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DESCRIPTION OF THE APEX MORPHOLOGY OF IMPACTED THIRD MOLARS WITH MANDIBULAR CANAL INVOLVEMENT USING PANORAMIC RADIOGRAPHY

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ABSTRACT
Background: *The use of panoramic radiography as the main diagnostic tool in Indonesia, is not equipped with adequate standard and preclinical capacity of dental students.* ***Objective:*** *To determine the shape and position of the apex of impacted third molars with mandibular canal involvement.* ***Method:*** *Cross Sectional Descriptive design. The research sample was selected through Purposive Sampling technique and obtained 287 teeth from 147 Orthopantomogram (OPG) patients. Data processing used descriptive analysis method with SPSS software.* ***Results:*** *The Interuption of the white line with the highest prevalence (n = 111, 42%), followed by dark and bifid root (n = 64, 24%), narrowing of the mandibular canal (n = 37, 14%), and diversion of the mandibular canal (n = 28, 11%). These four categories cover 91% of the total findings. Other categories, namely darkening of the root, deflection roots, and narrowing of the roots were reported with a percentage of less than 10%. Differences in prevalence of dark and bifid roots, darkening of the root, and deflection roots were influenced by patient age, genetics, and OPG identification techniques.* ***Conclusion:*** *Changes in apex morphology were seen from signs of darkening of the root, narrowing of the roots, deflection roots, and dark and bifid roots. Meanwhile, the position of the apex to the mandibular canal was indicated by the The Interuption of the white line, narrowing of the mandibular canal, and diversion of the mandibular canal.*

Keywords: Mandibular canal, Panoramic radiography, Radiological signs, Rood and Shehab classification
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INTRODUCTION

The third molar is the tooth most frequently affected by impaction, with a global case prevalence of 24%.[1] Salam *et al.* (2023) reported that the percentage of mandibular third molar impaction cases was higher than maxillary cases, accounting for 17.46% of all impaction cases.[2] Bone remodeling imbalances in the mandibular ramus region result in insufficient space for tooth eruption. This condition is influenced by mineral deficiency, lifestyle, and genetic factors.[3]

Odontectomy is a procedure to extract wisdom teeth by removing bone that prevents complete eruption.[4] However, improper extraction techniques may cause damage to the nerve canal in the mandibular region. The mandibular canal is a channel within the mandibular bone containing inferior alveolar neurovascular bundles, responsible for innervation and vascularization of mandibular teeth. This canal is protected by a cortical layer composed of minerals. If this cortical layer is perforated or damaged, inferior alveolar nerve injury becomes unavoidable, manifesting as numbness in the mandibular region (paresthesia).[5]

Jeon *et al.* (2023) reported that transient paresthesia occurred in 0.35–8.4% of cases, resolving within a maximum of 6 months. Permanent paresthesia occurred in 0.0145–3.6% of cases, defined as symptoms persisting beyond 6 months.[6] Al Khaq *et al.* (2022) reported recent paresthesia cases at one of Indonesia's leading dental universities, Universitas Padjadjaran, Bandung, identifying 4 patients (3%) out of 122 patients over a 2-year period (2017–2018).[7]

Balqis *et al.* (2025) noted that this situation stems from the absence of a national standard as a parameter for inferior alveolar nerve injury risk and the generally inadequate preclinical student capacity, yet students continue to be passed without standardized assessment criteria. Meanwhile, *Orthopantomogram* (OPG) remains the primary diagnostic tool for wisdom tooth surgery planning in Indonesia, despite its limitations as 2D imaging.[8]

Based on this background, this study aims to provide a description of the morphology and position of the apex of third molars with mandibular canal involvement, which is expected to serve as a basic guide for clinicians in assessing nerve injury risk. The Rood and Shehab classification was selected as the primary reference, as it focuses on the assessment of mandibular canal cortication and the spatial relationship pattern of the tooth apex relative to the inferior alveolar nerve as a determinant of physical nerve trauma during odontectomy.[9]

METHODS

This study is a descriptive study with a *Cross-Sectional*. This study used secondary data consisting of OPG patient data from Gusti Hasan Aman Regional General Hospital, Banjarmasin, for the period 2022–2024. The research sample comprised 287 teeth, consisting of 143 tooth 38 and 144 tooth 48 from 147 patient OPG records. Sampling was conducted using the *Purposive Sampling* method based on inclusion criteria. The primary inclusion criteria were patients aged 23–30 years with mandibular impaction. All OPG images were collected in computer files. When visual distortion was identified in OPG images, a negative effect was applied using *Adobe Photoshop* to clarify the anatomical structures between the third molar apex and the mandibular canal. Subsequently, data were identified using a *Dummy Table* to map the correspondence between tooth morphology and radiographic indicators, facilitating clinicians in assessing inferior alveolar nerve injury risk.

