removal of impacted mandibular third molars and had preoperative CBCT images available. Previous surgical procedures on the mandible, as well as pre-existing neurosensory disturbances, pathological conditions in the mandibular canal, mandibular trauma, and incomplete clinical and radiographic records were exclusion criteria. All subjects gave informed written consent to participate in the study. A structured proforma was used to gather the data. Data on demographic characteristics and clinical information. were collected. Preoperative CBCT images were analyzed for the spatial relationship of the inferior alveolar nerve canal and the impacted roots of mandibular third molars. The location of the mandibular canal was classified as buccal, lingual, inferior/apical, or interradicular, with respect to the tooth roots. Radiographic analysis of the angulation of the impacted third molar was determined and divided into mesioangular, distoangular, horizontal, and vertical. To detect any neurosensory deficits such as numbness, paresthesia, hypoesthesia, or changes in sensation in the lower lip and chin area, postoperative neurosensory studies were carried out.

Statistical Analysis

Data obtained were analyzed with SPSS version 25. The normality of the data was checked by the Shapiro–Wilk test for data distribution. The results of continuous variables with normal distribution were given as mean±standard deviation, whilst those of non-normally distributed continuous variables were presented as median (interquartile range). Frequencies and percentages were used for categorical variables. The Chi-square test or Fisher's exact test (when applicable) was used to evaluate the association between inferior alveolar nerve canal position, impaction angulation, and postoperative neurosensory deficit. An independent t-test or Mann– Whitney U test was used, depending on the distribution of the data, for continuous variables. If necessary, the independent predictive factors of neurosensory deficit were determined by multivariable analysis. P-values ≤ 0.05 were all deemed statistically significant.

Results

The study included 34 patients with a surgical extraction of impacted third molars in the mandible. The participants' age mean was 27.6 ± 5.4 years, with 58.8% of them between 21 and 30 years. There were more males (58.8%) than females (41.2%). It was slightly more common on the right side (52.9%) compared to the left side (47.1%). In 5 (14.7%) patients, there was a postoperative neurosensory deficit, and 29 (85.3%) did not have a neurosensory deficit. In this group of patients, numbness (60%) was the most frequent sensory symptom, followed by paresthesias (40%). (Table 1)

Table 1. Demographic, Clinical, and Surgical Characteristics of Study Participants (n=34)

Variable	Category	Frequency (n)	Percentage (%)
Age group (years)	18–20	6	17.6
	21–30	20	58.8
	31–40	8	23.6
Mean age (years)		27.6 ± 5.4	
Gender	Male	20	58.8
	Female	14	41.2
Side of impacted tooth	Right mandibular third molar	18	52.9
	Left mandibular third molar	16	47.1
Postoperative neurosensory deficit	Present	5	14.7
	Absent	29	85.3
Type of sensory disturbance (n=5)	Numbness	3	60.0
	Paresthesia	2	40.0

Table 2. CBCT-Based Radiographic Characteristics of Impacted Mandibular Third Molars (n=34)

Variable	Category	Frequency (n)	Percentage (%)
Inferior alveolar canal position	Buccal	12	35.3
	Lingual	10	29.4
	Inferior/Apical	9	26.5
	Interradicular	3	8.8
Impaction angulation	Mesioangular	16	47.1
	Vertical	8	23.5
	Horizontal	7	20.6
	Distoangular	3	8.8
Depth of impaction	Level A	14	41.2
	Level B	15	44.1
	Level C	5	14.7
Relationship with mandibular ramus	Class I	13	38.2
	Class II	17	50.0
	Class III	4	11.8

The inferior alveolar canal was located in the buccal position relative to the roots of the molars (35.3%), followed by the lingual, inferior/apical, and interradicular ositions (29.4%, 26.5%, and 8.8%, respectively). In regard to impaction angulation, mesioangular impaction occurred in the highest number of cases (47.1%), followed by vertical impaction (23.5%), horizontal (20.6%), and distoangular (8.8%). The most common finding was Class II ramus relationship (50%), and the highest incidence of impactions was Level B. (44.1%). (Table 2)

Table 3. Comparison of CBCT Findings and Clinical Characteristics According to Neurosensory Deficit Status (n=34)

Variable	Category	Present (n=5) n (%)	Absent (n=29) n (%)	p-value
Age (years)	—	31.2 ± 6.1	27.0 ± 5.1	0.09
Gender	Male	3 (15.0)	17 (85.0)	0.94
	Female	2 (14.3)	12 (85.7)	
Canal position	Buccal	1 (8.3)	11 (91.7)	0.041
	Lingual	2 (20.0)	8 (80.0)	
	Inferior/Apical	1 (11.1)	8 (88.9)	
	Interradicular	1 (33.3)	2 (66.7)	