RESULTS

The results of the *Cohen's Kappa* coefficient test based on inter-rater reliability are presented in **Table 1.**

Table 1. Results of the *Cohen's Kappa*

	Coefficient Kappa	*P value*
Tooth 38	0.89	0.000
Tooth 48	0.98	0.000

Based on Table 1, the *Cohen's Kappa* showed no significant difference (*p value<0.005*). The kappa coefficient values for the left third molar (tooth 38) and right third molar (tooth 48) were 0.89 and 0.98, respectively. The kappa coefficient values for both teeth were categorized as almost perfect.

Of the 287 impacted teeth, classification was performed based on patient characteristics, including sex (gender) and age. Classification by demographic group aimed to identify population groups at higher risk of impaction. The gender aspect was associated with the smaller jaw dimensions of females compared to males, resulting in more limited eruption space. The age aspect was related to the stage of root development and the eruption process. Data distribution is presented in **Table 2** and **Table 3**.

Table 2. Prevalence of Impaction by Gender

Gender	**Number of Patients**	**Tooth 38**	**Tooth 48**	**Total**
Male	54	52 (18%)	56 (20%)	108 (38%)
Female	93	91 (31%)	88 (31%)	179 (62%)
Total	147	143 (49%)	144 (51%)	**287 (100%)**

Table 3. Prevalence of Impaction by Age

Age Range	**Number of Patients**	**Tooth 38**	**Tooth 48**	**Total**
23–24 years	72	68 (24%)	71 (25%)	139 (49%)
25–27 years	43	44 (15%)	41 (15%)	85 (30%)
28–30 years	32	31 (11%)	32 (11%)	63 (22%)
Total	147	143 (50%)	144 (51%)	**287 (100%)**

Based on Table 2, impaction was more frequently observed in females than in males. Meanwhile, Table 3 shows that impaction was more common in patients under 25 years of age compared to those aged 25 or older. Table 3 also reveals a declining pattern of impaction cases with increasing patient age.

The impaction status of third molars was classified into two categories: contact and non-contact. Contact refers to the condition in which the root of the impacted third molar is in contact with the mandibular canal. Non-contact refers to the condition in which the root of the impacted third molar is not in contact with the mandibular canal.[6] Data distribution is presented in **Table 4**.

Table 4. Distribution of Impaction Status by Tooth Position

Impaction Status	Number of Patients	Tooth 38	Tooth 48	Total
Contact	132	134 (47%)	130 (46%)	264 (92%)
Non-Contact	15	9 (3%)	14 (5%)	23 (8%)
Total	147	143 (50%)	144 (51%)	**287 (100%)**

Based on Table 4, contact impaction was more predominant compared to non-contact impaction. The proportion of impaction cases was nearly uniform, with contact impaction dominating in both tooth groups.

More specific identification was performed on impacted teeth at high risk of nerve injury following odontectomy. Identification was based on the Rood and Shehab impaction classification theory applied to 264 contact-status impacted teeth. Radiologically, non-contact impacted teeth have no direct relationship between the tooth root and the mandibular canal, resulting in a lower risk of nerve injury. The identification results are presented in **Table 5**.

Table 5. Prevalence of Apex Morphology with Mandibular Canal Involvement Based on Rood and Shehab Classification

Category Rood and Shehab Classification	Tooth 38	Tooth 48	Total
Darkening of the Root	6 (5%)	8 (6%)	14 (5%)
Dark and bifid root	30 (22%)	34 (26%)	64 (24%)
Narrowing of the mandibular canal	24 (18%)	13 (10%)	37 (14%)
Deflection Roots	1 (1%)	1 (1%)	2 (1%)
The Interuption of the white line	55 (41%)	56 (43%)	111 (42%)
Narrowing of the roots	7 (5%)	1 (1%)	8 (3%)
Diversion of the mandibular canal	11 (8%)	17 (13%)	28 (11%)
Total	134 (100%)	130 (100%)	**264 (100%)**

Based on Table 5, The Interuption of the white line was the most frequently encountered category with 111 cases (42%), followed by dark and bifid root with 64 cases (24%), narrowing of the mandibular canal with 37 cases (14%), and diversion of the mandibular canal with 28 cases (11%) out of 264 contact-status impacted teeth. Other categories with an occurrence percentage below 10% were Darkening of the Root with 14 cases (5%), Narrowing of the roots with 8 cases (3%), and Deflection Roots with 2 cases (1%) out of 264 contact-status impacted teeth.