Impaction angulation	Mesioangular	1 (6.3)	15 (93.7)	0.018
	Vertical	0 (0.0)	8 (100)	
	Horizontal	2 (28.6)	5 (71.4)	
	Distoangular	2 (66.7)	1 (33.3)	

The position of the inferior alveolar canal was significantly associated with postoperative neurosensory deficit (p=0.041) when compared with radiographic and clinical variables according to neurosensory deficit status. Patients presenting with lingual and interradicular canal positions had a higher percentage of neurosensory deficits than other canal positions. Likewise, postoperative sensory complications were significantly related to impaction angulation (p=0.018), where horizontal and distoangular impactions were more likely to have sensory complications than mesioangular and vertical. There was no significant association between age and gender with regard to the development of neurosensory deficits (p>0.05). (Table 3)

Table 4. Comparison of Radiographic Measurements between Patients with and Without Neurosensory Deficit

Variables	Neurosensory deficit		p-value
	Present (n=5) Mean ± SD	Absent (n=29) Mean ± SD	
Depth of impaction (mm)	7.8 ± 1.4	5.9 ± 1.7	0.02
Distance between canal and roots (mm)	0.4 ± 0.2	1.8 ± 0.7	<0.001
Root-canal contact length (mm)	5.6 ± 1.3	2.9 ± 1.1	0.001
Number of roots involved	2.4 ± 0.5	1.6 ± 0.6	0.01

Patients who developed neurosensory deficits had a significantly greater level of impaction (p=0.02), smaller distance between the mandibular canal and tooth root (p<0.001), longer root-canal contact (p=0.001), and more number of roots affected (p=0.01). (Table 4)

Table 5. Multivariable Logistic Regression Analysis for Predictors of Neurosensory Deficit

Predictor Variable	Odds Ratio	95% Confidence Interval	p-value
Lingual canal position	3.8	1.1–12.9	0.034
Interradicular canal position	5.6	1.2–18.4	0.021
Horizontal impaction	4.2	1.3–13.5	0.015
Distoangular impaction	6.1	1.4–20.6	0.010
Canal-root distance ≤1 mm	7.4	1.8–24.5	0.006

Several independent factors that were associated with postoperative neurosensory deficit were identified by multivariable logistic regression analysis. Interradicular canal position was associated with a 5.6-fold higher risk, and an increase in risk by 3.8-fold for lingual canal position. Distoangular and horizontal impactions were significant, with odds ratios of 6.1 and 4.2, respectively, among impaction patterns. The distance of the canal root from the tooth surface showed the highest association with neurosensory deficit, with a risk of 7.4 times. (p=0.006) for a canal-root distance ≤1 mm. (Table 5)

DISCUSSION

In the present study, the relationship between the inferior alveolar nerve canal position measured by CBCT, the angulation of the third molar, and neurosensory deficits following surgery was assessed. Postoperative neurosensory deficits were found in 14.7% of cases in this study, and the lingual occlusal position, interradicular and complex impaction patterns (horizontal and distoangular) were significantly associated with neurosensory deficits. These results highlight the need for a 3-D evaluation of the location of the IAC and impacted third molars before surgery. CBCT allows for better visualization of the position of the canal, integrity of the cortical plates, and relationship of the root canal with the canal, all of which are not possible with conventional 2D imaging, which leads to better identification of patients at higher risk of nerve injury. More recent research has also shown the importance of the use of CBCT in the prediction of inferior alveolar nerve-related complications during the surgical removal of third molars.[7, 13]

The prevalence of neurosensory deficit in our study was higher than that previously reported in some studies. Rieder et al.2023 conducted a retrospective study of 418 patients and found that 5.9% had short-term neurosensory deficits and 1.3% had permanent deficits following the extraction of the third molar from the mandible.[12] Regarding the results of our study, a significant relationship between the position of the canal and the presence of postoperative sensory disturbance was noted in our study, which agrees with the results of the study by Göçmen et al. (2023), which showed that the position of the canal (lingual) had a higher frequency of postoperative sensory disturbance (20%).[14] The higher risk of lingual positioning can be attributed to the lower thickness of the cortical bone between

The canal and the tooth roots, which make the nerve more vulnerable to direct trauma, compression, or manipulation during extraction.