DISCUSSION

This study refers to the Rood and Shehab classification because the seven radiological signs mentioned play an important role in diagnosing inferior alveolar nerve injury. This study conducted a reliability test using the *Cohen's Kappa,* aiming to assess the consistency of measurements performed by two raters using the measurement instrument (*Dummy Table*). The kappa coefficient values for tooth 38 and tooth 48 were 0.89 (89%) and 0.98 (98%), respectively, based on Table 1. The coefficient values obtained indicate very good inter-rater consistency, meaning that both raters had nearly identical perceptions in identifying the position of impacted tooth roots relative to the mandibular canal. Furthermore, the non-significant difference between the kappa coefficient values of tooth 38 and tooth 48 also indicates no meaningful difference in root position identification relative to the mandibular canal, allowing the interpretation results of both tooth groups to be combined.[10]

Hasil klasifikasi posisi akar impaksi molar ketiga terhadap kanalis mandibula berdasarkan demographic characteristics (sex and age) from Tables 2 and 3 revealed that the highest prevalence of impaction was reported in females under 25 years of age (23–24 years). The higher prevalence of impaction in females was attributed to their narrower jaw dimensions compared to males.[9] Furthermore, the prevalence of impaction cases was also reported higher in patients under 25 years of age, as wisdom teeth undergo only partial eruption and reach full eruption at a maximum age of 26 years. Therefore, impaction cases in Table 3 showed a continuous decline as age approached 30 years.[11] Additionally, Table 4 shows that contact impaction was reported as more predominant than non-contact, with 264 cases (92%) out of 287 impacted teeth. Moraru *et al.* (2021) stated that limited space in the retromolar area is the primary cause, prompting teeth to shift their growth angle toward the path of least resistance. As a result, the tooth rests against the wall of the mandibular canal.[12]

Primary Radiological Indicators

The overall classification results of mandibular impacted third molar root positions relative to the mandibular canal showed the highest prevalence for canal white line interruption, with 111 cases (42%) out of 264 contact-status impacted teeth.

These findings are consistent with Singh, Khanal, & Dhungel (2020), who reported a prevalence of 196 cases (41%) of white line interruption out of 475 tooth samples.[13] The high prevalence of white line interruption is attributed to the tendency of tooth roots to grow against the mandibular canal, whereby the continuous pressure from the tooth eruption process causes resorption of the canal wall and exposes the inferior alveolar nerve canal. Therefore, canal white line interruption is considered a primary indicator in assessing nerve injury risk.[9,14]

Singh, Khanal & Dhungel (2020) reported that Darkening of the Root ranked as the second highest prevalence category after white line interruption, with 110 cases (23%) out of 475 tooth samples. Darkening of the Root reflects the loss of the cortical canal wall, which serves as a nerve protector, rendering the nerve susceptible to compression, laceration, or avulsion during tooth extraction. Therefore, Darkening of the Root is used as a primary indicator for assessing nerve injury risk.[13] However, Table 5 reported contrary results, with Darkening of the Root being one of the lowest prevalence categories at 14 cases (5%) out of 264 contact-status impacted teeth. This discrepancy was influenced by the different age ranges of the samples. In the 23–30 age range, tooth roots are newly fully formed, making Darkening of the Root difficult to identify. Darkening of the Root occurs as a result of root adaptation to the mandibular canal, a process requiring more time. The probability of Darkening of the Root is found in patients over 30 years of age.[15]

The present study findings and those of Singh, Khanal & Dhungel (2020) are consistent, with narrowing of the mandibular canal ranking as the third highest prevalence category, reported at 113 cases (24%) out of 475 tooth samples.[13] This prevalence is not significantly different from the Table 5 report of 37 cases (14%) out of 264 contact-status impacted teeth. The difference in proportion was solely attributable to differences in sample sizes and variations in anatomical characteristics across populations. Elkhateeb & Awad (2018) identified canal narrowing as a primary indicator for determining inferior alveolar nerve injury risk, as the narrowing sign indicates that the nerve canal is experiencing a space-occupying effect. The narrower the canal appears on radiographs, the greater the likelihood of nerve compression by the tooth root in contact with the mandibular canal, rendering it susceptible to nerve injury.[16]