Interradicular canal position had the highest risk of neurosensory deficit (5.6-fold risk on regression analysis) in the current study. The same has been noted in recent CBCT studies, which have found that intimate contact or proximity of third molar roots to the inferior alveolar nerve is a significant risk factor for IAN injury.[15] The degree of compression of the inferior alveolar canal measured on CBCT was found to be a significant contributor to the risk of postoperative nerve injury, as shown by Sklavos et al.'s 2021 work, which confirms that anatomic compression and the absence of canal-root separation are important risk factors.[16]
In the impaction angulation aspect, our study showed that horizontal and distoangular impactions were significantly correlated with postoperative neurosensory deficits. Distoangular impaction had the greatest percentage of nerve-related complications (66.7%), followed by horizontal impactions (28.6%). The current study's results are similar to previous studies, which found that deeper and more horizontal third molars are more difficult to surgically remove due to increased bone removal, increased manipulation of the roots, and increased risk of direct contact with the inferior alveolar canal.[17, 18] A study reported by Jin et al.2022 showed that the surgical difficulty, anatomical relationship, and radiographic risk factors are significant factors that affect the risk of inferior alveolar nerve injury after extraction of the third molar.[19]

Another aspect of our study that showed significant differences between patients with and without neurosensory deficits was the canal-root distance, which was 0.4mm ± 0.2mm for those with neurosensory deficits and 1.8mm ± 0.7mm for both non-deficits and controls, $p<0.001$. These results corroborate earlier studies linking a small interroot space to a high risk of nerve complications and suggest that the distance between the roots of the tooth and the mandibular canal is a key factor in determining the likelihood of such problems.[20, 21] A prospective study found radiographic parameters to be associated with inferior alveolar nerve exposure during 3rd molar surgery; loss of the bony separation between the canal and the root appeared to significantly increase the rate of nerve exposure and postoperative sensory disturbance.[22]

The majority of the impactions in our study were mesioangular (47.1%), which agrees with the results of previous studies performed with CBCT, which evaluated the anatomy of the third molars in the mandible. Evaluations that have involved canal position and impaction characteristics have reported that the mesioangular pattern is the most common, often with the canal being either lingual or inferior.[23] In our cohort, however, mesioangular impactions were the most common, but there was no strong association with neurosensory deficit, indicating perhaps that the relationship of the canal and the three-dimensional geometric relationships are more important clinical predictors than angulation alone.

The current findings are consistent with the increasing evidence that CBCT evaluation should be considered when dealing with any case of an impacted third molar in the mandible where there exists a high risk for the presence of such anatomy. A systematic review by Robbins et al.2022 compared the effect of CBCT on decreasing the incidence of IDNIs in high-risk situations for third molar surgery and noted that, while 3D imaging helps to assess the risk of IDNIs, the use of CBCT should be individualized based on clinical and radiographic findings.[24]

In general, the results of this study support evidence that the impairment of the position of the inferior alveolar canal, especially the lingual and the interradicular regions, along with the involvement of the complex angulations of impaction and the short distance between the canal and the inferior alveolar canal, are important factors that increase the risk of neurosensory complications after impacted tooth extraction. The results indicate that surgical planning, detailed interpretation of CBCT, and patient counselling before MDT extraction are important before extracting the third molar. These radiographic predictors may assist surgeons in choosing alternate surgical approaches, adjusting surgical techniques, or exploring other surgical options like coronectomy in certain high-risk cases to reduce nerve injury.

The results of this study have clinical relevance in the preoperative evaluation of an impacted third molar of the mandible and surgical treatment. The high correlation between the position of the inferior alveolar canal, the distance between the canal and root, and postoperative neurosensory deficit underscores the importance of a detailed three-dimensional radiographic assessment in high-risk situations. The identification of anatomic risk factors, including the positioning of the lingual or interradicular canal and complex impaction patterns, may enable surgeons to adjust treatment planning, provide better patient counseling, and implement NSS. The results provide evidence for selective use of CBCT for precise risk assessment, for choosing an appropriate surgical approach, and for the consideration of other surgical procedures, such as coronectomy, which in patients with a high risk of inferior alveolar nerve injury may be considered an alternative.

Study Limitations

Several limitations of this study must be taken into account when concluding the results. The limited number of participants and the study conducted at one site may restrict the applicability of the findings. The cross-sectional design of the study limited the assessment of the long-term recovery patterns of neurosensory deficits. Furthermore, although CBCT allowed for detailed evaluation of anatomical relationships, differences in surgical technique, operator experience, and individual healing responses might have affected the sensory outcomes after the surgery. Larger multicenter studies with longer follow-up periods are recommended to confirm these findings and to refine the predictive models of risk of nerve injury.

Conclusion

This study showed that evaluation of the position of the inferior alveolar nerve canal and characteristics of the impacted third molars using CBCT is important to predict neurosensory complications after oral surgery. Lingual and interradicular canal positions, canal-root proximity, and horizontally impacted and distoangular angulations were correlated with a higher risk of sensory deficits. Risk of sensory deficits was associated with anatomical variations, including lingual and interradicular canal positions, as well as canal-root proximity and complex impaction patterns such as horizontally impacted and distoangular angulations. The use of three-dimensional radiographic assessment in the preoperative planning of third molar surgery could improve risk stratification, improve surgical safety, and minimize the risk of potential nerve-related complications that may result in disability following third molar surgery.

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