Table 5 shows consistency with the findings of Lee *et al*. (2008) and Mulyani *et al*. (2020), who identified diversion of the mandibular canal as the fourth highest prevalence category. The prevalence was 57 cases (6%) out of 381 tooth samples and 4 cases (6%) out of 60 tooth samples, as well as the Table 5 report of 28 cases (11%) out of 264 contact-status impacted teeth.[17,18] However, these results are inconsistent with Singh, Khanal & Dhungel (2020), who classified diversion of the mandibular canal as one of the lowest prevalence categories at only 30 cases (6%) out of 475 tooth samples.[13] The change in direction of the mandibular canal indicates the absence of canal cortication (cortical border), which normally protects the mandibular canal pathway due to root pressure against the canal, resulting in a visible deflection of the mandibular canal on radiographic imaging. Loss of the cortical border causes the canal pathway to become more exposed, rendering it susceptible to neurosensory complications, particularly those resulting from mechanical trauma during wisdom tooth extraction. The risk of nerve injury increases alongside the surgeon's ability to determine clinical surgical planning. Therefore, diversion of the mandibular canal is generally used as a primary indicator in assessing nerve injury risk.[16] Abdulrahman & Awadh (2025) confirmed that differences in the prevalence of mandibular canal diversion may be influenced by varying mandibular growth patterns attributable to genetic factors.[19]

Supporting Radiological Indicators

Dark and bifid root was reported from Table 5 with 64 cases (24%) out of 264 contact-status impacted teeth, making it the second highest prevalence category. This finding contradicts the results of Singh, Khanal, & Dhungel (2020), in which it was categorized as the lowest frequency and reported with only 20 cases (4.21%) out of 475 tooth samples. Therefore, dark and bifid root is considered one of the supporting indicator categories in assessing inferior alveolar nerve injury risk.[13] Savani *et al*. (2018) explained that this is because the dark and bifid root category is more difficult to identify clearly on panoramic radiographs, as root shadows appear superimposed in 2D imaging, and in some cases when identified with 3D imaging, no canal involvement is observed, only distortion in the 2D image.[20] Additionally, differences in radiographic analysis techniques among operators may influence differences in study results, as the researchers applied a negative effect using *Adobe Photoshop* to enhance the visibility of the mandibular canal area, whereas the study by Singh, Khanal, & Dhungel (2020) did not describe using the same technique.[13]

The radiologically visible sign of Narrowing of the roots is one of the supporting indicators in assessing inferior alveolar nerve injury risk. This finding is consistent with Singh, Khanal, & Dhungel (2020), who classified Narrowing of the roots as one of the low-frequency categories with 32 cases (6.74%) out of 475 tooth samples, and the Table 5 report of 8 cases (3%) out of 264 contact-status impacted teeth.[13] Dudhia *et al*. (2010) defined Narrowing of the roots as a groove (perforation) on the buccal (cheek-facing) or lingual (tongue-facing) aspect of the root, as the primary indication of canal wall erosion by root activity (canal decortication). Panoramic radiography only produces 2D images, making it difficult to accurately visualize complex three-dimensional root morphology, such as perforations directed buccally or lingually (bucco-lingual inclination). Therefore, the Narrowing of the roots sign is less reliable as a clinical indicator for assessing inferior alveolar nerve injury risk.[21]

Deflection Roots is used as a supporting indicator for inferior alveolar nerve injury risk. Anatomically, Deflection Roots emerges as an adaptive mechanism to avoid dense structures such as the mandibular canal. Therefore, the Deflection Roots sign does not indicate damage to the mandibular canal wall, making this radiological sign less reliable in determining inferior alveolar nerve injury risk.[22] Based on Table 5, Deflection Roots was reported in 2 cases (1%) out of 264 contact-status impacted teeth. This finding contradicts the reports of Singh, Khanal, & Dhungel (2020) and Mustamu *et al*. (2025), with respective prevalences of 49 cases (10.32%) out of 475 tooth samples and 26 cases (12%) out of 210 tooth samples.[13,10] El-Naji *et al*. (2023) stated that differences in the prevalence of Deflection Roots depend on ethnic variation.[23] In Table 5, samples were drawn from the Banjar ethnic population in Banjarmasin, which has a lower urbanization rate. This lower urbanization is associated with lower variation in jaw morphology, thereby influencing the adaptive patterns of tooth roots relative to the mandibular canal, such as the tendency for Deflection Roots. In contrast, the findings of Singh, Khanal, & Dhungel (2020) were based on an ethnic population in Nepal with different genetic backgrounds from Indonesia, while the findings of Mustamu *et al.* (2025) were based on an ethnic population in Jakarta, a city with the highest urbanization rate in Indonesia. This demonstrates that genetic and environmental factors together can produce varying Deflection Roots characteristics.[13,10]

Based on the study results, it is concluded that radiological signs indicating the positional relationship of the apex to the mandibular canal serve as primary indicators for determining inferior alveolar nerve injury risk. These signs include The Interuption of the white line, narrowing of the mandibular canal, and diversion of the mandibular canal. Meanwhile, radiological signs indicating changes in apex morphology generally serve only as supporting indicators, encompassing Narrowing of the roots, Deflection Roots, and dark and bifid roots. However, Darkening of the Root constitutes an exception, as it is believed to be uninfluenced by the type of radiography or ethnic variation.

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